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Title of Dissertation: *Investment In a Macroeconometric Interindustry Model.*

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ABSTRACT

Title of Dissertation: *Investment in a Macroeconometric Interindustry Model.*

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This dissertation describes the development and simulation testing of alternative equipment investment equations incorporated within the INFORUM model, a large macroeconometric interindustry forecasting model of the U.S. economy. The equations are compared on the basis of their ability to track the actual behavior of investment at the industry level and to give reasonable forecasting results in a simulation framework.

The dissertation consists of four parts. In the first part I develop a selected survey of the relevant theoretical and econometric literature, including a discussion of previous models done at INFORUM and investment equations in some major macroeconomic models. In the second part I present the development and specification of 8 alternative econometric investment equations. In the third part I present and discuss the estimated parameters and fitted plots of these 8 models. Finally, in the fourth part I present the results of comparative tests of the 8 models. I conclude that an autoregressive model generally outperforms all other models considered here in both within-sample and out-of-sample simulations in a 7 year annual

simulation. However, models based on Cobb-Douglas production function and the Generalized Leontief cost function also perform well in the out-of-sample simulations, and are to be preferred on theoretical grounds.

This study is distinguished from other published works on investment in two ways. First, investment demand is studied at a much lower level of aggregation than in most other studies, using investment data developed by the author. Second, the performance of a variety of models is critically tested by using a simulation framework within what is essentially a general equilibrium econometric model.

INVESTMENT

IN A MACROECONOMETRIC INTERINDUSTRY MODEL

by

Douglas S. Meade

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CHAPTER I

RATIONALE FOR THIS STUDY

1. Introduction

Econometric studies on investment now number well into the hundreds. Theoretical studies are even more numerous. One would be justified asking what information could be gained from yet another econometric study on investment. This study addresses a question which has not been adequately dealt with in the investment literature to date: Which empirical specification explaining equipment investment performs the best at an industry level of detail in a dynamic general equilibrium framework? This matter is investigated using gross investment data for equipment for 53 industries comprising the total U.S. economy. Eight alternative sets of empirical investment equations are developed and tested within a macroeconomic interindustry model, developed at the Interindustry Forecasting Project at the University of Maryland (INFORUM). These equations are representative of the investment equations appearing in the empirical literature, in other macroeconomic models, and in previous versions of the INFORUM model.

The literature contains investment studies based on the accelerator theory, the liquidity theory, the neoclassical theory, the *q* theory, and others. Other theoretical developments that have aided our current understanding of the determinants of investment are the theory of adjustment costs, the theory of interrelated factor demands and from the theory of duality, with the concomitant proliferation of flexible functional forms.

Econometric techniques such as nonlinear three-stage least squares, maximum likelihood, and optimal control models have developed in parallel with the empirical estimation of investment equations. A multitude of polynomial distributed lag models have been used to capture the dynamic behavior of investment. Equations have been fit for aggregate, industry level and firm level data, cross sectional and time series (or pooled), quarterly and annual data, for equipment or structures investment, or for both combined.

A relevant, though ill-defined question should be addressed: Which investment model, with its empirical counterparts, is in some sense "the best"? The answer to this question may involve the consideration of a number of issues. Should we judge models by their fit to the historical data? Is the reasonableness and consistency of the underlying theory supporting the empirical equation important? What weight should be given to estimating proper signs and reasonable values for the parameters, versus fitting the data as closely as possible? To what extent has the increasing sophistication of theory and the relation of theory to econometric techniques contributed to our ability to model investment in applied work?

The first major contribution of this study is that it gives full consideration to the above issues. However, the main goal is to develop a set of equations which will yield accurate and reasonable forecasts in the context of a complete interindustry model. Therefore, I have given the most emphasis to performance of the alternative equations in the context of the full INFORUM model in dynamic simulations.

The second major contribution of this study is the construction of a set of constant dollar gross equipment investment data for roughly 53 industries comprising the U.S. private economy.[1] These data are the first set of industry level data that I know of that is consistent with the benchmark capital flow tables developed by BEA, and consistent with the published Producers' Durable Equipment (PDE) series in the National Income and Product Accounts (NIPA). The construction of this data is described in Appendix A.

These data were used to estimate the eight alternative investment equations from 1953 to 1985 and then simulate their performance within the INFORUM model. The same equations have also been estimated only through 1977, and then simulated from 1977 to 1985. This simulation shows how well the equations fit in periods beyond the sample set. The performance of the equations is appraised

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[1]This level of aggregation matches that of the B-matrix of the Inforum model. The B-matrix, or capital flow matrix, is a bridge which translates demand by investors (buyers) into purchases from various producers' durable equipment categories (sellers). Producers' durable equipment is a component of sectoral final demands, which in turn affect the sectoral output levels. Since all of the equations tested in this study are affected by changes in sectoral outputs, this constitutes a mutual feedback between output and investment.

by the closeness of fit of the simulation, the reasonableness of the sign and magnitude of responses to the explanatory variables, and to the timing of the responses. Obviously this method of appraisal is somewhat subjective. The individual researcher must determine the relative weights to assign to the various criteria used to evaluate the models. However, this is perfectly natural, since different researchers place different demands upon their models.

The following section briefly describes the INFORUM interindustry model in which these equations were tested.

2. The INFORUM Model

The INFORUM model[2] is a dynamic interindustry or input-output model that forecasts both final demands and prices at the industry level, with a forecast horizon of 5 to 20 years. The model is also in many respects a macro model, forecasting such variables as the unemployment rate, the savings rate, interest rates, and the government deficit. However, in the INFORUM model most of these macroeconomic variables are constructed from subaggregates at the industry level. For example, the calculated unemployment rate is directly related to the forecasts of employment by 55 industries. The intermediate coefficient matrix, or A-matrix, consists of 78 rows

[2]The following description of the INFORUM model is of necessity extremely brief, giving only a bare outline of the operation of the model. For a more detailed depiction of the various parts of the model, the reader is referred to Monaco (1983).

and 78 columns. Final demand consists of demands by consumers, government, investors in equipment and structures, government, inventory change and exports. Each of these final demands is specified for the products of each of 78 industries. However, equipment investment is first forecast for a total of 55 investing sectors, and then translated through a 78-by-55 B-matrix (capital bridge matrix) to arrive at producers' durable equipment (PDE) demands for 78 categories. Likewise, structures investment is forecast for 31 categories, and then translated through the 78-by-31 C-matrix (construction bridge matrix) to obtain demands relating to categories of construction for 78 types of construction inputs. Personal consumption expenditures (PCE) are forecast for 78 consumer goods categories (which are different from the 78 output sectors) and translated into demands for the 78 producing industries by a 78 row by 78 column consumption bridge matrix.

Sectoral outputs are calculated by the Gauss-Seidel method, using the A-matrix in conjunction with the sum of final demands. This is equivalent to the calculation of outputs by

(2.1) $$q = (I - A)^{-1}f$$

where q is the column vector of outputs, f is the column vector of the sum of final demands, and A is the A-matrix of intermediate coefficients.[3] Since the equipment and structures investment

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[3]This identity is derived from the basic identity:

equations are also solved simultaneously with output, the model returns to recalculate investment after outputs have been solved. The close relationship between output and investment gives rise to the investment-output loop, which repeats until outputs converge within a specified tolerance.

After the investment-output loop has converged, employment by industry is calculated, based in part on sectoral outputs. Given an exogenous labor force projection, and employment by industry, the unemployment rate is calculated as an identity.

The forecast of final demands and employment, and the calculation of output summarized above comprise the "real side" of the INFORUM model. This block of the model is responsible for the calculation of "real" or constant dollar (deflated) quantities. After employment has been calculated, the real side is essentially finished, and the flow of control moves to the "price side". The purpose of the price side is the calculation of value added components by roughly 40 value added sectors. Value added is then used to calculate domestic producer prices for the 78 input output sectors, from which consumption prices, equipment prices and energy

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$$Aq + f = q$$

which means simply that output is equal to the sum of intermediate plus final demands.

In the solution sequence of the model, both imports and inventory change are calculated in conjunction with the Gauss-Seidel loop that calculates outputs. This is due to the close interdependence of these final demand categories with output.

prices can be derived, as well as such macro aggregates as the GNP deflator. These value added components include profits, proprietors' income, rental income, dividends, corporate and noncorporate capital consumption allowances, labor compensation and net interest. Domestic producer prices are calculated from the A-matrix and value added using a version of the Gauss Seidel process that calculates outputs. This process is equivalent to the calculation:[4]

(2.2) $$p = v(I - A)^{-1}$$

where p is is row vector of domestic producer prices indexed to 1.0 in the base year of the A-matrix, v is a row vector of unit value added (value added per constant dollar of output), and A is the matrix of intermediate input-output coefficients.

In addition to the primary calculations of final demands and employment on the real side, and value added and price on the price side, the model includes a personal tax submodel, which calculates the before and after tax distribution of income, based on various components of the tax code. Another submodel is the "accountant", or NIPA model, which calculates many of the aggregates included in the National Income and Product Accounts. Miscellaneous macroeconomic variables that are calculated include interest rates, the savings

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[4] This is derived from the basic identity:

$$pAq + vq = pq$$

or $$pA + v = p$$

rate, disposable income, tax revenues and the government deficit.

After the price side has converged, and the NIPA calculations have been performed, the model returns to the real side to recalculate final demands and employment based on the prices and macroeconomic variables calculated on the price side. The model continues this iterative recalculation of the real side and the price side until the industry output solution converges. This iteration is necessary because the model is a general equilibrium model. Real quantities depend upon prices, but prices also depend upon real quantities. The iteration procedure in the model is an efficient way of solving for the inherent simultaneity between the real and price side.

In order to perform the simulation exercises discussed in Chapter V, it was necessary to reprogram the INFORUM model to give it full historical simulation capabilities.[5] The model can now start and end in any year, and subsets of the model can start simulating in any year. For example, equipment and structures investment could be simulated along with outputs, while treating the remaining parts of the model as exogenous. Values of right hand side variables can be taken from a previous run of the full model, or introduced exogenously, to perform hypothetical scenarios. A simulation of

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[5]The details of this reprogramming will not concern us here. However, the development of the INFORUM model into a full simulation model was a major part of the work required for the production of this study.

investment by itself over a historical period should yield the same results as the fitted value of the equation, and thus be a purely static simulation. Alternatively, other parts of the model can be brought into play to examine their effects on the simulation. I know of no other simulation tool of this size and complexity that can be brought to bear on the problem of finding an investment model that simulates well. The ability to model the interactions between investment and prices and outputs at the industry level provides an exhaustive test of the performance of the alternative investment models examined here.

3. Goals of This Study

The basic objective of this study, as mentioned in section 1, is to find a set of econometric equipment investment equations that simulate historical performance well at the industry level, and whose structure is well-grounded in microeconomic theory. These equations preferably should allow us to address typical questions such as the effects of various tax policies on investment, or what to expect from a general increase in real wages or real energy prices. We would expect the equations to give reasonable forecasts over the five to twenty year horizon.

Previous investment models tried at INFORUM will be reviewed in chapter II. Of the various investment models developed at INFORUM, only two have been tested in simulations, and only one of these was with the entire model used in the simulations. This study, on the other hand, reports the results of a whole battery of dynamic simulation tests both within and beyond the sample period for eight alternative models.

In the process of determining an optimal set of investment equations, I will assess some of the various methodologies for evaluating and comparing simulation performance. I will also deal with the question of whether or not the simulation approach is really appropriate for testing alternative models.[6] Finally, I will attempt to determine how well the price and output elasticities implied by our estimated equations conform to the behavior of the equations within the full model.

The next chapter will review some of the relevant theoretical and empirical literature on investment, as well as previous investment equations in the INFORUM model, and the investment equations used in other macroeconomic models. Chapter III will present the alternative investment models. Estimation results will be given in chapter IV, and simulation results in chapter V.

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[6]Howrey and Kelejian (1971) have pointed out that in a simultaneous equation model with nonlinearities, even if we were to estimate the "true" model, simulated values of model variables would diverge somewhat from the actual values. This behavior is due to the fact that the expected value of the error of an equation will not be zero when solved in the context of the entire model, even if the disturbance term in each individual equation has a zero expected value. Furthermore, the errors will compound over time. This question will be further dealt with in Chapter V.

CHAPTER II

SELECTED SURVEY OF THE LITERATURE

This chapter will review selected theoretical and empirical literature from the 1970s and 1980s that is relevant to the development of the various investment models tested in this study. The discussion of empirical investment studies in section 1 serves as an extension and update to Jorgenson's (1971) survey. Sections 2 and 3 summarize two important lines of theoretical work during that period. The first is the more complete development of the theory of interrelated, dynamic factor demands and the associated specification of how adjustment costs can be used to rationalize the dynamic response of investment to its determining factors. The second is the rise to prominence of the family of flexible functional forms, and the development of the underlying duality theory which gives theoretical support for the use of these functional forms. In section 4, previous investment equations used in the INFORUM model are discussed. Section 5 is an overview of the investment equations used in the major macroeconomic models.

One of the goals of this study is to determine if the recent developments in investment theory have really contributed to our ability to build a working, reliable econometric investment model. If the selection of investment equations from the macro models presented in section 5 is representative of current empirical forecasting use, then it appears that new theoretical developments are outstripping the ability of practitioners to successfully incorporate them into their models. Alternatively, it is possible that the sharpening of theoretical tools has just not improved our ability to develop useful forecasting models.

1. Empirical Investment Models

A review of the entire investment literature certainly is beyond the scope of this study. However, if we focus on the empirical literature, and more specifically on time series studies, we find the extent of the literature reduced drastically. Most of the empirical work is of course grounded in some theory, since every empirical researcher's model embodies a subjective decision as to what aspects of the theory are important, tractable, and likely to be reflected in the data. In reviewing the empirical literature, the researcher must at least touch upon the various strands of the development of economic theory that bear upon the problem of modeling and forecasting investment. Two extremely important topics are the development of estimable dynamic factor demand models with interrelated adjustment costs, and the development of duality theory and flexible functional forms. Although the treatment of these topics will be taken up more fully in sections 2 and 3, in the interest of continuity, empirical papers influenced by this work will be also discussed in this first section .

A good starting point in the empirical literature is the review by Jorgenson (1971).[7] This paper, which is probably the most recent comprehensive review of this subject, surveys the basic developments in investment equations for plant and/or equipment up to the late 1960s. The three major developments of this period were: (1) The formulation of distributed lag functions that conserved degrees of freedom by imposing a structure on the lag distribution; (2) The division of gross investment expenditures into replacement investment used to replace worn out or obsolescent capital, and net investment, which is a net addition to the capital stock; and (3) The specification of net investment as a response to the discrepancy between actual capital stock and desired capital stock, which is a function of output, relative prices, or other variables. Although sales, measures of liquidity, and profits were all used as explanatory variables, Jorgenson found that most of these models reduced to a flexible accelerator model, with desired capital proportional to a measure of output but still somewhat affected by other variables.

The time series studies of investment which Jorgenson reviews are of particular interest. Anderson (1964) develops equations using quarterly data for 13 industry groups using capacity, profits, interest rates, accrued tax liability, long term debt capacity and

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[7] A complement to Jorgenson's article is Klein (1974), who provides a well-organized summary of the controversy and unsolved questions concerning the empirical estimation of investment equations.

stocks of government securities as separate variables. He obtains mixed results. Meyer and Glauber (1964) estimate annual equations for each 2-digit manufacturing industry, using capacity utilization, profits, interest rates, and the change in prices of common stocks as determinants. The only consistently significant variable they find is profits. Neither of these two studies explicitly models replacement investment, and unreasonable lag structures are obtained. Resek (1966) models quarterly data for 13 industry groups, with output, the change in output, the rate of interest, a measure of debt capacity, and an index of stock prices as explanatory variables. The only variables he finds significant are the interest rate and the stock price. Evans' (1967) and Eisner's (1962, 1965) models include sales and other variables. According to Jorgenson, these both reduce to the flexible accelerator model. Hickman (1957) is one of the first to introduce a 'neoclassical' cost of capital into his model, which is measured as the product of the investment goods price index and the sum of the interest rate and the depreciation rate. Bourneuf (1964) models annual data for 13 industry groups and finds capacity utilization and the change in output alone to explain investment expenditures well.

Jorgenson proposes his 'neoclassical' model as an improvement with respect to the models listed above. Citing earlier work[8], he

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[8]Hall and Jorgenson (1967, 1969) is the most well-known presentation of the neoclassical theory of investment. Jorgenson (1963, 1965, 1967) and Jorgenson and Stephenson(1967a, 1967b, 1969)

demonstrates the usefulness of specifying desired capital stock to be derived from the functional form of the production function and related to a measure of the rental cost of capital that depends upon interest rates, economic depreciation, the corporate tax rate, the investment tax credit, and deductions of depreciation for tax purposes. He uses the geometric mortality distribution to model replacement investment. In this case, the same depreciation rate used to calculate replacement investment as a fixed proportion of the capital stock is also appropriate as the depreciation rate included in the rental cost of capital.[9] In this case, the capital stock can be represented as a weighted sum of past gross investment expenditures with geometrically declining weights. The production function chosen to derive an expression for the desired capital stock is the Cobb-Douglas production function, which has both an output elasticity and an elasticity of substitution of unity.

Eisner and Nadiri (1968,1969) however, tested Jorgenson's data using a CES functional form and found the elasticity of substitution to be significantly different from unity. They also found the elasticity of the capital stock with respect to output to be less

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also provide exposition of the neoclassical theory, with the latter papers presenting estimates on quarterly data at the industry level. Jorgenson and Siebert (1968a) and Jorgenson, Hunter and Nadiri (1970a, 1970b) compare the empirical performance of the neoclassical model to alternatives and find it superior by their criteria.

[9]Appendix C provides an overview of different methods of measuring the rental cost of capital and the version of the rental cost that is used for the current study.

than unity. They faulted Jorgenson for imposing the same lag structure on prices as on output, by including output and relative prices as a composite term in his equation. Feldstein and Foot (1971) criticize Jorgenson for assuming that the coefficient on his capital stock term represents the depreciation rate, and assert that there is evidence that the depreciation rate varies over time. They find that these changes can be related to changes in other economic variables.[10]

The distributed lag pattern chosen by Jorgenson for the measure of his desired capital stock was the Pascal lag, or rational lag. This formulation has been criticized as imposing too much subjective structure on the lag distribution.[11] The lag structure developed by Shirley Almon (1965) seems superior in many respects to lag distributions such as the Koyck lag, the Pascal lag or the rational lag. However, it was shunned by Jorgenson and many others until the 1970s, perhaps because of a perceived difficulty in implementation.

Another issue discussed by Jorgenson was the average length of the lag for determinants of investment. This was determined by choosing the length of lag that minimized the standard error of the

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[10]Bitros and Kelejian (1974) use data on capital scrappage in the electric utilities industry, and reject the proportional replacement hypothesis, finding that the replacement ratio varies cyclically in at least this particular industry, and is related to maintenance expenditures, changes in gross investment, the rate of interest, and the rate of capital utilization.

[11]See Eisner and Nadiri (1969).

estimate. In his industry-level work, he found this lag to vary from six to twelve quarters. However, he finds the optimal lag using annual data to be longer, from three to six years. The discrepancy between lag patterns found in quarterly versus annual data remains a puzzle.

At this time Nadiri and Rosen (1969) had already initiated a development which had important implications for the empirical estimation of investment equations. In their seminal paper, they presented a model of interrelated factor demand functions.[12] In this model, demands for capital, employment, man hours and capital utilization were estimated based on relative prices, lagged stocks, and output -- the coefficients on lagged stocks representing costs of adjustment. The assumption of a Cobb-Douglas production function was maintained, so that with all variables in logarithms, the coefficients of the model could be interpreted in terms of Cobb-Douglas parameters. All long run scale phenomena were embedded in the stock demand functions, whereas short run shocks were accomodated by changes in utilization rates.

Nadiri (1972) estimated a similar model using quarterly data from 1942 to 1971. He improved upon the Nadiri and Rosen model by estimating 'expected' relative prices and output as a weighted Almon autoregressive scheme. He found complementarity between investment and employment. He did not find the utilization rate to enter

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[12] Section 2 reviews the literature on adjustment costs and dynamic interrelated factor demands.

significantly into the investment equation. Another researcher who derived his empirical model from the adjustment cost literature was Schramm (1970), who estimated a model for labor, fixed capital and liquid capital. He incorporated the formation of expectations by adding the variables affecting expectations directly into the final equations to be estimated. The variables included in each equation were lagged stocks, lagged changes in stocks, and factor prices relative to the price of output. Schramm used quarterly data from 1949 to 1962 for all U.S. manufacturing. A distinguishing feature of this model is the absence of output from the equations. The relative user cost of capital was found to be significantly negatively related to investment. Wage rates were also important.

Coen and Hickman (1970) jointly estimated demands for capital and labor. The underlying production function they assumed is Cobb-Douglas, and factor demands are related by sharing common parameters derived by maximizing present value subject to a production function. Annual time series data for the entire economy were used, covering the two periods from 1922-1940, and 1947-1965. Estimates of the production function were obtained from the parameters in the estimates of the factor demand relations. Price and output expectations were specified to be determined by autoregressive equations. Factor demands are adjusted independently towards desired values at a constant, geometric rate. The adjustment period of capital to a change in prices or output was estimated to be long, with only half the adjustment taking place within five years.

Bishoff (1969, 1971a) developed some models that focused particularly on the timing of the effects of the various determinants of investment. The crucial feature of his model is that changes in the rental price of capital may affect investment expenditures with a lag distribution different from that for changes in desired capacity, as indicated by output. This specification is based on the notion that production processes are *putty-clay*.[13] In a purely putty-clay world, factor proportions are variable only up to the point at which new machines are installed, either for replacment or expansions to capacity. In general, the optimal capital-output ratio at any given time is a function of relative prices. The amount of investment necessary to replace a unit of capacity that wears out or becomes obsolete will depend on relative prices, rather than the amount of investment that originally took place. Therefore the effects of changes in relative prices will show their full effect later than changes in output. This is because an increase in output immediately draws forth demand for new capacity, whereas price changes effect the *proportion* of capital to output in each successive vintage of capacity.

Bischoff assumed a CES production function, and derived an optimal capital-output ratio based on relative prices and the price elasticity of capital. The following equation was estimated using quarterly data on total U.S. expenditures on PDE from 1951 to 1965:

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[13]See Johansen (1959), Bliss (1968). For doubts about the relevance of the putty-clay concept see Hall (1977).

$$(1.1) \qquad I_t = \zeta \sum_{j=0}^{n} \sum_{i=0}^{m} \beta_{ij} V_{t-i} Q_{t-j} + \varepsilon_t$$

where ζ is a constant to be estimated, β is a matrix of parameters to be estimated, V is the optimal capital-output ratio determined by relative prices and the price of output, and Q is output. The elasticity σ is contained in the expression for V and also must be estimated. The maximum length of lag (n or m) chosen was 12 quarters. The β coefficients were constrained to lie along a third degree polynomial in i, and a nonlinear iterative technique was used to determine σ. Bischoff compared his model to a variant of Jorgenson's neoclassical model, and found that his model fitted better. Although he found the long run price elasticity of capital to be near unity, the short run elasticity was much less than this, and capital responded much more slowly to a change in relative prices than to a change in output. Inspecting the β matrix, he found that the response of equipment spending to a change in V varied with the rate of growth of output; the faster output grows, the faster factor substitution will take place. He claimed that this finding supported the putty-clay hypothesis.

Chang and Holt (1973) and Craine (1975) contributed to the theory of investment in the presence of adjustment costs by adding the treatment of uncertainty to the problem. Chang and Holt in their paper first derive a solution to the dynamic problem faced by the firm, and determine the desired stock of capital in each period that would maximize expected profits under certainty. In the second stage of the analysis, conditions are derived under which a firm miminizes dynamic costs that result from the fluctuation of demand. Desired capital stock in the first stage was determined by sales, the ratio of the wage rate to capital rental costs, and the ratio of the output price to capital rental costs. The addition of uncertainty to the problem was achieved by adding the coefficients of variation of the wage rate, output price, sales, and the correlation coefficients among these variables to the list of determinants of desired capital stock. The model was estimated using appropriations data for both durable and nondurable manufacturing. Results showed that the elasticity of capital with respect to expected sales to be high in the nondurable goods industries, but not in durable goods industries.

Craine derived an investment decision rule from a dynamic stochastic model of the firm, and used this theoretical specification to estimate an investment model. A Cobb-Douglas production function was assumed, with capital and labor as inputs. The derived cost function was augmented with a quadratic function of gross investment to represent adjustment costs. Exogenous variables included the discount rate, the wage rate, the current price of investment, and the rate of technological change. Uncertainty was handled in this model by developing conditional expectations on the (random) exogenous variables by modelling them as ARIMA processes. This model, like that of Schramm, shows that factor prices alone can do a good job of explaining investment. Craine finds the own price elasticity of capital to be -1.0, and the cross-price elasticity capital with respect to the wage rate to be about 0.4.

Another strain of the literature that burgeoned in the mid 70s was the estimation of static factor demand models based on flexible functional forms.[14] These models were not used to estimate an investment function *per se*, but rather a demand for capital stock, which was often specified as a factor share. Berndt and Christensen (1973) used the translog function to fit factor shares for structures, equipment, and labor in U.S. manufacturing from 1929 to 1968. Duality theory, in addition to making the estimation of factor demands possible with a minimum of *a priori* assumptions about elasticities, also specifies the conditions under which various inputs can be combined to form a meaningful aggregate. Berndt and Christensen used an iterative Zellner technique to estimate the translog share equations, and find that structures and equipment are more highly substitutable with each other than with labor. However, they reject the hypothesis that equipment and structure can be consistently aggregated.

Another flexible form is the generalized Leontief[15], used by Woodland (1975) to estimate factor demand equations for 10 industries comprising the Canadian economy. Two broad conclusions emerge from his study: (1) Relative factor prices play an important role in the

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[14]Section 3 will delve more fully into the topic of using flexible functional forms to derive factor demand equations.

[15]See section 3.

determination of factor demands; and (2) Price elasticities and output elasticities are significantly different across industries. Woodland's results suggest that much is lost by estimating factor demand or investment equations at the aggregate level.

Hall (1977) tried to assess the effects of interest rates on investment, to determine how much this link should be relied upon in standard IS-LM analysis. He advanced a number of arguments in defense of the view that a high interest elasticity of investment is a good description of long run behavior. Although many researchers working with time series data have found only a small interest elasticity of investment, Hall noted that this may merely reflect a slow adjustment process. Bischoff's findings are cited in support of this argument.[16] Many researchers use a long-term interest rate in their formula for the rental cost of capital, or as an independent variable explaining investment. Hall argued that the short term rate is the appropriate variable, since in maximizing present value, each firm makes a comparison of the stream of future returns of an investment made this period with the stream from investment postponed one period. Hall presented the results of estimating a fairly simple investment equation that tends to suggest that the long-term interest

[16] Hall does not agree however that Bischoff's findings can be construed as evidence of putty-clay technology. First, many decisions about the combination of labor and capital are made month to month, after the capital has already been put in place. Capital can be utilized in varying degrees, by combining it with different proportions of labor.

elasticity of investment is actually somewhat less than one.

In the late 70s and early 80s a number of papers appeared that attempted to use Tobin's q ratio to explain aggregate investment. The results of this work have not been very successful empirically. The q ratio, as developed by Tobin and Brainard (1977), is the ratio of the market value of firms to the replacement cost of their assets. This theory, which is derived from the same conditions for the maximization of the present value of the firm as the neoclassical theory, states that firms should undertake investment whenever their q ratio is greater than one, since this will increase the present discounted value of the firm. If q is less than one, firms should simply let old capital depreciate. One problem with empirical attempts to use q is the construction of a meaningful q ratio from the available data. The appropriate concept from a theoretical viewpoint is marginal q. To construct this value it would be necessary to know the marginal increment to the value of the firm due to new investment, and the increase in replacement cost of assets at the margin. Since these data are unobtainable, researchers usually construct an average q by dividing current market value by some measure of the replacement value of the capital stock. Using aggregate data is especially egregious for q theorists, since aggregate q can be expected to give much less information than individual firm or industry q ratios.

von Furstenburg (1977) developed quarterly estimates of aggregate q for nonfinancial corporations, and estimated orders and investment equations based on this measure. He found that although q explains a good bit of the variance in aggregate investment, capacity utilization performs much better. Furthermore, the difficulty in forecasting q makes it a poor candidate for forecasting investment in the context of an econometric model. Malkiel, von Furstenburg and Watson (1979, 1980) achieved more sanguine results with a q model of investment for two-digit manufacturing industries. Their estimated equation has the change in investment divided by the trend level of the capital stock regressed on the change in output divided by the trend level of output, and the change in industry level q divided by its industry level average. Their results show that changes in q appear to have more explanatory power than changes in output in signalling changes in investment. Ciccolo and Fromm (1980) also found a significant linkage between q and the ratio of investment to the capital stock. Their study examined Compustat data on 277 individual firms from 1965 to 1976. They found that q ratios have fallen since the early 1970s, possibly due to energy and agricultural price shocks and higher inflation.

Summers (1981) presented an ambitious attempt to incorporate the effects of tax policy into the measurement of q. He found that a tax-adjusted measure of aggregate q explains aggregate investment better than conventional measures of q. In this framework, inflation is found to have a significant negative effect on investment. However, Summers found that capital follows a very slow adjustment process in response to changes in q, with a half-life of over

10 years, which seems unreasonable.

Feldstein (1982) also found evidence of a negative impact of inflation on investment. Using data on total business investment from 1963 to 1978, he estimated three alternative models that all seem to indicate a decline in investment since the late 1960s due to the interaction of inflation and existing tax rules. Feldstein points to four separate nonneutralities in the tax system that lead to negative effects of inflation on investment. First, the use of historical cost depreciation for tax purposes understates true depreciation, and thus raises the effective corporate tax rate. Second, firms that use FIFO inventory accounting incur additional tax liabilities on their inventory profits. Third, firms are permitted to deduct nominal rather than real interest payments for tax purposes, which tends to partially offset the effects of historical cost depreciation deductions and inventory capital gains. Fourth, the taxation of nominal rather than real capital gains on equipment and structures leads to an artificial increase in the measured before-tax return on equity to investors. Feldstein called for revisions in the tax system to remove these nonneutralities.[17]

A recent paper casting doubt on the empirical usefulness of the *q* theory is Abel and Blanchard (1986). These authors computed a

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[17]However, see Barbera (1987), who examines Feldstein's equations in a non-nested comparison test with other reasonable alternatives that do not find a significant negative impact of inflation on investment. Barbera finds that these other equations reject Feldstein's equations, but are not rejected by Feldstein's equations.

series on marginal q, which they interpret as the present value of marginal profits. Their major finding is that the cyclical movement in marginal q is due less to movements in marginal profit than to movements in the cost of capital. In this case, there is not much information in the q measure beyond movements in the cost of capital.

The current dissertation is an extension of another strand in the literature, which is the comparison of the performance of alternative investment equations. Griliches and Wallace (1965) found it hard to discriminate among alternative theories of investment using time series data. Jorgenson and Siebert (1968) tested two versions of Jorgenson's neoclassical model with a liquidity model, an expected profits model and an accelerator model. The liquidity model used a measure of cash flow as its main explanatory variable. The expected profits model, which is a precursor of the q model, used the market value of the firm, as measured by stock values. The accelerator model simply used lagged values of the change in output. The models are estimated on data for 15 firms from 14 OBE-SEC industry groups. A Pascal lag distribution was used for the lagged determinants of each equation. The model comparison was made on the basis of goodness of fit, and tested also against a naive autoregressive theory. The two neoclassical models were found to perform the best, followed by the expected profits model, the accelerator model, the liquidity model, and finally the autoregressive model. Elliot (1973) compared the same models considered by Jorgenson and Siebert, but used data for 184 firms from

1953 to 1967 from the Compustat data bank, for 72 4-digit industries. He found only small differences in the explanatory power of the neoclassical, liquidity and accelerator models in time series regressions, with the expected profits model showing slightly inferior results. A combined cross-sectional and time-series analysis gives the highest ranking to the liquidity model, and the second best ranking to the accelerator model.

In a pair of articles, Jorgenson, Hunter and Nadiri (1970a, 1970b) compared alternative investment models both in terms of fit, and in terms of post sample prediction capability. The four models compared are Anderson's (1964) model, which is based on capacity pressure, profits, and interest rates; Eisner's (1962) model, based on changes in sales, profits, lagged investment and capital stock; the Meyer-Glauber (1964) model, which uses capacity utilization, profits, interest rates and the change in stock prices; and the Jorgenson-Stephenson (1967a, 1967b) neoclassical model, which uses output, the price of output, the cost of capital, lagged net investment, and lagged capital stock. These models were estimated using quarterly OBE-SEC data for 13 industries, from 1949 to 1964, and the models were ranked in terms of the proportion of "wins" over each other model, in terms of R^2. The Jorgenson-Stephenson and Eisner models were both found to be superior, whereas the Anderson and Meyer-Glauber models showed a lackluster performance. The predictive comparisons in the second paper (1970b) were made with an F-test that compares the errors in the prediction period with the errors in the period of estimation. This test reduces to a simple test of structural change between the two periods. The maintained hypothesis is that models showing significant structural change are likely to be misspecified. On the basis of this test, the models were ranked as follows: (1) Eisner, (2) Jorgenson-Stephenson, (3) Meyer-Glauber, and (4) Anderson. This is essentially the same ranking obtained in terms of R^2.

Bischoff (1971b) approached the model comparison problem using aggregate quarterly time series data from 1953 to 1968, and includes an *ex post* simulation comparison. He compared the following five model specifications for both equipment and structures:

The Generalized Accelerator Model:

$$(1.2) \qquad I_t = b_0 + \sum_{i=1}^{n} b_i Q_{t-i} + b_{n+1} K_{t-1}$$

The Cash Flow Model:

$$(1.3) \qquad I_t = b_0 + \sum_{i=1}^{n} b_i (F/q)_{t-i} + b_{n+1} K_{t-1}$$

The Securities Value Model:

$$(1.4) \qquad I_t = \left[b_0 + \sum_{i=1}^{n} b_i (V/qK)_{t-i} \right] K_{t-1}$$

The Standard Neoclassical Model:

$$(1.5) \qquad I_t = b_0 + \sum_{i=1}^{n} b_i (pQ/c)_{t-i} + b_{n+1} K_{t-1}$$

The Federal Reserve - MIT - Penn Model:

$$(1.6) \qquad I_t = b_0 + \sum_{i=1}^{n} b_{1,i}(p/c)_{t-i-1}Q_{t-i} + \sum_{i=1}^{n} b_{2,i}(p/c)_{t-i-1}Q_{t-i-1} + b_{n+1}K_{t-1}$$

where

I = gross investment in plant or equipment

Q = output

K = the capital stock of plant or equipment

F = sum of corporate profits after taxes plus corporate capital consumption allowances

q = the price deflator for equipment or structures

V = market value of equities plus corporate bonds

c = the rental cost of capital

The cash flow model is similar to what Jorgenson calls the liquidity model, the securities value model corresponds to his expected profits model, and the neoclassical model is Jorgenson's model. Note that the FRB-MIT-Penn (FMP) model is essentially a variant on the model presented in Bischoff (1971a). Bischoff found that all five models fit the data fairly well, so that R^2 is not a useful criteria for comparison. However, in the *ex post* simulations, the FMP equation performed the best, followed by the accelerator equation. The cash flow equation performed the worst by far. For all of the models considered, the root mean squared errors (RMSE) in the simulation period are significantly higher than the standard error in the estimation period.

Clark (1979) performed a comparison similar to that of Jorgenson, Hunter and Nadiri (1970b) with quarterly data extending to the second quarter of 1978. He compared a generalized accelerator model, accelerator-cash flow model, neoclassical model, modified neoclassical model, and securities-value model. The accelerator, neoclassical and securities value models are the same as those used in Bischoff (1971a). The accelerator-cash flow model adds a cash flow term to the accelerator specification, and the modified neoclassical model derives from Bischoff's putty-clay model. In terms of fit, Clark found the neoclassical and the accelerator models to be superior. A test of the predictive power of the models was performed by comparing single equation *ex post* forecasts over the period from 1973:3 to 1978:4, with equations that had been estimated up through 1972:2. In general, the models tended to underpredict equipment investment for this period, and overpredict structures. The accelerator and accelerator-cash flow models showed the best performance. A test of a shift in the equation parameters indicated that all but the securities value model show no shift.

Kopcke (1982) performed essentially the same type of comparison test, except that he modified the securities value model to include a measure of Tobin's q, and replaces the liquidity model with an autoregressive, "time-series" model. He estimated equations for plant and equipment separately, using quarterly data from 1954 to 1977 for aggregate U.S. investment. His best fitting equation was the generalized cash flow, followed by the neoclassical and *q* models. However, in *ex post* simulations from 1978:1 to 1981:4, Kopcke found the autoregressive equation to perform the best. The generalized accelerator came in a close second. All of the models tended to underpredict both structures and equipment investment for this period. The RMSE in the forecast period was nearly double the standard error in the estimation period, for all five models. Kopcke concludes that none of these models is the "true" model.

More recently, Wisely and Johnson (1985) have done an evaluation of alternative investment models using the non-nested test pioneered by Davidson and McKinnon (1981). They compared four models: (1) the accelerator model, (2) the elementary cash flow model, (3) the generalized cash flow model, and (4) the neoclassical model. The forms of the accelerator and neoclassical model were standard. The cash flow model uses cash flow divided by an investment deflator as its main explanatory variable, and the generalized cash flow model uses a measure of *q* divided by cash flow. All models are of the form:

$$(1.7) \qquad I_t = \alpha + \sum_{i=0}^{n} \beta_i X_{t-i} + \gamma K_{t-1} + \varepsilon_t$$

where X is the main explanatory variable in the model considered, and K is the capital stock. To perform a pairwise non-nested test, one model is maintained as the null hypothesis, and another model is regarded as the alternative hypothesis. The residuals from the null hypothesis equation are then regressed on the the original variables in the null hypothesis equation and a variable which is constructed as the difference in the predicted value of the alternative equation from the predicted value of the null equation. The coefficient on this auxiliary variable can be tested for significance with a normal t-test. If the coefficient is significant, then the non-nested test fails to reject the alternative model with respect to the null model. In two-way comparisons, the authors found that the accelerator model seems to be the preferred model, and that the elementary cash flow model is rejected by all the other models. Since transitivity does not hold in the pairwise comparisons, a joint test is also constructed. The accelerator equation also fails to be rejected by any of the other models in this joint test.

The general conclusion emerging from these model comparisons is that equations that rely on output as the main explanatory variable tend to perform better than liquidity (cash flow) models, q or securities value models, and models relying on a cost of capital measure without including output. Although Kopcke found the autoregressive specification to perform best in a simulation framework, his simulation period was very short. Therefore, movements in output seem to be the main driver of investment both at the aggregate and at the industry level. However, microeconomic theory suggests that both output and investment should be endogenous to the firm, and should respond mostly to changes in relative prices. The solution to this discrepancy between what theory suggests, and what is found empirically is somewhat of a mystery. Some models such as that Hall and Jorgenson, have implicitly imposed price responsiveness on their empirical equations. However, other researchers also claim to find a large response of investment to prices and interest rates, and although they may also be imposing their results in the formulation of the problem, any estimated equation contains a mix of subjective belief and results from the data, with no clear dividing line.

Bernanke (1983) noted that at least in the late 1970s and early 80s, high interest rates were combined with slack investment, suggesting that interest rates may indeed play a notable role in determining investment. He formulated a dynamic adjustment cost model in which capital is the only quasi-fixed factor of production. The equation he derived states that net investment is approximately proportional to the present value of expected net returns to capital, with the adjustment cost parameter determining the factor of proportionality. Separate equations were estimated for equipment and nonresidential structures, using annual data for the aggregate U.S., from 1947 to 1979. Bernanke found a significant response of investment to tax laws and interest rates.

An in-depth investigation of the relationship between the cost of capital and the investment boom in the mid-80s was undertaken by Bosworth (1985). Bosworth's study attempted to address the issue of why investment was so high for the period 1982-1985, when the cost of capital also was very high. By examining the problem closely, he found that the question is complicated both by the changing mix of investment goods and a lack of agreement on how to best measure "the cost of capital".

Bosworth found that most of the gains in the investment boom were in producers' durable equipment (PDE), particularly in computers and business automobiles.[18] This finding is intriguing, since these are two assets whose effective tax rates were raised by the 1981-82 tax acts. In order to examine the relationship between the changing tax laws and investment by asset type, Bosworth estimated investment equations for each of 19 PDE categories, using an accelerator equation based on gross domestic product. His maintained hypothesis was that the errors from this simple accelerator equation should be negatively correlated with changes in the cost of capital, which he calculated on an asset specific basis, based on relative acquisition prices, the cost of capital plus depreciation, and tax effects. All in all, he found that there seems to be no significant correlation between assets that have a higher than expected capital stock, as predicted by the accelerator equation, and the relative magnitude of tax reduction per asset.

Bosworth surmised that perhaps the changes in effective tax

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[18] In real terms, office equipment and automobiles account for 93 percent of the growth in equipment spending from 1979 to 1985. However, this figure should be taken with caution in light of the extreme difficulties in constructing meaningful deflators for these two asset categories.

rates are outweighed by changes in the cost of funds.[19] Yet in general the correct way to calculate this cost of funds is unclear. Most econometric models failed to predict the investment boom of 1982 to 1985. This may be due to the fact that these models generally showed a cost of funds that rose significantly during this period. Corcoran and Sahling (1982), on the other hand, calculate a cost of funds which falls during this period. Their formula for the cost of funds is a weighted average of the required return to equity and the required return to debt. Because the tax laws allow the deduction of nominal interest payments, debt finance can be considerably cheaper than equity finance. The main cost balancing the cheapness of debt is the increased risk of bankruptcy or takeover caused by increased leverage. Thus, industries that generally buy assets with good resale markets should display a disposition to debt financing. The increased use of debt financing in the mid 80s may be related to the boom in autos and computers. Alternatively, there may new technological developments determining these investments.

Summarizing the developments of the last 20 years in the empirical study of investment is problematic, since there are a number of issues on which there is no clear consensus. It is clear that some measure of output or capacity is a very useful variable to explain investment, although according to microeconomic theory,

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[19] The cost of funds is the discount rate (or internal rate of return) required to equate the expected future stream of capital income to the present market value of the firm.

output prices and relative input prices should also be important determinants. However, capital is of a more long-term nature than labor, materials or energy, and the correct concept of the 'price' of capital is not obvious. Jorgenson's user cost measure has become the conventional formula for measuring the price of capital in the sense of a rental cost. But many of the correct variables for constructing this measure are expectational variables, and therefore not measurable. Of course, the same caveat applies to the use of output in an investment equation, since expected output is the variable the variable motivating firms in their decisions.

There is still no consensus as to the appropriate way to determine the response of investment to changes in relative prices. In the cross-sectional literature reviewed by Jorgenson (1971), fairly large substitution elasticities were estimated, yielding the conclusion of strong price effects. However, most of the time series literature has yielded low estimates of substitution. This discrepancy could be related to the differences in capital-energy elasticity estimates in cross-sectional versus time series studies. Cross sectional estimates usually find capital and energy to be substitutes, whereas time series studies usually find them to be complements. The discrepancy may possibly be due to an inadequate treatment of dynamics, since cross-sectional studies may be measuring long-term elasticities, and time-series studies may be measuring short-term elasticities.

In the 1980s there have not been many empirical studies investigating investment expenditures *per se.* Most of the studies with implications for investment behavior have been part of more encompassing studies of dynamic factor demands. The discussion of these studies will now be taken up in section 2.

2. Interrelated Factor Demands and Adjustment Costs

This section is a review of the theoretical development and empirical implementation of some concepts that have revolutionized thinking about the demand for capital and other factors. These are the related concepts of adjustment costs, expectations formation, and the interrelated adjustment of 'quasi-fixed' and variable factors in production.

At least since the time of Marshall, economists have realized that adjustment of fixed capital to its desired level takes time, and it has become customary to follow Marshall in referring to short-run, intermediate-run, and long-run equilibrium in the theory of the firm. Alchian (1959) was one of the first to note that the speed of adjustment to long-run equilibrium is subject to the techniques of economic analysis. He noted that doing something more quickly is usually more expensive than doing it slowly, and that one could construct an adjustment cost function to describe the costs involved in adjusting to equilibrium over a period of time. Beginning with Eisner and Strotz (1963), a substantial literature developed leading to formulations of the demand for capital stock based explicitly on the notion of increasing costs of adjustment. They assumed quadratic profit and adjustment cost functions, and derived a Koyck flexible accelerator distributed lag as an approximation to the optimal accumulation path of the capital stock. Lucas (1967a), Treadway (1969, 1970, 1971, 1974) and Mortensen (1973) provided a more explicit theoretical justification for the flexible accelerator and derived empirically testable restrictions of the accelerator specification that are implied by adjustment costs.

Nadiri and Rosen (1969) gave impetus to another line of research that recognizes that decisions about hiring and adjusting one factor cannot be modeled without considering the equilibrium or disequilibrium of other factors. They used the notion of adjustment costs as the theoretical underpinning for their model, which they considered as a first approximation to a solution of an optimal control problem in which the firm maximizes its net worth over time, knowing that it will face adjustment costs in changing the levels of its fixed factors.

The modeling of expectations is an important complement to the consideration of adjustment costs. If factor stocks cannot be adjusted instantaneously when prices and output change, then expectations about the prices and outputs that will hold over the future life of the factor are important in making current decisions. In fact, Gould (1968) has shown that an optimal decision about the allocation of factor stocks requires knowledge about expectations for all future time.

Reconciling the requirements of these three concepts and formulating a tractable empirical model that satisfies them has proved to be a difficult task. In the 1970s, most empirical studies focused on one of these requirements at the expense of the others.[20]

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[20] The studies of Nadiri and Rosen (1969), Schramm (1970),

Since the early 1980s however, much progress has been made in the development of dynamic interrelated factor demand models, and the modeling of expectations within a dynamic framework. We will continue the review of section 1 below with a discussion of some of these studies. But first a simple introduction to the problem is needed.

The conventional treatment of adjustment costs until the late 1960s was the partial adjustment model:

$$(2.1) \qquad k_t - k_{t-1} = \beta(k^*_t - k_{t-1})$$

where k_t is the level of a factor stock at time t and k^*_t is the optimal long run level of the stock, given the exogenous conditions. This treatment of adjustment costs, although empirically useful, was somewhat *ad hoc*, and did not specify how β, the constant speed of adjustment, was determined. Nadiri and Rosen expanded this framework to include more than one input with interrelated adjustment parameters. The simplest form of this model can be represented with two factors. Suppose the production function is $Q = f(k_1, k_2)$, where Q is output, and k_1 and k_2 are the inputs. A generalization of (2.1) is

$$(2.2) \qquad \begin{bmatrix} k_{1t} - k_{1t-1} \\ k_{2t} - k_{2t-1} \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \cdot \begin{bmatrix} k^*_{1t} - k_{1t-1} \\ k^*_{2t} - k_{2t-1} \end{bmatrix}$$

The β matrix allows disequilbrium in one factor to affect the

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Coen and Hickman (1970), Chang and Holt (1973), and Craine (1975) reviewed in section 1 are examples.

adjustment of the other factor, if the off-diagonal elements are non-zero. The empirical estimation of the system (2.1) was in reduced form, and Nadiri and Rosen did not impose any theoretical restrictions on the elements of β.

Treadway (1971, 1974) modified this framework by explicitly including internal costs of adjustment in the production function[21], so that $Q = f(k, \dot{k})$, where k is now a vector of inputs, and $\dot{k}$ is a vector of their rates of change. Treadway set up the firm's problem as that of maximizing the present value of cash flow subject to endpoint conditions on the factor stocks, and including the above production function in the formula for cash flow. Upon deriving the Euler equations for the maximization of this problem, and linearizing around k^*, Treadway showed that the locally optimal result is of the multivariate flexible accelerator form:

$$(2.3) \qquad \dot{k} = M^*(k^*, r)\ [k - k^*]$$

where r is the rate of interest, k^* is the "target" level of k, and M^* is a *stability matrix* satisfying certain restrictions which can be characterized as functions of the first and second derivatives of f. The stability matrix is analogous to the β matrix employed by Nadiri and Rosen. However, Treadway also demonstrated that the target level of k implied by static optimization was the same as that implied by

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[21] *Internal* costs of adjustment are incorporated in the production function as foregone output. *External* costs of adjustment are represented by an adjustment cost function auxiliary to the normal cost function.

dynamic optimization only if adjustment costs were separable from other inputs, an assumption which he showed to be infeasible.

Faurot (1978) used Treadway's framework to specify and estimate a dynamic factor demand model for capital and labor with a Cobb-Douglas production function. Nonseparable adjustment costs are modeled by including gross investment as an argument in the production function. Capital is assumed to be quasi-fixed and labor is freely variable. Faurot sets up the firm's optimization problem, solves for the Euler equations, and derives two nonlinear interrelated demand functions for capital and labor, with the stability matrix M also dependent upon parameters to be estimated. Faurot obtains the puzzling result that the elasticity of output with respect to capital is not significantly different from zero, and obtains an estimate of M that implies implausibly slow adjustment of the capital stock to its target level.

Faurot assumed static expectations in deriving his model. Kennan (1979) and Sargent (1978) estimated labor demand equations and actually modeled the firm's expectations of future exogenous variables, while assuming simplistic production and cost of adjustment functions. Meese (1980) extended this approach by modeling demand for both capital and labor, and allowing for interaction terms in the production function and cost of adjustment function. Using aggregate quarterly data on U.S. manufacturing from 1947:1 to 1974:4, he estimated a four equation system, in which two of the equations are the decision rules for capital and labor, and the other two equations embody the stochastic processes for the wage rate and the cost of capital. He found an average value of the capital-labor elasticity of substitution of 1.85, which is rather high.

In an extension of Treadway's work to empirical estimation, Berndt, Fuss and Waverman (1980) develop a model for capital, labor, energy, and materials (*KLEM*) based on a quadratic normalized restricted cost function. In this model, labor, energy and materials are explicitly treated as variable factors, whereas capital is a *quasi-fixed* factor, i.e., the firm undergoes internal adjustment costs in trying to adjust capital to its optimal level. The demand for net investment is determined using an accelerator model where the adjustment coefficient is determined by a formula in Treadway (1971).

Berndt, Fuss, and Waverman apply their model both to aggregate data as well as to some two-digit SIC manufacturing data. They find adjustment costs to be significant for capital at both the aggregate and at the industry level, and at least for the aggregate data, they find the estimated elasticities to be reasonable. The system is a *dynamic factor demand model*, since the speed of adjustment of capital to its long-run level is explicitly modeled. This approach allows them to calculate short-run, intermediate-run and long-run price and output elasticities.

This dynamic factor demand approach is also followed in a paper by Morrison and Berndt (1981). In order to investigate the phenomenon of 'short-run increasing returns to labor' (*SRIRL*) observed over the business cycle, they estimated two dynamic factor demand models, one for capital, labor, energy and materials (*KLEM*), and another model that treats skilled and unskilled labor separately (*KUSEM*). These models were estimated using annual data on total U.S. manufacturing, from 1952 to 1971. They assumed a quadratic restricted variable cost function which includes internal costs of adjustment for the quasi-fixed factors. In the *KLEM* model, capital is the only quasi-fixed factor, while in the *KUSEM* model, both capital and skilled labor are quasi-fixed. Static expectations are assumed. Results from the *KLEM* model show labor and capital to be long run complements, and the short-run output elasticity of labor to be less than the long run elasticity, providing a verification of *SRIRL*. The *KUSEM* model estimates show that capital and skilled labor are complements, while capital and unskilled labor are substitutes. Capital and skilled labor are both found to have high adjustment costs, so that the behavior of skilled labor may explain most of the observed *SRIRL*.

Epstein and Denny (1983) estimate a multivariate flexible accelerator model for total U.S. manufacturing from 1947 to 1976 using annual data. Their model assumes that firms minimize expected production costs subject to a technology which implies that capital and labor stocks are costly to adjust, while materials are freely variable. In deriving this model, Epstein and Denny present a general functional form which they approximate for estimation, and a set of exhaustive restrictions implied by the flexible accelerator specification. Expectations in this model are static. Capital and labor are found to adjust interdependently, and the hypothesis that labor is a variable input is rejected strongly. They find that the investment equation is strongly responsive to changes in factor prices.

In a set of two related papers, Pindyck and Rotemberg (1983, 1985) present the results of a dynamic factor demand model incorporating rational expectations and with technology represented by a flexible functional form. In their 1983 paper, dynamic demands are derived for capital, labor, energy and materials. Capital and labor are considered to be quasi-fixed, while energy and materials are variable. A translog restricted cost function is assumed, which is conditional on capital, labor and output. Minimizing the expected present value of costs yields two demand functions for the variable factors, and two Euler equations for the quasi-fixed factors. The model is estimated using annual data on aggregate U.S. manufacturing from 1948 to 1971, obtained from Berndt and Wood (1975). Expectations are modeled by using a "conditioning set" of instrumental values to derive conditional future values of the exogenous variables, and the system is then estimated with three-stage nonlinear least squares. Two alternative sets of instruments are used to estimate the model. Pindyck and Rotemberg find that adjustment costs for capital are more important than those for labor. Both capital and energy, and capital and labor are found to be complements in the long run. A strong response of investment to relative prices is also found, which agrees with the findings of

Epstein and Denny. However, the choice of the set of instruments used significantly affects the estimated parameters, casting doubt on the use of this instrumental variables framework. The second paper of Pindyck and Rotemberg is similar, except that they estimate demands for structures, equipment, and blue and white collar labor. The only variable factor in this model is blue collar labor. Adjustment costs are found to be small for white collar labor, but large for both equipment and structures. Blue collar labor and equipment are found to be complementary.

Kokkelenberg and Bischoff (1986) also develop and estimate a model of interrelated dynamic factor demands with rational expectations and adjustment costs. A normalized restricted cost function is approximated by a second order Taylor series expansion. The three inputs modeled are capital, labor and energy, with capital quasi-fixed. Unlike Pindyck and Rotemberg, who use instrumental variables, Kokkelenberg and Bischoff model the exogenous variables (output, output price, and the price of investment goods) with ARIMA models, and substitute the expected value of these ARIMA processes into the Euler equation for capital. The model is estimated using quarterly aggregate data for U.S. manufacturing from 1959 to 1977. Energy and capital are found to be complementary in this model. Unlike Pindyck and Rotemberg, and Epstein and Denny, this study finds a very low elasticity of capital with respect to user cost.

Morrison (1986) investigated the consequences of imposing three alternative expectations forming procedures on the Euler equations.

She estimated a KLEM model with aggregate U.S. manufacturing data from 1947 to 1981. Capital is the only quasi-fixed factor. *Static expectations* are defined as the expectation that current values of exogenous variables will hold for all future time periods. *Adaptive expectations* are assumed to be formed by a partial adjustment model, which is equivalent to an IMA time series model. *General expectations* are defined to be formed by an ARIMA process. Each expectations forming process uses only information known up to the time period in question. The final step in the specification of the model is the substitution of the expected values of the exogenous variables into the capital demand equation, using each of the expectations forming procedures. Morrison found that the static expectations model shows a much slower adjustment of the capital stock to its long run equilibrium level. The static expectations model finds complementarity between labor and capital, whereas the adaptive and general expectations models find weak substitutibility. In general however, differences between the expectations models are not great.

Shapiro (1986b) estimated dynamic factor demands for labor, capital and hours worked. Although he did not explicitly model the forming of expectations, he replaced conditional expectations with actual values, and used an instrumental variable technique for his forcing variables. His model is derived from a Cobb-Douglas production function, including capital, production workers and non-production workers, augmented by quadratic adjustment costs and a productivity shock. He found significant adjustment costs in varying the number of non-production workers, but found the adjustment of capital to its steady state level to be fairly rapid. This finding conflicts with the findings of researchers such as Summers (1981), who estimates the adjustment costs of capital to be extremely high. Shapiro also found a significant response of investment to changes in the cost of capital. In a similar paper, Shapiro (1986c) added the workweek of capital as an input, and examined how the ability to change capital utilization affects the demand for capital. In this model, the firm responds to "temporary" shocks by changing utilization, and to "permanent" shocks by changing the levels of stocks. The estimates arising from this model imply that the productivity of lengthening the workweek of capital is very low. This is consistent with other studies which find a low apparent productivity of shift work, and may explain why most capital stock is kept idle much of the time.

In another recent dynamic factor demand paper focusing on investment, Shapiro (1986a) showed how the paucity of empirical support for the hypothesis that the cost of capital affects investment may be traced to an identification problem, and attempts to reconcile the lack of direct correlation between investment and the cost of capital with the finding of price responsiveness of investment in many other dynamic factor demand models. He investigated this problem using quarterly data from 1955:1 to 1985:3 for the aggregate U.S. private economy. Shapiro first assumed that firms maximize the expected present discounted value of real after-tax profits. He then posits a multi-period objective function based on a CES production function augmented by an expression for internal costs of adjustment from gross investment and a productivity shock. Capital investment is also constrained by labor supply, which is subject to a labor supply shock. Equilibrium is determined by the behavior of these two supply shocks and by shocks to the components of the cost of capital. Shapiro's model generates dynamics and cross-correlations that are consistent with those found in the actual data, including a correlation in the movements of investment and output and a lack of correlation of investment with the investors' required rate of return. However, an exogenous change in the after-tax purchase price of capital has a strong impact upon investment. This finding corresponds to the estimates obtained from other dynamic factor demand models.[22]

Mohnen, Nadiri and Prucha (1986) estimated dynamic factor demands for research and development (R&D), capital, labor and materials, for the manufacturing sectors of three countries: the U.S., Japan, and West Germany. Annual time series data from 1965 to 1977 were used. The normalized restricted cost function is of linear quadratic form. Firms were assumed to hold static expectations. The Euler equations were solved to obtain an system of quasi-fixed demand

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[22]For example, Shapiro (1986b, 1986c), Pindyck and Rotemberg (1983, 1985) and Epstein and Denny (1983). Contrary results from this genre of model are on Kokkelenberg and Bischoff (1986).

equations for capital and R&D, and Shephard's Lemma was used to obtain the demands for the variable factors, labor and materials. Short-run, intermediate-run and long-run elasticities of factor demand were calculated. The long run price elasticity of capital is found to be higher than the short run elasticity, with 70% of the adjustment to its long run level occuring after four years. Labor and capital are found to be complements in Japan and Germany, but substitutes in the U.S.

An alternative parameterization of the dynamic factor demand model can be found in Mahmud, Robb, and Scarth (1986, 1987), who developed a four factor model of demands for capital, labor, energy and materials using the original data set of Berndt and Wood (1975). In this model, capital is the quasi-fixed factor, and labor, energy and materials are the variable factors. Mahmud *et al.* showed how many of the dynamic factor demand models that use a normalized restricted cost function are plagued with asymmetry stemming from the normalization procedure. This asymmetry creates a bias in that the parameter estimates are sensitive to the factor chosen for the normalization. They adopt a variant of the Generalized Leontief (*GL*) function to avoid this problem. Their model appears to yield sensible results which are free from the asymmetry and bias found in some other models.

Morrison (1988) used another version of the *GL* variable cost function in a similar manner, to study and compare factor demand patterns of Japanese and U.S. manufacturing. She estimated the Euler equations for demands for the quasi-fixed factors, since the *BFW* approach is intractable with the complicated derivatives of the *GL* function. Two alternative models were estimated, one with only capital as a quasi-fixed factor, and the other with both labor and capital. She found labor and capital price responsiveness to be higher in Japan than in the U.S.

A study which distinguishes itself through the use of industry level data is that by Rosanna (1987), which examines demands for production workers, average hours, materials, work-in-process inventories, finished goods, equipment and structures, for twenty two-digit industries comprising the U.S. manufacturing sector. Rossana uses annual data from the *Annual Survey of Manufactures* from 1958 to 1984. The paths of prices and output, which are assumed to be exogenous, are determined by autoregressive techniques. The demands for each factor are determined by ordinary least squares in regressions using lagged values of all inputs, as well as expected output and prices. Rossana's calculated adjustment speeds are unusual, with employment slow to adjust, but equipment adjusting quickly. He finds evidence that equipment and employment are complements.

The developments from this area of research are promising, and there will no doubt be more progress in the application of dynamic decision and expectations forming models to the estimation of factor demands. A possible weakness of most of these empirical studies is the use of aggregate data. Although they are predicated on models of firm-level decision making, the data used generally represent the entire economy or all manufacturing. The use of industry-level data would provide more meaningful estimates of dynamic factor demands, as well as avoid some simultaneity problems that arise from treating output and prices as exogenous.

For the most part, these studies have not made use of flexible functional forms because of the extreme complexity in modeling adjustment costs and expectations in conjunction with these functional forms. However, substantial use has been made of duality theory in the derivation of the normalized restricted cost function, and in the use of Shephard's Lemma to derive conditional demands for variable factors. In the next section we will review some of the recent developments in duality theory and flexible functional forms that are relevant to the estimation of empirical investment equations.

3. Duality Theory and Flexible Functional Forms

The fundamental principle of duality in production states that the cost function of a firm summarizes all of the economically relevant aspects of its technology.[23] This notion, along with Shephard's Lemma, has allowed us to infer the structure of production as embodied in the cost function through the estimation of factor demand functions, or through the direct estimation of the cost function in conjunction with the factor demand functions.[24]

For production structures that use both quasi-fixed[25] as well as variable inputs, a normalized restricted cost function (NRCF) is utilized to derive the variable factor demands. This cost function is restricted in the sense that its value is conditional on the level of the quasi-fixed factors and output. The normalization is usually on the prices of one of the variable factors. Demands for the variable factors can be obtained from the NRCF by Shephard's Lemma. The optimal paths for the quasi-fixed factors must be calculated by dynamic optimization techniques.

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[23] Varian (1978, 38).

[24] An alternative which is equally appealing theoretically, but not used much in practice, is the estimation of the profit function, possibly in conjunction with an output supply function or factor demands. Due to a lack of good data on profits, the direct estimation of the profit function is rarely pursued. For that matter, direct estimation of the cost function is rare, because of simultaneity problems.

[25] A *quasi-fixed* input is an input subject to costs of change, or adjustment. Because of these adjustment costs, a firm may not adjust immediately to a new long-run optimum for this input. The solution to the demand for this input is a dynamic problem.

Assume that the production characteristics of a firm can be represented by a production function relating productive capacity to input levels and other factors such as technology. By the principles of duality theory, this same information can be characterized by the dual cost function. If the form of the production function implies a dynamic response of the quasi-fixed factors, the dual is a normalized restricted cost function. In order to derive estimable factor demand equations, a specific functional form must be adopted as an approximation to the cost function.

The choice of any functional form for the cost function implies the adoption of a number of maintained hypotheses. These are necessary for the estimation of any empirical factor demand equations. If these maintained hypotheses are not plausible, then tests performed in their presence may not be convincing. For instance, it would not be appropriate to test an assumption such as convexity of the technology if we were assuming a CES production function.

Flexible functional forms have arisen to satisfy the need for forms which embody as few maintained hypotheses as possible, yet can represent important characteristics of technology. Historically, the focus has been on five main characteristics: (1) *Distribution* (the income shares of factors of production); (2) *Scale* (the existence of constant, increasing, or decreasing returns to scale); (3) *Substitution* (the degree of substitutibility of factors of production); (4) *Separability* (the decomposition of production into nested or additive components); and (5) *Technical Change* (modification of the technological structure over time).[26] Desirable functional forms should be able to represent these aspects of technology with as few parameters as possible, be easy to interpret and compute, and exhibit robustness of behavior outside the sample range. However, any functional form implies the imposition of subjective maintained hypotheses upon the problem so that tests performed with the functional form are not equivalent to tests relevant to the actual cost function.

Before reviewing some actual forms that have been proposed as approximations to cost functions, the basic derivation and qualities of the cost function will be stated. Assume a production function, or production possibilities set, that defines all feasible input-output combinations:

$$Q = \{ \mathbf{x},\mathbf{q}: \ \mathbf{x} \text{ can produce } \mathbf{q}\}$$

For each **q** an input requirement set can be defined, showing all input combinations which can produce **q**:

$$X(\mathbf{q}) = \{ \mathbf{x}: (\mathbf{x},\mathbf{q}) \in Q\}$$

With cost-minimizing behavior, the cost function can be derived as the minimized total cost conditional on **q** and factor prices **p**:

$$C(\mathbf{q},\mathbf{p}) = \min \{ \mathbf{p}\cdot\mathbf{x}: \ \mathbf{x} \in X(\mathbf{q})\}$$

The input requirement set is assumed to have the following properties:

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[26] Fuss, McFadden, and Mundlak, (1978, 221).

R.1 *Location.* **X** is a non-empty subset of the non-negative orthant.

R.2 *Closure.* The frontier of **X** belongs to **X**.

R.3 *Monotonicity.* If a given output can be produced with an input-mix **v** it can also be produced with a larger input.

R.4 *Convexity.* **X** *is convex.*

Diewert (1971) has shown that these assumptions imply the following five properties of the cost function:

C.1 *Domain.* $C(\mathbf{q},\mathbf{p})$ is a positive real-valued function defined for all positive prices and outputs; $C(0,p) = 0$.

C.2 *Monotonicity* $C(\mathbf{q},\mathbf{p})$ is non-decreasing in output and non-decreasing in prices.

C.3 *Continuity.* $C(\mathbf{q},\mathbf{p})$ is continuous from below in **q** and continuous in **p**.

C.4 *Concavity.* $C(\mathbf{q},\mathbf{p})$ is concave in prices.

C.5 *Homogeneity* $C(\mathbf{q},\mathbf{p})$ is linear homogeneous in prices.

Empirical work usually assumes the property of *differentiability* as well, which yields Shephard's Lemma and the symmetry of cross-price effects. Economic properties embodied in the cost function, such as returns to scale, distributive shares, and price or substitution elasticities, can be quantified in terms of the cost function and its first and second derivatives.

A necessary and sufficient condition for a functional form to reproduce comparative statics effects such as these *at a point* without imposing restrictions across these effects is that it have $(n+1)(n+2)/2$ distinct parameters. This condition is satisfied by a second order Taylor's expansion. Table 3.1 catalogues a number of the most well-known functional forms used in empirical analysis. The Cobb-Douglas function is the simplest, and can be viewed as a first-order Taylor series expansion of $\ln Q$ around $\ln p_i$. The CES is a first-order expansion of Q^{ρ} in powers of p^{ρ}. The translog is a second order expansion of $\ln Q$ in powers of $\ln p_i$, whereas the generalized Leontief and quadratic functions are second-order expansions of Q in powers of $p_i^{1/2}$ and p_i, respectively.

Theoretically, choice between these functional forms should be based upon their quality as approximations to the "true" functions over the domain of interest. The Cobb-Douglas and the CES functions satisfy regularity conditions globally, but cannot be used to model very sophisticated technologies. On the other hand, the more flexible functional forms can represent more aspects of production technology, but may be unreliable outside a certain range of data. A number of researchers have attempted to determine just how well various flexible forms can model technology.

Berndt, Darrough and Diewert (1977) fitted the translog, generalized Leontief, and generalized Cobb-Douglas forms to Canadian expenditure data and found the translog to have the most reasonable properties. Appelbaum (1979) and Berndt and Khaled (1979) have examined the Box-Cox functional form, which contains the translog, generalized Leontief, and generalized square root quadratic as limiting cases. Using U.S. manufacturing data from 1929 to 1971, Appelbaum found that the generalized Leontief and generalized square root quadratic were the best forms for the representation fo the primal and dual specifications of technology. Berndt and Khaled used 1947-1971 manufacturing data, and tested the three alternative functional forms as restrictions on the more general Box-Cox form. They were able to reject the generalized square root quadratic, but unable to reject the generalized Leontief. Tests for the translog were inconclusive.

Caves and Christensen (1980) used analytical techniques to compare the ranges of observations over which the translog and generalized Leontief are capable of modeling well-behaved tehnologies. They found the translog to be well-behaved over a wider range when the true elasticities of substitution have large values, and the generalized Leontief to be well-behaved over a wider range when the elasticities of substitution have small or dissimilar values.

Another line of attack has been to test alternative functional forms within a Monte Carlo approach. Wales (1977) used Monte Carlo techniques to determine the range of data points over which the translog and generalized Leontief provided acceptable approximations to a two-input linearly homogeneous CES technology. Wales found that the performance of the translog deteriorated as the true elasticity of substitution departed from unity in either direction, and that the performance of the generalized Leontief deteriorated as the true elasticity of substitution increased away from zero. The performance of both forms deteriorated with increases in the dispersion of the independent variables in the estimating equations. Guilkey and Lovell (1980) used Monte Carlo techniques to investigate the ability of the translog form to track technologies of increasing complexity with a fixed degree of dispersion in the data. They found only modest deterioration with increases in complexity, unless the true elasticities of substitution departed from unity in either direction. Guilkey, Lovell, and Sickles (1983) developed a similar experiment, but tested the ability of the translog, generalized Leontief, and generalized Cobb-Douglas to track returns to scale and complementarity and substitution between inputs. Their findings indicate that all three approximations perform well when the true technology is Cobb-Douglas, although there is a slight preference for the translog. They also find that the generalized Leontief dominates when the true technology has small elasticities of substitution. However, the generalized Cobb-Douglas and translog are better at detecting input complementarity. The authors conclude that they have failed to find a functional form that outperforms the translog.

Pollak, Sickles and Wales (1984) introduced two new functional forms, the CES-translog and the CES-generalized Leontief, focusing particularly on the behavior of the CES-translog. The CES-translog is compatible with a wider range of substitution possibilities than either the CES or the translog function. They brought together eight data sets from other studies, and compared the relative performance of the CES, translog and CES-translog. According to likelihood-ratio tests, the CES-translog was found to be superior to either the CES or the translog, and violated regularity conditions less often than the translog.

Barnett (1982) proposed a functional form based on the Laurent expansion, as opposed to a Taylor series expansion. This is the *minflex Laurent* functional form, since it uses the minimum number of parameters necessary to attain flexibility in the sense defined by Diewert. Barnett shows that the remainder term of a Laurent expansion varies less severly over the region of approximation than that of the Taylor series expansion. Also, the imposition of global regularity on the minflex function is less restrictive than upon a generalized Leontief function. Barnett and Lee (1985) follow Caves and Christensen (1980) in using an analytical technique, but compare the regular regions for the translog, generalized Leontief, and minflex Laurent functional forms. They find that the minflex Laurent generally has the largest regular regions of these three forms.

Gallant (1981, 1982) has introduced a form based upon the Fourier expansion: the Fourier flexible form. This form allows for arbitrarily accurate approximations to a "true" functional form by dropping all high-order terms of the Fourier expansion past an appropriate truncation point. Elbadawi, Gallant, and Souza (1983) show that, given the assumption that elasticities of substitution do not oscillate wildly over the region of interest, then consistent estimation of elasticities is possible with the Fourier form, provided that the number of parameters is allowed to increase with the number of observations. Chalfant and Gallant (1985) in a Monte Carlo study use the Box-Cox function to generate various technologies, and then try to approximate these technologies using the Fourier form. They find that the bias of the Fourier form in estimating elasticities is small, no matter what the true technology. Gallant and Golub (1984) use the Fourier flexible form to illustrate a general method for estimating the parameters of a flexible functional form subject to convexity, quasi-convexity, concavity, or quasi-concavity constraints at a point, at several points, or over a whole region. Altogether, this flexible form appears promising. However, the estimation technique is complex, and the form has not been widely used to this date.

Diewert and Wales (1987) introduced some new functional forms in order to develop methods to impose curvature conditions globally in the context of cost function estimation. The generalized McFadden cost function is shown in Table 3.1. Using this functional form, the imposition of the appropriate curvature conditions at one point imposes them globally. The generalized Barnett cost function, also shown in Table 3.1, is a generalization of Barnett's minflex Laurent function. Using the data set of Berndt and Khaled (1979), these forms are estimated and compared to the estimation results from the translog, translog with concavity imposed, and generalized Leontief. Elasticity estimates for the five models are roughly similar, except for the concave translog. All the functional forms yield plausible estimates of returns to scale and technological change, and the results are similar to the conventional functional forms. However, these two forms do have the advantage that they impose globally the restrictions implied by microeconomic theory.

Which functional form to use for empirical work is still an unsettled question. Although the Fourier, generalized McFadden, and generalized Barnett have desirable properties, estimation is more complex, and there is no guarantee that they will prove superior in other than the static models for which they have been tested.

There are generally two approaches that have been followed for the specification of econometric equations. The first is to derive a static expression for the demand for capital using marginal productivity conditions or Shephard's Lemma. Costs of adjustment are introduced in an *ad hoc* manner through the specification of simple distributed lags. The second approach involves explicitly solving for the time path of the optimal stock of fixed factors, considering costs of adjustment and the expected paths of exogenous variables. A functional form then must be specified for the normalized restricted cost function, which is conditional on output, prices of the variable factors, and stocks of the quasi-fixed factors. The most commonly used functional form for the NRCF is the quadratic function, since it yields demands which are linear in input prices. Pindyck and

Rotemberg (1983, 1985) use a translog form for the restricted cost function.

I have chosen the generalized Leontief to estimate two models presented in the next chapter. This functional form has a number of advantages. First, the form for the factor demands arising from the generalized Leontief form is fairly convenient to estimate. Second, in the presence of measurement error in the factor prices, the generalized Leontief implies more conservative maintained assumptions about the underlying technology.[27] Third, from the generalized Leontief factor demand equations can be derived directly, whereas from the translog and other forms factor share equations must be derived. In the static framework, it is more difficult to derive an investment function from a factor share equation than from a factor demand equation.

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[27] In the presence of measurement error, the translog function is biased towards the Cobb-Douglas form, with a unitary elasticity of substitution. The generalized Leontief, on the other hand, is biased towards the Leontief form, with a zero elasticity of substitution.

Table 3.1
FUNCTIONAL FORMS USED TO APPROXIMATE COST FUNCTIONS

Cobb-Douglas

$$\ln C(p,Q) = a_0 + \sum_{i=1}^{N} a_i \ln p_i + a_Q \ln Q$$

CES

$$\ln C(p,Q) = a_0 + a_Q \ln Q + \ln\left[\sum_{i=1}^{N} a_i p^{1-\sigma}\right]^{1/(1-\sigma)}$$

Translog

$$\ln C(p,Q) = a_0 + a_Q \ln Q + \frac{1}{2} a_{QQ}(\ln Q)^2 + \sum_{i=1}^{N} a_i \ln p_i$$

$$+ \frac{1}{2}\sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} \ln p_i \ln p_j + \sum_{i=1}^{N} a_{Qi} \ln Q \ln p_i$$

Generalized Leontief

$$C(p,Q) = Q \sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} p_i^{1/2} p_j^{1/2} \qquad \text{(homothetic version)}$$

Quadratic

$$C(p,Q) = a_0 + a_Q Q + a_{QQ} Q^2 + Q \sum_{i=1}^{N} b_i p_i + \sum_{i=1}^{N} a_i p_i + \sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} p_i p_j$$

Generalized Square-Root Quadratic

$$C(p,Q) = Q \left[\sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} p_i p_j\right]^{1/2} \qquad \text{(homothetic version)}$$

Generalized Cobb-Douglas

$$\ln C(p,Q) = a_0 + a_Q \ln Q + \frac{1}{2} a_{QQ}(\ln Q)^2$$

$$+ \sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} \ln(b_i p_i + b_j p_j) + \sum_{i=1}^{N} a_{Qi} \ln Q \ln p_i$$

CES-Translog

$$\ln C(p,Q) = a_0 + a_Q \ln Q + \ln\left[\sum_{i=1}^{N} a_i p_i^{1-\sigma}\right]^{1/(1-\sigma)}$$

$$+ \frac{1}{2}\sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} \ln p_i \ln p_j + \sum_{i=1}^{N} a_{Qi} \ln Q \ln p_i$$

CES-Generalized Leontief

$$C(p,Q) = Q \left[\sum_{i=1}^{N} a_i p_i^{1-\sigma}\right]^{1/(1-\sigma)} + Q \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j\neq i}}^{N} a_{ij} p_i^{1/2} p_j^{1/2}$$

$$a_{ij} = a_{ji}, \ \forall\ i,j.$$

Minflex Laurent

$$C(p,Q) = Q \left[\sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} p_i^{1/2} p_j^{1/2} - \sum_{i=1}^{N} \sum_{j=1}^{N} b_{ij} p_i^{-1/2} p_j^{-1/2} \right]$$

$$a_{ij} = a_{ji},\ b_{ij} = b_{ji},\ a_{ij} \geq 0,\ b_{ij} \geq 0,\ a_{ij} b_{ij} = 0, \quad \forall\ i,j$$

Generalized McFadden

$$C^1(p,Q) = Q\, g^1(p) + Q \sum_{i=1}^{N} a_{Qi} p_i + \sum_{i=1}^{N} a_i p_i + a_{QQ} \left[\sum_{i=1}^{N} b_i p_i\right]^2$$

where $g^1(p) = (1/2) p_1^{-1} \sum_{i=1}^{N} \sum_{i=1}^{N} c_{ij} p_i p_j \quad c_{ij} = c_{ji},\ 2 \leq i,j \leq N$

and the 1 superscript refers to the normalized price.

Generalized Barnett

C is identical to the Generalized McFadden, but:

$$g^1(p) = \sum_{i=1}^{N} \sum_{\substack{j=1 \\ j \neq i}}^{N} a_{ij} p_i^{1/2} p_j^{1/2} - \sum_{i=2}^{N} \sum_{\substack{j=2 \\ j \neq i}}^{N} b_{ij} p_1^2 p_i^{-1/2} p_j^{-1/2}$$

$$- \sum_{i=2}^{N} c_{ij} p_1^{-1/2} p_i^{-1/2} p_j^2$$

where $a_{ij} = a_{ji} \geq 0,\ b_{ij} = b_{ji} \geq 0,\ c_{ij} = 0 \quad \forall\ i,j$

Generalized Box-Cox

$$C(p,Q) = Q^{\beta(Q,p)} \left[1 + \lambda\ G(p)\right]^{1/\lambda}$$

where $G(p) \equiv a_0 + \sum_{i=1}^{N} a_i p_i(\lambda) + \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij} p_i(\lambda)\ p_j(\lambda)$

$$\beta(Q,p) \equiv \beta + \frac{\theta}{2} \ln Q + \sum_{i=1}^{N} \phi_i \ln p_i$$

$$p_i(\lambda) \equiv \frac{p_i^{\lambda/2} - 1}{\lambda/2}$$

$\lambda = 2 \Rightarrow$ Generalized Square Root Quadratic

$\lambda = 1 \Rightarrow$ Generalized Leontief

As $\lambda \Rightarrow 0, \Rightarrow$ Translog

4. Previous Investment Models at INFORUM.

The investment equations used in the INFORUM model have changed over the years, incorporating new developments in the investment and factor demand literature, and taking advantage of the increased scale and flexibility of the full model. The models have moved in the direction of becoming more consistent with the properties dictated by microeconomic theory, but have also become more complex.

One question this study will address is whether the increased complexity and economic rationale of the equations has contributed or detracted from good simulation properties. It is quite true that a more complex specification may provide us with more economic content. On the other hand, the equation may be misspecified in some sense, yielding false or biased parameter estimates, which may lead to bad simulation properties. Of course, if I find that a simple accelerator model outperforms another model well grounded in the theory of production, this does not mean that the apparently more sophisticated and economically sensible theory should be abandoned. In many cases the particular failures found in the simulation exercise can lead to the discovery of a flaw in the model specification. Examples will be given in chapter V, where the simulation performance of the investment models is compared.

Almon's Model

The original treatment of investment in the INFORUM model is reviewed in Almon (1966). This was based on the functional approximation method for finding the necessary investment to attain equilibrium growth. However, for ordinary forecasting of the U.S. economy, this method was considered to be too cumbersome. Therefore an econometric approach was adopted, in which investment for a given year was explained in terms of output, cash flow and other variables.[28] In this framework, each year's investment depended upon variables calculated in the preceeding year.

The typical investment equation in this model specified that gross equipment investment I_t is proportional to the gap between desired stock K^* and the stock that would be available at the end of the year if no investment was made: $(1-d)K_t$, where K_t is the actual stock at the beginning of the year and d is the depreciation rate. This can be expressed by:

$$(4.1) \qquad I_t = a_t[K_t^* - (1-d)K_t]$$

K_t^* is specified to depend linearly upon output:

$$(4.2) \qquad K_t^* = c_0 + c_1 Q_t$$

The rate of adjustment depends upon the adequacy of cash flow, CF relative to the size of the gap to be filled between actual and desired capital stock:

$$(4.3) \qquad a_t = c_2 + c_3 CF/[K_t^* - (1-d)K_t]$$

Substituting (4.3) and (4.2) into (4.1) yielded the estimating

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[28] This model is developed in Almon (1968).

equation:

$$(4.4) \qquad I_t = \beta_0 + \beta_1 Q_{t-1} + \beta_2 K_{t-1} + \beta_4 CF_{t-1} + \varepsilon_t$$

where the β's are regression coefficients.

This equation was estimated for 69 industries comprising the U.S. economy. Results were mixed, with about half of the sectors giving good fits, small standard errors, and sensible forecasts. However, the remaining sectors suffered from a number of problems, the most common of which was a positive coefficient on the capital stock term. It was found that these sectors gave poor forecasts that did not respond correctly to changes in output. Therefore, the coefficients on the stock term were specified *a priori*, and the fits were still just about as good as those from the *OLS* estimates.

Mayor's CES Model

Thomas Mayor's investment model (1968, 1971) borrowed from the early work of Hall and Jorgenson (1967), specifying investment as the sum of replacement investment and net investment. Net investment was based upon the notion of a desired capital stock, which depended in turn on changes in output and a relative user cost of capital. The derivation of the optimal capital stock assumed the existence of a constant elasticity of substitution (*CES*) production function characterizing each of 68 investing industries:

$$(4.5) \qquad Q = \Omega[\gamma K^{-\rho} + (1-\gamma)L^{-\rho}]^{-1/\rho}$$

where Q is industry output, K is the capital stock, L is the labor input, Ω is the Hicks neutral efficiency parameter, γ is the distribution parameter, and ρ is the distribution parameter, where the elasticity of substitution between capital and labor $\sigma = 1/(1+\rho)$. The functional form of this production function, together with the assumption of profit maximizing behavior yields an expression for the desired capital stock. The demand for capital equipment by the firm is set by the equilibrium condition that the marginal cost of equipment c equals the value of the marginal product of capital:

$$(4.6) \qquad c = P \frac{\partial Q}{\partial K}$$

where P is the price of output Q, and K is the capital stock. If we assume the *CES* production function, the marginal product of capital can be written:

$$(4.7) \qquad \frac{\partial Q}{\partial K} = \beta \ (K/Q)^{\sigma}$$

where β is a scalar, and σ is the elasticity of substitution between capital and labor. Substituting (4.7) into (4.6) yields a relationship between desired capital K^*, output Q and the relative user cost of capital $r = c/P$:

$$(4.8) \qquad K^* = \alpha Q r^{-\sigma}$$

where $\alpha = 1/\beta$. (The measurement of c is discussed in Appendix C.) From this relationship for desired stock a net investment equation is derived for estimation purposes. Mayor used the following approximation for desired net investment:

$$(4.9) \qquad X_t = \left[\frac{Q_t}{r_t^{\sigma}} - \frac{Q_{t-1}}{r_{t-1}^{\sigma}} \right]$$

where X_t approximates the change in desired capital between periods t

and $t-1$. Since the effects of changes in the relative rental rate of capital r and changes in output Q affect investment with a spread of several periods, net investment is modeled in the estimating equation by a distributed lag on X_t:

$$(4.10) \qquad N_t = \sum_{i=1}^{n} w_i X_{t-i} + \varepsilon_t$$

where n is the length of the specified lag. If we assume, with Jorgenson, that capital depreciates geometrically at a rate δ, then replacement investment can be modelled simply by δK_t. This yields the expression for gross investment:

$$(4.11) \qquad I_t = \sum_{i=1}^{n} w_i X_{t-i} + \delta K_t$$

In addition to the restriction that $\sum_{i=1}^{n} w_i = 1$, Mayor assumed that the first two or three w_i's were arbitrary, but that the rest declined geometrically at the rate λ. Mayor's full regression model for net investment was:

$$(4.12) \qquad I_t = aw_0 \left[\frac{Q_t}{r_t^{\sigma}} - \frac{Q_{t-1}}{r_{t-1}^{\sigma}} \right] + a(w_1 - \lambda w_0) \left[\frac{Q_{t-1}}{r_{t-1}^{\sigma}} - \frac{Q_{t-2}}{r_{t-2}^{\sigma}} \right]$$

$$+ \lambda I_{t-1} + \varepsilon_t$$

Estimates of the w's in this model follow from the regression coefficients and the restriction that the w's sum to unity.

Since the elasticity of substitution σ enters this equation non-linearly, a simple scanning technique was used to find the value of σ which yielded the best fit, within a reasonable interval. Overall, Mayor achieved fairly good fits, with an average R^2 of .70

for net investment. Alternative regressions were run with a version of the flexible accelerator model, which yielded poorer results. While estimates of σ varied considerably among industries, there was an unmistakable tendency for this parameter to take on values significantly different from unity. A lag structure similar to that of Hall and Jorgenson was found, with about 70% of the investment response occurring within the first three years.

Mayor did not attempt to test this model in a historical simulation framework. If he had done so, he might have found the inclusion of the lagged dependent variable to be a problem. In a footnote[29] he admits only that the use of this variable can lead to a bias in small samples. He discusses a reparameterization of the model that would remove the lagged dependent variable, but finds the results unsatisfactory, supposedly because of specification and data errors.

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[29] Mayor (1971, 29).

Reimbold's Version

Thomas Reimbold (1974) improved upon Mayor's model in a number of ways. Using a slightly different specification for net investment, and assuming that the investment response occurs within five years, he avoided the use of the lagged dependent variable. Using a quadratic programming algorithm to estimate the parameters, he was able to impose more reasonable constraints on the parameters. Finally, he adopted a more flexible and realistic approach to the treatment of capital stock and replacement investment.

Reimbold approached the derivation of desired net investment as follows. Differentiating both sides of (2.8) with respect to time, an expression for the change in the desired capital stock can be obtained, which can be interpreted as desired net investment:[30]

$$(4.13) \qquad \dot{K}^{*} = \alpha\ [\dot{Q}r^{-\sigma} - \sigma Q\dot{r}r^{-(1+\sigma)}]$$

where the dot over a letter signifies differentiation with respect to time. Now divide both sides by K^{*} to obtain

$$(4.14) \qquad (\dot{K}^{*}/K^{*}) = (\dot{Y}/Y) - \sigma(\dot{r}/r), \text{ or}$$

$$(4.15) \qquad \dot{K}^{*} = [(\dot{Y}/Y) - \sigma(\dot{r}/r)]\ K^{*}$$

Using a first-difference approximation to represent the differential with respect to time, and replacing the unobservable desired capital K^{*} with "actual" capital stock K, the above equation becomes:

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[30]The following exposition is found in Reimbold (1974) Chapter IV.

$$(4.16) \quad X_t = \left[\frac{Y_t - Y_{t-1}}{Y_{t-1}} - \sigma \frac{r_t - r_{t-1}}{r_{t-1}} \right] K_{t-1}$$

where X_t approximates the change in desired capital between periods t and $t-1$. Like Mayor, Reimbold then modelled actual net investment as a distributed lag on desired net investment (See equation (2.10). However, unlike Mayor's model, where replacement investment was assumed to be a constant proportion of the capital stock, replacement investment was calculated as the spill from the second bucket of a two bucket scheme for measuring the capital stock.[31] In the two bucket scheme, capital stocks are constructed as follows:

$$(4.17) \quad K_t = B_1(t) + B_2(t)$$

where

$$(4.18a) \quad B_1(t) = I_t + (1-d_t)\, B_1(t-1)$$

$$(4.18b) \quad B_2(t) = d_t\, B_1(t-1) + (1-d_t)\, B_2(t-1)$$

and I_t is gross investment at time t and $d_t = 2/L_t$, where L_t is the average service life of equipment. Replacement investment consistent with this specification for the capital stock is $d_t B(t-1)$.

This investment equation was estimated with a number of constraints imposed. The weights w_i were expected to be non-negative, and once they begain to decline, to continue declining. It was also desired that these weights should sum to one. Although a

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[31] See Appendix B on the calculation of capital stocks and replacement investment.

constant term was included in the equation, it was softly constrained to zero. Finally, the service life assumption used in the calculation of the capital stocks and replacement investment was constrained to be close to its 1960 value. Since the fitted equation is non-linear, and subject to inequality constraints, it was estimated by the Dantzig quadratic programming algorithm. The basic objective function for the quadratic programming routine was the following:

$$(4.19) \qquad \min Z = \frac{g_1}{s_N^2} \sum_{t=1}^{T} (N_t - a - \sum_{i=0}^{5} w_i X_{t-i})^2 + g_2(1 - \sum_{i=0}^{5} w_i)^2 + g_3\left[\frac{a^2}{s_N^2}\right] + g_4\left[\frac{L_{1960} - L^*_{1960}}{L^*_{1960}}\right]$$

subject to $w > 0$ for all i, where the g's are constants and s_N^2 is the variance of N_t. The g's express the subjective rates of tradeoff between R^2 and the strength of the three *a priori* expectations.

Reimbold estimated one set of regressions with data from 1953 to 1971, and another set from 1953 to 1966, which was tested with a simulation from 1967 to 1971. The regressions were performed for 87 sectors comprising the U.S. economy. He found quite a diversity in the lag response of net investment to its determinants. The estimated elasticity of substitution between capital and labor was well below one in all but a few industries.

It is notable that for 28 out of 87 sectors, Reimbold found a smaller average absolute percentage simulation error than the corresponding average absolute percentage regression error. Most of the sectors had simulation errors of less than 10%. Reimbold also estimated a version of the equations without imposing any constraints. Of course, the unconstrained version fit at least as well as the constrained version for all industries. However, it is notable that for 55 out of 87 sectors, the constrained version outperformed the unconstrained version in the simulation exercise. This was particularly true in the manufacturing sectors, where better data exists.

Reimbold also examined the sensitivity of the equations to the period of estimation by comparing the results of the 1953 to 1967 regressions to those estimated from 1953 to 1971. He found: (1) that there was a general slowdown in adjusting the capital stock to its desired level, since most equations showed a lower cumulative weight after the third year when they were estimated to 1971, rather than only to 1967. He also found that the extra five years of data improved the regression fit.

Reimbold went far in an attempt to test his equations in a simulation framework. He presents the results of four simulations using the constrained or unconstrained equations with or without rho-adjustments. His general findings are that the constrained equations simulate better than the unconstrained equations, but that the rho-adjustment improved the performance of the unconstrained equations dramatically. The contribution of the rho-adjustment is also more significant for short term forecasts, which should be obvious.

Almon and Barbera's Model

This model[32], like those of Mayor and Reimbold, is based on the *CES* production function. However, the output and price effects in this model were estimated separately, each with its own set of distributed lag parameters.

The theoretical model is based on equation (2.8) above for the desired capital stock. However, the distributed lags for output and the price of capital are specified separately because of the expectation that the lag in reaction to r is likely to be slower than the lag in reaction to Q. The fundamental equation for the desired capital stock is:

$$(4.20) \qquad K_t^* = \alpha_t \prod_{i=0}^{m} Q_{t-i}^{w_i} \prod_{i=0}^{n} r_{t-i}^{-\sigma_i}$$

where

$$\sum_{i=0}^{m} w_i = 1 \qquad\qquad \sum_{i=0}^{n} \sigma_i = \sigma$$

In this case, σ is the long run elasticity of substitution. The assumption is made that $\alpha_t = \alpha_0 e^{at}$ where a is a small number of order .01. Taking logarithms of both sides and then taking first differences yields:

$$(4.21) \qquad \underline{\Delta K}_t = a_t + \sum_{i=0}^{m} w_i \, \underline{\Delta Q}_{t-i} + \sum_{i=0}^{n} \sigma_i \, \underline{\Delta r}_{t-i}$$

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[32]Almon and Barbera (1979).

where the symbol $\underline{\Delta}$ means the first difference of a logarithm, which is represented by a fractional change. For example:

$$\underline{\Delta}Q_t \cong (Q_t - Q_{t-1})/Q_{t-1}$$

Multiplying both sides of (2.20) by K_{t-1} we obtain:

$$(4.22) \qquad \Delta K_t = a\, K_{t-1} + K_{t-1} \sum_{i=0}^{m} w_i\, \underline{\Delta}Q_{t-i} + \sum_{i=0}^{n} \sigma_i\, \underline{\Delta}r_{t-i}$$

Equation (4.22) was estimated for net investment in 87 sectors comprising the U.S. economy by a quadratic programming technique similar to that used by Reimbold. This technique was used in order to get the equations to satisfy various *a priori* expectations about what would constitute reasonable values of the parameters. Capital stock and replacement investment were estimated by the "two bucket" method used by Reimbold.

Overall, the results support the contention that investment responds more quickly to changes in output than to changes in the cost of capital. It was also found that different assumptions as to the appropriate construction of the user cost of capital did not greatly affect the fit of the equations. Although Almon and Barbera simulated the response of these equations to a change in the investment tax credit they did not test the performance of the equations within the full INFORUM model with a historical simulation.

Barbera's Generalized Leontief Model

Anthony Barbera (1982) developed an investment equation based on an interrelated factor demand model derived from the generalized Leontief cost function. His model consists of a three-equation system of demands for capital, labor and energy, based on sectoral outputs, the user cost of capital, the prices of labor and energy, and the capital stock. He also further generalized and extended the bucket approach to the measurement of capital stock and replacement investment.

Barbera assumed a production function based on capital, labor, and energy, augmented by technical change:

$$(4.23) \qquad Q = F(Ke^{a_1 t}, Le^{a_2 t}, E^{a_3 t})e^{a_D t}$$

where t represents time and the a parameters are technical change coefficients.

The cost function dual to (4.23) was approximated by the Generalized Leontief (*GL*) cost function developed by Diewert[33]. A general homothetic representation of this function is:

$$(4.24) \qquad C(P, Q) = e^{-a_D t} Q \sum_i \sum_j b_{ij}(P_i P_j)^{1/2}$$

where $b_{ij} = b_{ji}$; $i,j = 1,3$

Shephard's Lemma states that optimal static input demands can

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[33]See Diewert (1971) for the development of this flexible functional form. The choice of this form over the translog and other flexible forms is that the Diewert function yields factor demands directly, whereas most of the other flexible functional forms yield demands for input shares. Section 3 contains further discussion on the use of flexible functional forms and duality theory to obtain empirical investment equations.

be obtained from (4.24) by taking the derivative of the cost function with respect to the input price:

$$(4.25) \qquad X_{it} = \frac{\partial C}{\partial P_i} = e^{-a_D t} Q_t \left\{ \sum_{j=1}^{3} b_{ij} \; (P_{jt}/P_{it})^{1/2} \right\} \qquad i = 1,3$$

where $\quad X = (Ke^{a_1 t}, L^{a_2 t}, E^{a_3 t})$

The estimated equations for energy and labor demand are directly obtained from this expression, except that the factor augmenting and disembodied technical change terms are combined into $a_L = a_2 + a_D$ and $a_E = a_3 + a_D$. These equations are shown below.

$$(4.26) \qquad L_t = e^{-a_L t} \left\{ \sum_j b_{Lj} (P_j/P_L)^{1/2} \right\} \sum_j w_j^L Q_{t-j}$$

$$(4.27) \qquad E_t = e^{-a_E t} \left\{ \sum_j b_{Ej} (P_j/P_E)^{1/2} \right\} \sum_j w_j^E Q_{t-j}$$

In order to derive an expression for net investment, first note that (4.25) can be transformed to yield an expression for the desired capital-output ratio:

$$(4.28) \qquad (K/Q)^* = e^{-a_K t} f(P)$$

where $f(P) = \sum_j b_{Kj} (P_j/P_K)^{1/2}$; $\qquad a_K = a_1 + a_D$

Desired net investment, N_t^* can then be written as the total differential of (4.25) with respect to time:

$$(4.29) \qquad N_t^* = (K/Q)^* dQ + e^{-a_K t} Q \; df - a_K (K/Q)^* \; Q$$

The first term of this expression is that part of desired net investment that results from a change in the level of demand, which is the product of the change in output and the change in the optimal capital-output ratio. The second term reflects net investment due to a change in relative prices, given a certain level of demand. The third term shows that portion of desired net investment resulting from an increase or decrease in the productivity of capital.

In moving from (4.29) to an empirically estimated equation, estimated, several possible specifications could be chosen. One issue entertained by Barbera was whether or not production should be modeled as "putty-putty" or "putty-clay". The interpretation of putty-clay which he adopts is that of Bischoff (1971), which is that once capital is purchased and installed, the capital-output ratio is fixed for that vintage of capital. But as equipment depreciates, each firm can purchase replacement capital in combination with other factors consistent with cost minimization, given the relative factor prices at the time of replacement.[34] In a putty-putty model, on the other hand, changes in current relative prices can lead to changes in the capital-output ratio even on older vintages of capital.

In the context of this model, the distinction of putty-clay versus putty-putty for net investment reduces to whether or not we should include the second term of (4.29) in our estimating equation.

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[34]See Barbera (1985) for a published version of this model. This version of the *GL* model was also used in a tax impact study by Barbera, Pollock and Meade (1986). Bliss (1968) contains an excellent survey and theoretical discussion of the various interpretations and implications of the putty-clay concept originally developed by Johansen (1959).

If this term is present, then current changes in the relative prices of capital, labor and energy can affect the entire capital stock. Otherwise, only changes in output will affect the determinination of the optimal net investment in the current period. Of course, the quantity of net investment desired for a given change in output is dependent on relative prices, since the optimal capital-output ratio depends upon relative prices. The form of the equation for net investment in the *GL* net investment equation is

$$(4.30) \qquad N_t = e^{-a_K t}\left\{ \sum_j b_{Kj}(P_j/P_K)^{1/2}\right\} \sum_j w_j^K \Delta Q_{t-j} - a_K K_{t-1}$$

where $\sum_j w_j^K = 1$

Replacement investment in this model is specified in a manner consistent with the putty-clay hypothesis.[35] As equipment is being replaced, firms are free to combine this new equipment with other factors to produce output at rates consistent with cost minimization given the relative prices holding at the time of replacement. This notion is summarized by the expression for the optimal capital-output ratio $(K/Q)^*$ as a function of relative prices.[36] If I_{t-i} is real gross investment in year $t-i$ then capacity installed in that year, C_{t-i}, can be expressed as

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[35]Barbera (1985) contains an exposition of the derivation of a replacement measure consistent with putty-clay.

[36]Although *expected* relative prices and changes in output are the relevant determining variables, current period prices were used to model expected prices, and a distributed lag of changes in output were used to model the expected change in output.

$$(4.31) \qquad C_{t-i} = I_{t-i}/(K/Q)^{*}_{t-i}$$

This is a measure of capacity in terms of the amount of incremental output that can be produced by the new capital equipment installed, assuming K/Q^{*} is the optimal capital-output ratio. The total amount of capacity lost in year t due to depreciation is given by

$$(4.32) \qquad \bar{C}_t = \sum_{i=1}^{t} d_i C_{t-i}$$

where the d_i's are determined by the pattern of depreciation and the average service life of capital and must sum to unity.[37] Consequently, replacement investment in year t is

$$(4.33) \qquad R_t = (K/Q)^{*} \bar{C}_t$$

Combining the equations for net investment and replacement investment into one equation for gross investment yields the following equation, estimated for each industry:

$$(4.34) \qquad I_t = e^{-a_K t}\left\{ \sum_j b_{Kj}(P_j/P_K)^{1/2}\right\} \left\{\sum_{j=0}^{4} w_j^K \Delta Q_{t-j} + \bar{C}_t\right\} - a_K K_{t-1}$$

A five period distributed lag was chosen for the change in output, since this gave the best fit, and was consistent with other empirical studies. The equation was estimated in conjunction with the equations for labor and energy demand, with cross equation constraints and linear inequality constraints imposed. These constraints will be discussed below, when we compare the results of

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[37] See Appendix B for more on the determination of patterns of depreciation, using combinations of 1st, 2nd and 3rd order Pascal lags.

the putty-putty and putty-clay models. The algorithm used to estimate the parameters was the Dantzig quadratic programming algorithm.

Barbera's approach to the putty-putty model was quite different. The second term of (4.29) was included in this specification to allow for an *ex post* effect of a change in relative prices on the composition of factor inputs. In addition, the effect of changes in relative prices on the demand for net investment was modelled as a 3 year distributed lag. Finally, the lagged capital-output ratio was used as an approximation to the optimal capital-output ratio, to simplify the estimation procedure. The putty-putty equation for net investment can be written

$$(4.35)\quad N_t = (K/Q)_{t-1}\sum_{j=0}^{3} w_j^K \,\Delta Q_{t-j} + e^{-a_K t} Q_t \sum_m \sum_{l=0}^{3} \beta_l^{Kj}\, \Delta(P_i/P_K)^{1/2}_{t-1}$$

$$-a_K K_{t-1} \qquad m = L,K,E$$

where $\sum_j w_j^K = 1$,

and $\sum_{l=1}^{3} \beta_l^{Kj} = b_{Kj}$, where b_{Kj} is the corresponding paremeter from the *GL* cost function. Replacement investment in this model is represented by a weighted combination of Pascal lags, or equivalently, as a weighted average of the spills from a three bucket scheme for measuring the capital stock.[38] This can be simplified as

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[38] See Appendix B.

$$(4.36) \qquad R_t = \sum_{i=1}^{3} d_i \; D_i(t)$$

where $\sum_{i=1}^{3} d_i = 1$

and $D_i(t) = (1-\lambda) \; B_i(t-1)$, where B_i is the i'th bucket in a three bucket scheme for measuring the capital stock, and λ is a spill rate. Combining the equations for net investment and replacement investment yields the estimated equation for gross investment:

$$(4.37) \qquad I_t = \left[\frac{K}{Q^*}\right]_{t-1} \sum_{j=0}^{4} w_j^K \, \Delta Q_{t-j} + e^{-a_K t} Q_t \sum_m \sum_{l=1}^{3} \beta_l^{Kj} \; \Delta(P_m/P_K)^{1/2\,*}_{t-l}$$

$$- \; a_K K_{t-1} + \sum_{i=1}^{3} d_i D_i(t) \qquad\qquad m = E, K, L$$

where $Q^* = \sum_{i=0}^{3} Q_{t-i}/4$ and $\Delta(P_j/P_K)^{1/2\,*} = \sum_{j=0}^{4} \Delta(P_j/P_K)^{1/2}/5$

$$\sum_{j=0}^{4} w_j^K = 1, \quad w_j^K \geq 0, \quad j = 0, \ldots 4$$

$$\sum_{i=1}^{3} d_i = 1, \quad d_i \geq 0, \quad i = 1, \ldots 3$$

$\sum_{l=1}^{3} \beta_l^{Kj} = b_{Kj}$, a parameter of the Diewert cost function

The expressions with the star superscript are an attempt to approximate measures of expected output and changes in prices. This equation was estimated in conjunction with a labor demand equation with labor divided by output as the dependent variable. This labor demand equation included a second time trend to account for the dramatic change in the rate of growth of labor productivity that began around 1970. The estimated labor equation for the putty-putty model was:[39]

$$(4.38)\quad \left[\frac{L}{Q}\right] = e^{-a_{L1}t_1} e^{-a_{L2}t_2} \left\{ \sum_m \sum_{l=1}^{3} \beta_l^{Lj} \, \Delta(P_m/P_L)^{1/2}_{t-l} \right\} + \left[\frac{L}{Q}\right]^*_{t-1} \sum_{j=0}^{3} w_j^L \, \underline{\Delta Q}_{t-j} \qquad m = E,K,L$$

where $\left[\frac{L}{Q}\right]^* = \sum_{i=0}^{3} \left[\frac{L}{Q}\right]_{t-i} \div 4$

and $\underline{\Delta Q}_t = (Q_t - Q_{t-1})/Q_{t-1}$; $\sum_{i=0}^{3} w_i^L = 0$

$t_1 = 1$ in 1947

$$t_2 = \begin{cases} 0 & t < 1970 \\ t-1969 & t = 1970 \ldots \end{cases}$$

Note that symmetry of the β's is imposed between these two equations, so that $\beta_l^{ij} = \beta_l^{ji} \;\forall\; l,i,j$. This implies symmetry of the price responses as well as symmetry in the time pattern of response.

Both the putty-putty and the putty-clay models were estimated subject to a set of constraints. Some of these are displayed above. In the investment equations, the w_j^K's are required to sum to unity. This implies that if the optimal capital-output ratio remains constant, a given increase in output will eventually result in a proportionate increase in desired capital. The weights were also required to be positive, because negative weights were considered unreasonable. The d_i's in both specifications were also constrained

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[39] This model was estimated earlier than the three-equation putty-clay model, and at that time Barbera did not have energy data available.

to sum to unity, and to be nonnegative. This ensures that each dollar of equipment is eventually fully depreciated. The symmetry effects were imposed to ensure that all equations were consistent with the same underlying cost function. Constraints were imposed upon the $\{b_{ij}\}$ matrix to ensure that own price elasticities were negative, and that capital and labor were substitutes.[40]

Both systems of equations were estimated for roughly 55 industries covering the entire private sector of the U.S. economy. The data used was from 1952 to 1980. A comparison of the estimation results of these two alternative systems of equations is problematic, since there are so many possible sources of differences. However, two significant facts emerge from looking at the estimated elasticities from the two models. The first is that the elasticities are significantly different between the putty-putty model and the putty-clay model. In the putty-putty model, 33 out of a total of 53 own price elasticities for capital are zero, while only 4 industries show zero own price elasticities in the putty-clay model. Since the own price elasticities have been constrained by the estimation procedure to be nonpositive, a zero elasticity means that the estimate would probably have shown the wrong sign in the absence of

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[40]Since the *GL* cost function is a flexible functional form, there always exists some vector of prices for which labor and capital would be considered complements, unless the function satisfies concavity globally. The constraint that labor and capital be substitutes was applied by constraining $b_{KL} \geq 0$.

the constraint. Of the remaining 20 industries, 14 show a higher own price elasticity in the putty-clay model than in the putty-putty model. On the other hand, labor's own price elasticity is generally smaller in the putty-clay model, except for 12 industries. The interpretation of these results can only be conjectural, but the divergence between the two models would lead us to doubt that we have any sense estimated "true" elasticities, or the "true" cost function lurking behind these estimates. There are probably more zero elasticities for capital in the putty-putty model because it is more tightly constrained. In this model, not only are the price effects forced to be symmetric, but the distributed lag, or timing of the adjustment process of capital and labor are constrained to be symmetric. In view of recent evidence, this may be an unreasonable assumption.[41] Another reason may be advanced as to why measured own price elasticities for capital are smaller in the putty-putty model. Since this specification includes the $f(P)$ term, which is multiplied by output, changes in prices can affect the entire capital stock needed to produce Q *ex post*. In this specification, a smaller value of the own price elasticity is necessary to effect a given change in

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[41] See Epstein and Denny (1983), who find the adjustment of quasi-fixed labor stocks and capital related, but not symmetric. Shapiro (1986) finds that hours worked adjust more quickly than either labor stocks or capital. Morrison and Berndt (1981) find skilled labor to be complementary with capital and to behave more like a quasi-fixed stock, whereas unskilled labor is more flexible and a substitute for capital.

investment. In the putty-clay model, where the $f(P)$ term is associated with *changes* in output, a larger price elasticity is required to cause a given change in investment. In any case, it seems that for forecasting purposes, elasticities in the two models do not imply the same response to a given change in prices.

It should be noted that the cross price elasticity between labor and capital was significantly positive in all but less than 5 industries for both models. The cross price elasticity between capital and energy was negative in about 40 industries for both models, supporting the finding of complementarity in many of the aggregate time series studies of factor demand. Industries that do show energy-capital substitutibility generally have small elasticities.

Barbera performed a limited simulation test of the equations he estimated by integrating them within the full INFORUM model and comparing the results with actual data.[42] The putty-putty equations were simulated from 1978 to 1981. The average absolute percentage error (*AAPE*) of these equations was 5.8, 11.0, 19.3 and 9.1 percent, with the model overpredicting investment in every year. However, the overprediction was mostly in a few sectors. A simulation comparison of the putty-clay equations was made from 1978 to 1980, and *AAPE*'s

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[42]At the time the putty-putty equations were estimated, actual data for investment was only available to 1977, so data was constructed by projecting existing investment data with regressions on BEA's *Plant and Equipment Survey.*

were calculated by industry. These varied from 8.1% for Electric Lighting and Wiring Equipment(34) to 80.8% for Apparel(8).

Barbera also did an aggregate simulation comparison with the employment equations from the putty-putty model. The *AAPE* for total employment for 1978-1981 was 1.7, 2.3, 3.2, and 3.8 per cent, respectively. Employment was underpredicted in every year. By 1981, this resulted in a forecast unemployment rate of 11.5% instead of the actual 8.1%.

Not surprisingly, the *AAPE* for investment was much higher than that for employment, since investment expenditures are more volatile than employment. It is interesting that in the aggregate simulations with the putty-putty model, the investment forecasts erred on the high side while the employment forecast was below actual. This possibly indicates that the substitution effect between capital and labor is stronger than the effect of output on employment. In an employment model driven purely by changes in outputs, higher investment would lead to higher outputs, which would stimulate higher employment. Of course, it is also possible that the investment equations were already predicting on the high side towards the end of the estimation period, with the employment equations on the low side.

Comparing the overall simulation performance of the two models is not really possible from Barbera's results, since he only shows aggregate results for the putty-putty model. Chapter V will compare the full model simulation performance of a putty-putty and a putty-clay model derived from Barbera'a models.

The form of the investment equations used in the INFORUM model has evolved considerably since work on the model began in the 1960s. However, we have no indication of whether the more recent models have improved the ability of the INFORUM model to forecast investment. As these models have developed, the data set has changed, as has the industry classification scheme. The INFORUM model has changed significantly as well, so that in comparing forecasts, it is not clear how much the differences in forecasting ability are due to the investment equations *per se*, and how much they are due to other differences in the model. The exercises in Chapter V will present the first organized attempt to compare the relative performance of these alternative models using the same data set and the same model environment.

5. Investment Equations in Other Macroeconomic Models

Relevant to a study such as this one is a review of the investment equations used in full-scale macroeconomic models. These are models most often used to address questions such as the impact of tax policy or inflation on investment. Their design may be regarded as an example of what is considered common practice in the area where simulation capability should be considered most important. The range of approaches exemplified by these models may serve as a benchmark for the models in this study, in order to gauge what is thought to be a reasonable response of investment expenditures to changes in exogenous variables.

In this section I will review the structure of the equipment investment equations in the BEA, Chase, DRI, Wharton, MPS, Michigan[42] and Fair[43] quarterly macro models. Unfortunately, I have found no literature describing investment in models similar to the INFORUM model, with investment equations at the industry level contained within an annual macroeconomic model. The INFORUM model forecasts investment expenditures on an annual basis, for 53 industries

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[42] The description of the BEA, Chase, DRI and Wharton models borrows extensively from Green (1981) and Chirenko and Eisner (1982, 1983), and the description of the MPS and Michigan models is derived from Chirenko and Eisner (1983). These papers also compare the various models in an *ex ante* simulation framework. The versions of the models described here are accurate as of the early 80's. I have checked more recent documentation on the DRI and Wharton macro models, and the equipment investment equations have not changed significantly during this time.

[43] See Fair (1984) for the theoretical background and empirical implementation of the investment equations in his model.

covering the entire economy. These investment forecasts interact with the forecasts of other final demands and prices at the industry level. Of the seven models listed above, only the Wharton model really has sectoral equations, and these are for nonresidential fixed investment in both equipment and structures, and for only 9 or 10 sectors.

Although the types of analysis that can be performed with the INFORUM model are richer, the disaggregated approach is also limited by lack of sectoral data on variables that are available only at the aggregate level. Also, it is still an open question whether investment in the aggregate can be predicted better with aggregate equations or as the sum of industry equations. Nevertheless, in a closed input-output model, investment must be translated into demand for producers' durable equipment (PDE) by type, and this is best done by forecasting investment by industry, in order to capture the changing mix of investment demand. Indeed, one criticism of partial simulations of the response of investment to tax policy, such as that of Hall and Jorgenson (1967), is that these studies ignore the secondary effects of increased output due to investment. To implement these feedback effects, a full macro model is needed. An input-output model with an investment-to-PDE bridge makes it possible to determine the indirect effects of investment on further investment as interactions between individual industries.

The investment equations in the following models will be critically reviewed, with a special emphasis on their treatment of the cost of capital, the number of exogenous variables required to make a simulation, and their possible interactions with the rest of the model. The BEA quarterly econometric model will be discussed first.[44]

The BEA Model

The BEA model uses two aggregate investment equations, one for equipment and one for structures. The estimated equipment investment equation is based on the assumption of a CES production function. In this equation, investment is driven by the product of the ratio of the price of output to the rental price of capital. The value of σ, the elasticity of substitution, is estimated at .74. The equation basically contains two distributed lags: one lag is based on differences in output; and the other is based on a measure of tightness of capacity which leads to the demand for new capital. The BEA equation is:

$$\textbf{BEA:}\quad E = \sum_{j=0}^{11} b_{jY}(p/c)^{\sigma}_{t-j}(Y-.87Y_{t-1}) + \sum_{j=0}^{8} b_{jU}(p/c)^{\sigma}\left[\frac{Y}{UT} - Y\right]_{t-j}$$

where

E = total producers' durable equipment

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[44] In the following outlines, an attempt is made to use a consistent nomenclature across models. For the most part, variables are defined as they are introduced.

$c = q(\rho - \pi^e + .38)(1-.7374k - uz)/(1-u)$ (rental cost of capital)

$\rho = .22i^e(1-.2u) + .011div/SP$ (opportunity cost of capital)

p = aggregate price index

q = price of investment goods

σ = elasticity of substitution

Y = level of output

UT = rate of capacity utilization

π^e = the expected rate of inflation

k = the investment tax credit

z = the present value of depreciation

u = corporate tax rate

i^e = expected interest rate

div = average dividends per share

SP = Standard and Poor's index of 500 shares

q is measured as the implicit price deflator of total fixed nonresidential investment, i^e is constructed as a distributed lag on recent values of Moody's domestic corporate bond rate, in nominal terms. π^e is constructed as a distributed lag on various prices. The rate of depreciation is constant at .38, and the corporate tax rate is set at its maximum statutory value, but the investment tax credit is multiplied by .7374 to get an estimate of the effective tax credit. The required rate of return, or opportunity cost of capital, is constructed as a combination of the after-tax interest rate and a measure of returns to shareholders.

This model follows Jorgenson (1967, 1969, 1970) in constraining the response of prices to follow the same distributed lag as the response to output changes. The length of the lag period was presumably chosen to obtain the best fit. Although this model should be recommended for considering both the cost of debt and equity financing in the construction of ρ, the user cost formula does not take the tax deductibility of interest payments into account. The reliance on the capacity utilization variable *UT* is a weak link, both because of problems of definition, and the difficulty of forecasting this variable.

The Chase Model

The driving force of the equipment investment equation in the Chase model is the new orders equation. This equation includes separate terms for the tax parameters u, k and z, as well as a price index, housing starts, capacity utilization, the current rate of output of defense and space equipment, and a distributed lag on consumer nondurable expenditures. The opportunity cost of capital, ρ, is created as an average of interest rates and earnings-price ratios. The economic rate of depreciation, δ, is constant at .181, and the present value of depreciation z is measured by a weighted average of straight line, sum of years digits, and double declining balance, with weights that vary over time. The investment tax credit k enters at its statutory rate.

The equipment investment equation in turn is based upon adistributed lag on new orders, an index of credit rationing, the sum of consumption expenditures on durable and nondurable goods, and the ratio of the implicit rental price of capital to the wholesale price index <u>index</u> of industrial commodities. The rental price of capital also enters indirectly into the equipment investment equation by also being in the new orders equation. The interest rate in this model is measured as the rate on newly issued AA bonds (nominal, before-tax). Statutory maxima are used for corporate tax rate and tax credit. The credit rationing variable is an attempt to pick up imperfections in the capital market.

The equations for new orders and equipment investment in the Chase model are:

Chase:

$$NOR = b_0 + b_1 cnd\_ + b_2 P\_ + b_3 hs_{t-1} + b_4 UT_{t-1} + b_5 YMIL + b_6 u + b_y k + b_8 \left[\frac{z}{1 - u}\right]$$

$$E = a_0 + a_1 (cd + cnd\_) + \sum_{j=0}^{9} w_j (c/p)_{t-j} + a_2 CRED\_ + a_3 NOR$$

where

NOR = new orders

*cnd_* = a distributed lag on consumer nondurables[45]

cd = consumer durables

*P_* = a distributed lag on a price index

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[45]The underscore notation is used to stand for a distributed lag of unspecified length and type.

hs = housing starts

$YMIL$ = the level of output of defense and space equipment

$CRED$ = an index of credit rationing

The cost of capital c in this equation is calculated as:

$$c = \frac{q(\rho + .181)(1 - k - uz)}{1 - u},$$

and $\rho = \left[i + \frac{prat}{SP}\right] \div 2$

where $prat$ = after-tax corporate profits

The combined use of a new orders equation with an equipment investment equation is intriguing, since this allows the model to capture explicitly the indirect path by which demand for equipment is expressed. However, there is no lag on new orders in the investment equation, probably because most new orders are filled in one quarter. The inclusion of consumption purchases and housing starts in an investment equation seems odd, even though it is likely that these categories eventually stimulate equipment investment somewhat indirectly.[46] The use of a capacity utilization variable and an index of credit rationing doubtless improve the fit of the historical equation, but the strength of these variables in a full closed modeling framework is doubtful. An interesting feature of the model is that u, k and z can produce separate effects outside of the cost

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[46] It would be better practice to model these links explicitly, rather than using the correlations in the data to explain investment.

of capital variable *c*, through the new orders equation. The expression for the opportunity cost of capital is a weighted cost of debt and equity, but uses the current nominal interest rate as the cost of debt, unadjusted for taxes. The use of after tax profits as a measure of equity cost would seems to be inferior to BEA's use of average dividends per share, both because of its volatility and its *ex post* nature. Altogether, the Chase equation would not be expected to hold up well in a long-term forecast, but allows for many levers in the simulation of tax and other macroeconomic policies.

The DRI Model

This model is basically a neoclassical Cobb-Douglas model,although it includes a term to capture imperfections in the capital market, and responds to changes in utilization and unexpected output changes.

The investment equation is based upon a distributed lag on theproduct of expected real private output and the ratio of output prices to the implicit rental value of capital. The output price is the implicit deflator for GNP. The statutory maxima is used for the corporate tax rate. However, the effective rate of the investment tax credit is determined endogenously. The present value of depreciation, *z*, depends on exogenous variables reflecting tax lives and the percentage of assets depreciated by accelerated methods, as well as on the opportunity cost of capital. The opportunity cost of capital is determined as a weighted average of interest rates and the cost of equity, which in turn is defined as the dividend/price ratio plus the expected growth in earnings per share. The weights are determined by the relative importance of various forms of financing in corporate balance sheets. The weights and expected growth in earnings are determined within the financial block of the model. The expected output variable is a weighted average of past output as measured by real final sales less imputed rent and government purchases of services, but increased to reflect increased investment required by government regulations, such as pollution abatement requirements.

In addition to the output term is a debt service variable. Thisis defined as a weighted average of interest rates times various forms of debt divided by a measure of cash flow. Other variables in the equation include the difference between expected and actual output, to allow for surprises; the lagged value of the capital stock, which captures the negative stock adjustment effect of capital on investment; and the product of capacity utilization and the lagged value of the capital stock, designed to capture the positive replacement investment induced by increases in the capital stock. The full equation is shown below.

DRI:

$$E = b_0 + \sum_{j=3}^{9} b_j \left[\frac{pY}{c} \right]_{t-j} + \sum_{j=1}^{7} d_j DS_{t-j} + f_1 KE_{t-1} UT^e + f_2 KE_{t-1} + f_3 (Y^e - Y) + f_4 VNWAR$$

where

DS = debt service variable, defined as the ratio of debt payments to cash flow.

KE = capital stock of producer's durable equipment

UT^e = expected capacity utilization

Y^e = expected output

$VNWAR$ = dummy variable for the Vietnam war period(65.1 - 66.4)

The cost of capital c in the DRI model is defined as follows:

$$c = q(\rho + \delta)(1 - k - uz\{1 - kDk\})/(1 - u)$$

and the opportunity cost of capital ρ is defined:

$$\rho = i(1 - u)wt + \left[\frac{div}{SP} + g\right](1 - wt)$$

where

Dk = dummy variables for the suspension of the investment tax credit

wt = percentage of financing due to debt issue

div = average dividends per share

g = expected growth in earnings per share

The composite term pY/c is critical, since it constrains the distributed lag parameters of c to be identical to those of p and Y, as in Jorgenson's Cobb-Douglas model. If accelerator and replacement effects dominate, and the long-run elasticities of capital with respect to output are unity, then this will bias the estimate of the own-price elasticity of capital towards unity.

The DRI equation for ρ improves upon the BEA and Chase versionsby allowing for taxes in the measure for the cost of debt, and using both dividends and the expected growth in earnings per share in the cost of equity. However, it would seem that the latter is not an easy variable to forecast. The capital utilization terms and capital stock terms represent the best attempt of the three models so far discussed to model the demand for net versus replacement investment.

Since this equation is essentially a dressed-up version of thestandard Jorgenson neo-classical equation, the same criticisms can be voiced, and the reader is referred elsewhere for more on this debate.[47] It is not clear how much one gains in forecasting ability from the inclusion of the debt-service and capacity utilization variables, since these are notoriously hard to forecast. Also, the measure of the cost of equity included in the equation for ρ is purely *ex post*, and is rather volatile. The assumption of a Cobb-Douglas technology assures that tax policy leading to a change in the cost of capital will have a large effect. This assumption of strong capital cost effects on investment has not been decisively proven or refuted by thorough historical simulation studies.[48]

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[47] See especially Eisner[1969, 1970].

[48] Contrary to Jorgenson's claims that the unitary elasticity of substitution was supported by the empirical literature, this is still an open question, with the more conservative assumption being that of zero elasticity.

The Wharton Model

The Wharton model is the most disaggregated of the modelspresented here. The first 9 sets of equations of the investment block of the model estimate industrial components of the BEA *Plant and Equipment* series. Each set consists of a one-quarter and two-quarter ahead anticipations equation, along with an actual investment equation based upon anticipations, output, and lagged capital stock. Each equation estimates total structures and equipment investment for that industry. The 10th equation divides total expenditures into equipment and structures as reported in the NIPA. The 9 industrial sectors used in the Wharton model are: durable manufacturing, nondurable manufacturing, mining, transportation, public utilities, communication, commercial and other, farm, and a residual category to make the sum of the industrial sectors add to the total of the real nonresidential fixed investment in the NIPA. This residual category includes such sectors as real estate, medical, legal, educational and nonprofit enterprises.

The anticipations equations are basically neoclassical, based ondistributed lags on real output, the rental price of capital divided by the sectoral output deflator, and the real capital stock. (Some of the sectoral equations contain only a subset of these variables.) The one-quarter ahead anticipations equation includes the forecasted value of the two-quarter ahead equation on the right hand side.

In calculating ρ, the nominal opportunity cost of capital, allinvestment is assumed to be debt financed, and a Moody's corporate bond rate is used for i. However, the deductibility of interest payments is ignored in calculating the implicit rental price of capital. A real rate is calculated from i by subtracting expected price changes in each industry. Depreciation rates are exogenous and constant, but vary across industries. The effective investment tax credit also varies across industries. This effective tax credit is calculated by adjusting the statutory tax credit by the ratio of the value of credits actually taken by firms in a particular sector to the value of investment expenditures in that sector.

The present value of depreciation, z, is calculated with the straight line depreciation formulaassumed for all industries through 1953, and sum of the years digits the sole method after 1953. There is strong evidence, however, that the move to accelerated depreciation* by U.S. firms was much more gradual than this. The nominal Moody's rate is the discount rate used to calculate the present value. The effective tax rate used is the ratio of corporate profits tax accruals to before-tax profits in each industry. The actual effective tax rate depends in part upon the investment tax credit.

The equation that splits total investment into equipment andstuctures investment is based on a lagged dependent variable, time, and a weighted average of sectoral effective investment tax credit rates (to pick up the reduction in the rental price of equipment relative to structures as a result of the increase in the investment tax credit. The equation also contains a distributed lag on the ratio of the PDE deflator to the implicit deflator for total fixed nonresidential investment.

It is notable that the rental price variable affects investmentindirectly through the anticipations variable. The anticipations variables are functions of industry output, the price of industry output relative to the price of capital, and the capital stock. The length of the lags varies by sector. The typical Wharton equation

for each industry, with possibly one or two variables dropped, is:

Wharton: $$(E + S)^{a} = b_{0} + b_{1}(E + S)^{1} + b_{2}(E + S)^{2} + b_{3}Y + b_{4}K_{t-1}$$

(actual investment)

$$(E + S)^{1} = d_{0} + d_{1}(E + S)^{2} + \sum_{j=0}^{n1} d_{jY}Y_{t-j} + \sum_{j=0}^{n2} d_{jK}K_{t-j} + \sum_{j=0}^{n3} d_{jc}(p/c)_{t-j}$$

(one-quarter ahead anticipations)

$$(E + S)^{2} = f_{0} + \sum_{j=0}^{m1} f_{jY}Y_{t-j} + \sum_{j=0}^{m2} f_{jK}K_{t-j} + \sum_{j=0}^{m3} f_{jc}(p/c)_{t-j}$$

(two-quarter ahead anticipations)

where Y, K and p are sectoral outputs, capital stocks, and output deflators, respectively. Structures investment is represented by S.

The forecasting of investment anticipations is an interestingapproach, although in light of the unreliability of the anticipations survey in forecasting investment, it is difficult to see the usefulness of these equations. It would probably be more effective to combine all the variables used here into one equation.

The estimated equations generally show a very low response tochanges in c, so the Wharton model does not display a marked stimulus from policies such as an increase in the investment tax credit. However, many of the changes in investment tax laws over the years have stimulated equipment or structures at the expense of the other, and these types of effects would not appear in these equations.

The Michigan Model

This model includes separate equations for 3 categories ofequipment: production, agriculture, and 'other'. Each equation is estimated with different right hand side variables. The 3 equations are:

Michigan: $$EX = b_0 + b_1 \Delta Y\_ + b_2 (c/w)\_ + b_3 S_{t-1} + b_4 EX_{t-1}$$
(production)

$$EA = b_0 + b_1 \Delta Y\_ + b_3 \Delta (c/w)\_ + b_4 (\dot{p}_F - \dot{p}_{NF})_{t-1} + b_5 EA_{t-1}$$
(agriculture)

$$EO = b_0 + b_1 \Delta Y\_ + b_2 (c/w)\_ + b_3 (i_L - i_s) + b_4 DASTRIKE$$

$$+ b_5 S_{t-1} + b_6 EO_{t-1}$$

(other)

where

EX = equipment used in the production sectors

EA = equipment used in the agricultural sector

EO = equipment used in the 'other' sector

S = structures expenditures

$\dot{p}_F$ = percentage change in the price index of farm product

$\dot{p}_{NF}$ = percentage change in the price of nonfarm product

i_L = long-term interest rate

i_S = short-term interest rate

$DASTRIKE$ = dummy variable for auto strikes

w = an average wage rate

The calculation for the cost of capital in this model is as follows:

$$c = q\left[\rho - \pi\_ + 1/6 - \left[k/6 + (5k/6)DF + u\left\{TD - 1/6 + \pi\_\right\}\right]/(1-u)\right]$$

where

DF = discount factor

TD = rate of tax depreciation

Each equation contains a distributed lag on changes in Y(GNP),and on the ratio of the aggregate rental price of capital to an aggregate wage index. The inclusion of structures expenditures on the right hand side of the EX and EO equations is subject to the same criticism leveled at the Chase equations for including consumption and housing starts: these variables are stopgap measures, necessary because the model does not identify the flow whereby construction expenditures (part of final demand) help determine output, which in turn influences investment. The use of the lagged dependent variable in all three equations bodes ill for longer term forecasts with these equations, a problem also evident in the Fair model.

The MPS Model

Investment in this model is driven by the new orders equation, which is based on a distributed lag of output and changes in ouput, each multiplied by $(p/c)^{\sigma}$. The value of σ is constrained to be unity. The opportunity cost of capital ρ is defined in terms of a dividend-stock price ratio adjusted by a risk premium, all adjusted by the proportion of capital costs which is tax-deductible. The effective rate of the investment tax credit is used. z takes into account the varying proportions of depreciation by straight-line and accelerated methods. The equations for new orders and equipment investment are:

MPS:

$$NOR = \sum_{j=1}^{8} (p/c)^{\sigma}_{t-j}(b_j \Delta Y_{t-j} + c_j Y_{t-j}) + \sum_{j=1}^{3} d_{jk} Dk_j + \sum_{j=1}^{6} d_{jp} DP_{t-j}$$

$$E = b_1 NOR + b_2 (YC_{t-1} - b_3 UOR_{t-1})(UOR_{t-1}/YC_{t-1})$$

where

Dk - dummy variable for the suspension of the investment tax credit

DP - dummy variables to take account of double ordering during the price controls period (73.4 - 75.1)

UOR = unfilled orders

YC = level of potential output

The cost of capital c is calculated by the standard formula:

$$c = \frac{q(\rho + \delta)(1 - k - uz)}{(1 - u)}$$

where the opportunity cost of capital ρ is

$$\rho = (1 - uv)\left\{2[div/SP - .01] + \sigma_Y\right\}$$

where

v = the proportion of the opportunity cost of capital which is tax deductible

div = average dividends per share

σ_Y = a measure of the variation in output

This model reacts to changes in the cost of capital through the new orders equation, which is constrained to respond strongly, again by combining the price and the output variables into one composite term. However, this response can be reduced quite a bit with a small b_1 coefficient in the second equation, so it is puzzling why σ was constrained to unity. The use of a distributed lag on both output and changes in output would appear to pose problems of extreme multicollinearity in the new orders equation. The equipment equation is also strongly influenced by the relationship between potential output and unfilled orders, but it is not clear how these variables are derived.

The Fair Model

The investment equation in the Fair model is for total plant andequipment investment by "the firm sector", which consists of total private nonresidential fixed investment less investment by farms, nonprofit organizations, and the banking sector. Fair's underlying theoretical model is of the "putty-clay" type, where at the time of purchase, any of a number of types of machines can be purchased. However, once the machines are put in place, there is assumed to be a fixed machine-worker ratio for each type of machine. Since there are costs involved in changing the work force or the size of the capital stock, it is sometimes optimal for a firm to be operating below capacity. Fair assumes a fixed proportions Leontief production function, where the amount of output produced is constrained both by the capital stock and labor on hand. In order to calculate an estimate of this minimum amount of capital stock required, called *KKMIN*, he divides capital stock *KK* by output *Y*, and then forms a peak-to-peak interpolation of the result.

The estimate equation Fair uses is basically an accelerator model with a term for excess capacity, to determine how far *KK* is from *KKMIN*, and two terms for the lagged capital stock, and lagged investment:

Fair: $$(E + S) = b_0 + b_1(KK - KKMIN) + b_2\Delta Y + b_3\Delta Y_{t-1} + b_4\Delta Y_{t-2} + b_5\Delta Y_{t-3} + b_6(E + S)_{t-1} + b_7KK_{t-1}$$

where

$E + S$ = combined structures and equipment investment of the firm sector

KK = capital stock, calculated by a perpetual inventory method

$KKMIN$ = minimum capital stock required to produce output, calculated as a peak-to-peak interpolation of KK/Y.

Y = production, calculated as total sales plus inventory change

This equation fails to capture the essence of the theoretical model Fair uses to derive it. Two problems that would be encountered in using it to forecast are the inclusion of the lagged dependent variable, and the reliance on the minimum capital stock variable. It is requires strong assumptions to form a peak-to-peak interpolation in an *ex ante* forecasting framework, although the equation can be used to perform historical simulations.

Summary

There is no clear consistent winner in a comparison such as the *Blue Chip Forecast*, which compares the forecasts and performance of over 40 econometric models, but DRI's and Wharton's investment equations could be taken as typical examples of "successful" forecasting equations. DRI follows the Jorgenson neoclassical approach, but adds other factors such as cash flow and capacity utilization, thus making the equation reliable in the short-term, at best. The Wharton approach using anticipations is intriguing, but it seems that it would be just as effective to include the anticipations variables directly in the investment equation. The DRI Model and the Michigan model should both be credited for their careful treatments of ρ, the opportunity cost of capital. Corcoran and Sahlings (1982) find that differences in the measurement of ρ comprise much of the differences in the cost of capital among different models.

CHAPTER III

EIGHT ALTERNATIVE INVESTMENT MODELS

This chapter develops the theoretical background and presents the form of the estimated equations for the eight alternative equipment investment models tested in this study. Except for the Autoregressive Model and the Accelerator Model in the first and second sections, these models all belong to the neo-classical family of models.[49] In each neo-classical version, investment responds to changes in relative factor prices (including the user cost of capital), and also to output as an indicator of the general demand for capacity. Other models that have typically been compared to the neoclassical model are the *q* model, the liquidity or cash flow model, and profits models related to the *q* model. Although the *q* model is also based on the same basic theory of the firm as the neo-classical, the emphasis is on measuring the market and book value of the firm, as opposed to focusing on output, relative prices, and depreciation

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[49]Although there is some disagreement as to the meaning of the term 'neo-classical', a neo-classical model is defined here to mean a model based on the premise that firms are motivated by long-run profit maximization or cost minimization. Firms are assumed to operate in a simple market structure, competitive in the long-run. Finally, some degree of factor substitutibility in the production function is usually assumed.

requirements. Theories of investment based on cash flow and profits are indirectly related to the neo-classical theory, in that increases of cash flow or profits may be taken as an indicator of future capacity growth.

However, these models share a fundamental weakness in that they rely upon variables which are even more difficult to forecast than investment, which makes them unsuitable for use in a large-scale closed model such as the INFORUM model. For example, Tobin's *q* ratio is not a variable that modelers attempt to forecast, because its measurement is unclear and its determinants are too numerous and vague.[50] In addition, most methods of measuring *q* rely on quoted asset market prices, which suffer from a good deal of noise in the short run. One would not benefit much from the use of this variable to forecast investment. On the other hand, output and relative prices are important components of any general model of the economy. In the INFORUM model, forecasts are available for 53 industries of output, output price, factor prices, and the components of user cost.[51] Therefore, a neoclassically based investment sub-model is well-suited to a general equilibrium model calculating prices and quantities, such as the INFORUM model.

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[50] If one were to attempt to forecast *q*, the most promising explanatory variables would be relative prices and movements in output, which are the variables used in the neoclassical equations.

[51] Of course, the tax components of user cost are exogenous. The endogenous components of the user cost are the price of equipment and the AAA bond rate.

The equations presented in the sections below range from the naive to the moderately complex. A simple autoregressive model discussed in section 1 is used as benchmark for the equations that follow. An accelerator model based on output, but not relative prices is presented in section 2. In section 3 we demonstrate the version of Jorgenson's neoclassical Cobb-Douglas model used for this study. Sections 4 and 5 present two models based on the CES production function. The next two models, in section 6, are derived from a generalized Leontief cost function, and appear in both a putty-putty and a putty-clay form. The model in section 8 is a 'dynamic factor demand model', which incorporates adjustment costs, and is based on a quadratic cost function.

These models are the fruit of a search for the best estimating form, length of lag, and construction of data. This search may have been uneven, in that more energy was applied to improving some models than others. However, I feel that the model comparison is useful. If a simple model outperforms a more complicated model upon which more energy was expended, it would cast doubt on the validity or value of the latter model. On the other hand, even if the more complex model does not perform as well in a forecasting framework, it could still provide useful information, such as price elasticities or the rates of technical change. Reasonable values for parameters expressing economic effects imply a more realistic response of the model to alternative scenarios in which relative prices or tax policy is changing. However, the failure of a model to forecast well should lead to some caution in the interpretation of the model parameters. After the background of the models has been developed in this chapter, chapter IV will present the results of estimating the parameters of these eight models.

1. The Autoregressive Model

It is probably best to start with a simple, naive model. For this purpose, a very basic autoregressive model has been specified, which includes four lagged values of gross investment. The estimated equation is:

$$(1.1) \qquad I_t = a_0 + \sum_{i=1}^{4} a_i I_{t-i}$$

This model is a simple benchmark with which the more theoretically sophisticated models can be compared. In terms of data, this model is cheap, requiring only lagged values of the dependent variable. However, it has no economic content and it does not provide any insight on the links between investment and the rest of the economy. Four lags were chosen, partly because this corresponded roughly to the number of lags present in the other models presented in this study. Also, since the simulation period is eight years (1977 to 1985), this equation must forecast at least four periods based on its own previous forecasts, and therefore gets a chance to prove if it can predict well without the aid of actual historical lagged values. It is expected that this particular model is most apt to fulfill the stereotype of an equation that fits extremely well, but cannot forecast many periods ahead. Models that are theoretically more well-grounded should perform better in a forecasting framework than this naive autoregressive model.

There are many arguments for using a time series model as a base model. Rational expectations proponents claim that an autoregressive model is a valid representation of expectations in a world where information costs are important. Other practitioners of time-series modeling point out that for a linear economic model, the reduced form expression for a variable may be approximated by a time-series model. Even if a model is not strictly linear, it is possible for a time-series model to outperform more theoretically based models.[52] However, this superiority in performance is not likely to hold in any but a short-term forecast. It is evident that an autoregressive model suffers from the basic weakness of propagation of its own errors. If the autoregressive model is too low or too high in one period, it will tend to blindly continue to err in this direction, since it is not based on any economic information besides its own past performance. With these qualifications in mind, the autoregressive model is included as a representative of naive time series models and models with lagged

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[52] Kopcke (1982) finds that the autoregressive model outperforms a number of structural models in a simulation test. However, the simulation period he uses is short. In general, forecasting experience has shown that autoregressive models perform poorly in long-term forecasts.

dependent variables.

2. The Accelerator Model

Some version of the accelerator model has been tried in just about every major comparative study of investment equations.[53] It is one of the oldest theories of investment, based on the notion that a firm's desired stock of capital is directly dependent on its level of output, with no measurable influence from prices, wages, taxes, or interest rates. The model is attractive because it is simple, and it can be used in a comparative test to determine the marginal effect of adding prices or other variables to the model specification. The general consensus among researchers on investment is that output is more important in explaining investment expenditures than relative prices. This premise can be tested by comparing the performance of an accelerator model with other models incorporating price variables.

The estimated equation for the accelerator model consists of a distributed lag on changes in outputs with a term appended to capture the demand for replacement investment:

$$(2.1) \qquad I_t = a + \sum_{i=0}^{3} b_i \Delta Q_{t-i} + cW$$

where ΔQ is the change in industry output, and W is a measure of the

[53] Jorgenson and Siebert (1968a), Jorgenson, Hunter, and Nadiri (1970a), Elliot (1973), Bischoff (1971), Clark (1979), Kopcke (1982) and Wisely and Johnson (1985).

"wear" or deterioration of the physical capacity of capital equipment. It is calculated as the depreciation spilling out of the second of two "buckets".[54] The time pattern of response to changes in output should be reasonable, and therefore the *b*'s are softly constrained to lie along an Almon polynomial. The value of *c* is expected to be close to 1.0, since *W* is a measure of replacement investment, and the ΔQ terms represent demand for new capacity.

3. The Jorgenson Cobb-Douglas Model

This model is an adaptation of Jorgenson's (1963, 1967) neo-classical model based on the Cobb-Douglas production function. It explicitly accounts for replacement investment through the inclusion of a capital stock term. The distributed lag pattern for output and the relative user cost of capital are constrained to be the same, by including both in one composite variable within the regression.

Assuming a Cobb-Douglas production function describing production possibilities, along with competitive markets and profit maximization, the expression for the desired level of capital stock K^* is

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[54] See Appendix B for a review of measures of capital stock and replacement investment in the context of "buckets" and "spills". This topic is developed in more detail in *The Craft of Economic Modeling* by Clopper Almon [1989].

(3.1) $$K^* = \alpha \frac{pQ}{c}$$

where

α = the share parameter of capital in the Cobb-Douglas function

p = the price deflator for output

Q = output

c = the user cost of capital

To account for the lag between changes in the desired capital stock and actual investment, the specification for net investment includes a distributed lag of the first difference of the above expression:

(3.2) $$N_t = a_0 + \sum_{i=0}^{3} a_i \left[\Delta \frac{pQ}{c}\right]_{t-i}$$

Replacement investment in this model is assumed to be determined by the product of the depreciation rate and the capital stock of the previous period, as in Jorgenson's original model. Instead of using Jorgenson's rational lag, the model is estimated as a gross investment model, with a term capturing replacement investment included on the right hand side. Therefore the final estimated equation is:

(3.3) $$I_t = a_0 + \sum_{i=0}^{3} b_i \left[\frac{pQ}{c}\right]_{t-i} + \delta K_{t-1}$$

Net investment is derived as $I_t - \delta K_{t-1}$. Since the last term represents replacement investment, the parameter δ can be interpreted as the geometric depreciation rate. However, when this parameter is estimated, it may not conform to the depreciation rate based on service lives used to calculate net investment (see Chapter IV). A five period lag was chosen for the composite price-output term in order to keep the lag period comparable to that of the other models in this study.

The use of the composite output/price variable admittedly confuses the degree of response of investment to output and price changes. In doing so, the model is assured of finding strong price effects. In fact, this brand of neo-classical model suffers from a number of other defects, including the fact that α is not constrained to take on reasonable values (i.e. less than 1.0), and that output should be endogenous, since the model is based on the assumption of profit maximization. Nevertheless, the model has had a significant impact on the way investment equations have been specified in many macroeconomic models, and is included as an example of a typical Cobb-Douglas neo-classical model. The next four models, however, are alternative ways to implement the neoclassical approach. However, they are all based on the basic neoclassical framework that Jorgenson introduced. As such, they are all derived from assumptions about production technology, such as the form of the production or cost function, they model investment as the combination of expansion and replacement investment, and embody assumptions about price-induced factor substitution, where the price of capital investment is the user cost of capital measure.

4. CES Model I

This model, based on a CES production function, is essentially that used by Reimbold and reviewed in Chapter II, section 4, except that a simpler estimation technique was used. The estimated equation is:

$$(4.1) \qquad N_t = a_0 + \sum_{i=0}^{3} w_i X_{t-i}$$

where

$$X_t = \left[\underline{\Delta} Q_t - \sigma \underline{\Delta} c \right] K_{t-1}$$

where Q is output, c is the relative user cost of capital, σ is the elasticity of substitution of factor inputs, and $\underline{\Delta}$ represents discrete proportional change. In other words, the expression $\underline{\Delta} Q_t$ is calculated as:

$$\underline{\Delta} Q_t = \frac{Q_t - Q_{t-1}}{Q_{t-1}}$$

Capital stock is measured as the sum of two buckets from a two-bucket system, and replacement investment is represented as the depreciation or spill from the second bucket.[55] The parameters to be estimated are σ, the w_i's, and the intercept a_0. All parameters are expected to be

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[55] See Appendix B, or Almon[1989].

positive in sign, except for the intercept a_0, which ideally should be close to 0. The elasticity of substitution must be positive for a CES function, and investment is expected to respond positively to output changes, and negatively to changes in the cost of capital, which enters the equation with a negative sign. Like the Jorgenson Cobb-Douglas version, this equation imposes the same distributed lag on prices as on outputs. This feature may cause difficulty in obtaining the proper value of σ if the time pattern of effects of output versus relative prices is significantly different.

5. CES Model II

This specification, while nominally based on a CES production function, bears little resemblance to the previous model, and allows for a different distributed lag on outputs from that on relative prices. This model is drawn from the work of Almon and Barbera [1980], reviewed in Chapter II. This specification, like the previous, is based on the expression for desired capital derived from the CES production function:

$$(5.1) \qquad K^* = \alpha Q c^{-\sigma}$$

where α is a constant. In this version, the distributed lagged effects of output and relative prices are assumed to enter multiplicatively. The implied formula for the desired capital stock is:

(5.2) $$K^*_t = \alpha_t \prod_{i=0}^{m} Q_{t-i}^{w_i} \prod_{i=0}^{n} c_{t-i}^{-\sigma_i}$$

where

$$\sum_{i=0}^{m} w_i = 1 \qquad \sum_{i=0}^{n} \sigma_i = \sigma$$

and σ is the long run elasticity of substitution. By taking logarithms of both sides of the above equation, and then taking first differences, and letting $m = n = 3$ we obtain the following:

(5.3) $$\underline{\Delta}K_t = a_t + \sum_{i=0}^{3} w_i \underline{\Delta}Q_{t-i} - \sum_{i=0}^{3} \sigma_i \underline{\Delta}c_{t-i}$$

where the symbol $\underline{\Delta}$ represents discrete proportional change. Multiplying both sides of (2.20) by K_{t-1} we obtain:

(5.4) $$N_t = a K_{t-1} + K_{t-1} \sum_{i=0}^{3} w_i \underline{\Delta}Q_{t-i} - K_{t-1} \sum_{i=0}^{3} \sigma_i \underline{\Delta}c_{t-i}$$

which is the form of the equation to be estimated. Capital stock series were obtained as the sum of the two buckets from a two bucket system[56], and replacement investment was calculated as the spillage from the second bucket. Net investment for the estimated equation was then calculated as gross investment minus replacement investment. Both the w_i's and the σ_i's are expected to be positive, since net investment should be positively related to increases in output, and negatively related to increases in the cost of capital. The sign of a may be either positive or negative, since it is merely a constant

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Again, see Appendix B or Almon[1989].

term. The summation limits m and n were both chosen to be three, to maintain consistency with the length of lags in the other models.

6. The Generalized Leontief Putty-Putty Model

The next two models are based on the Generalized Leontief Cost function. Each model consists of a three-equation system of demands for capital, labor, and energy, based on sectoral outputs, the user cost of capital, the prices of labor and energy, and the capital stock. The crucial difference between these two models lies in the pattern of response assumed for the optimal capital stock with respect to a change in relative input prices. The putty-putty model assumes that all vintages of capital may be adjusted in response to a change in prices even with no change in the scale of production, whereas the putty-clay model assumes that capital can only be adjusted as new capacity is purchased or as old capacity is replaced.

Both of these models assume that labor and energy are freely variable inputs. The factor demand equations for these inputs, are derived from the generalized Leontief cost function using Shephard's Lemma and are as follows:

$$(6.1) \qquad L_t = e^{-a_L t}\left\{ \sum_j b_{Lj}(P_j/P_L)^{1/2}\right\} \sum_{j=0}^{3} w_j^L \, Q_{t-j}$$

$$(6.2) \qquad E_t = e^{-a_E t}\left\{ \sum_j b_{Ej}(P_j/P_E)^{1/2}\right\} \sum_{j=0}^{3} w_j^E \, Q_{t-j}$$

$$(6.3) \qquad K_t^* = e^{-a_K t}\left\{\sum_j b_{Kj}(P_j/P_K)^{1/2}\right\}\sum_{j=0}^{3} w_j^K\, Q_{t-j}$$

where a_L, a_E and a_K are technical change coefficients for labor, energy and capital, the *b*'s are the parameters from the *GL* function that determine substitution and complementarity, and the *w*'s are distributed lag weights on output. Output enters the equations (6.1) to (6.3) as a distributed lag in order to try to capture "expected" output. The pattern of the lag response can be taken as an indication of how quickly firms adjust their future expectations to changes in the current level of demand.

As shown in Chapter II, section 4, to derive an expression for net investment, an equation for the long run demand for capital K^* is derived using Shephard's Lemma, and then transformed to yield an expression for the desired capital-output ratio:

$$(6.4) \qquad (K/Q)^* = e^{-a_K t} f(P)$$

where $f(P) = \sum_m b_{Km}(P_m/P_K)^{1/2}$ $(m = E,L,K)$; and a_K is the coefficient of technical change for capital. Desired net investment is the total differential of (6.3) with respect to time:

$$(6.5) \qquad N_t^* = (K/Q)^* dQ + e^{-a_K t} Q\, df - a_K (K/Q)^*\, Q$$

where *dQ* and *df* are differentials of *Q* and *f*, which can be considered as varying with respect to time.

This equation states that the demand for net investment comes from three sources. The first term of (6.5) represents demand for new capacity, at the currently optimal ratio of *K/Q*. The second term represents changes in the demand for capital brought about by changes in relative prices. The final term represents investment demanded because of the time trend in the capital-output ratio. One distinction between the putty-putty and the putty-clay model is the treatment of the second term of (6.5). The putty-putty includes the second term in the estimated equation to allow changes in relative prices to affect the optimal capital output ratio for all vintages of capacity. In the putty-clay model this term is omitted.

Experimentation with various possible forms for the putty-putty model showed that the inclusion of the last term of (6.5) was not desirable. The following specification was finally chosen for estimation:

$$(6.6) \qquad N_t = e^{-a_{K1}t_1 + a_{K2}t_2}\left[\left\{\sum_m b_{Km}(P_m/P_K)^{1/2}\sum_{i=0}^{3} w_i^K\,\Delta Q_{t-i}\right\} + Q_t\sum_{i=0}^{3} v_i^K\left\{b_{KL}\Delta(P_L/P_K)_{t-i}^{1/2} + b_{KE}\Delta(P_E/P_K)_{t-i}^{1/2}\right\}\right]$$

$$m = E, L, K$$

where $\sum_{i=0}^{3} w_i^K = 1, \quad \sum_{i=0}^{3} v_i^K = 1$

P_K = the user cost of capital

P_L = the wage rate of labor

P_E = the price of energy, indexed to 1.0 in 1977

Q = output

t_1 = first time trend, starting in 1953

$$t_2 = \begin{cases} 0 & t < 1970 \\ t-1969 & t = 1970 \ldots \end{cases}$$

a_{K1}, a_{K2} = technical change coefficients

The second term within the large square brackets in equation (6.6) corresponds to the second term in (6.5), and represents the change in desired capital stock applicable to all earlier vintages of capital caused by current relative price changes. The distributed lag in this term can be interpreted either as a proxy for the formation of expectations about relative prices, or the lag in reactions to changes in relative prices. The second technical change coefficient is introduced to account for a change in the rate of growth in capital output ratios that seems to occur sometime in the early 1970s in many industries. Capital stock, replacement investment and net investment were calculated with a two-bucket system, similar to the CES models above.

Own price elasticities are expected to be negative. This implies certain restrictions on the b parameters. For example, with this version of the Diewert cost function, the own price elasticity of capital can be expressed by:

$$(6.7) \qquad E_{KK} = -\frac{1}{2}\cdot(Q/K)\cdot\left\{b_{KL}(P_L/P_K)^{1/2} + b_{KE}(P_E/P_K)^{1/2}\right\}$$

For $E_{KK} \leq 0$ the following must hold:

$$(6.8) \qquad b_{KL}\cdot(P_L/P_K)^{1/2} + b_{KE}\cdot(P_E/P_K)^{1/2} \geq 0$$

This would imply a constraint for each historical year of data. I have decided to impose this constraint only in the last year of the estimation, so that it will be more likely to hold in the forecast period. The other constraints may be simply expressed by the following inequalities:

$$(6.9) \qquad b_{LK} \cdot (P_K/P_L)^{1/2} + b_{LE} \cdot (P_E/P_L)^{1/2} \geq 0$$

$$(6.10) \qquad b_{EK} \cdot (P_K/P_E)^{1/2} + b_{EL} \cdot (P_L/P_E)^{1/2} \geq 0$$

In addition to these constraints, bounds were placed on the time trends. These constraints will be discussed in more detail in chapter IV, which contains the estimation results.

7. The Generalized Leontief Putty-Clay Model

The putty-clay model differs from the putty-putty model in that the second term in equation (6.4) is dropped, and replacement investment is treated differently. The estimated equation for net investment is:

$$(7.1) \qquad N_t = e^{-a_{K1}t_1 + a_{K2}t_2} \left\{ \sum_j b_{Kj} (P_j/P_K)^{1/2} \sum_{i=0}^{3} w_i^K \, \Delta Q_{t-i} \right\}$$

where the parameters and variables have the same meaning as in equation (6.5). Equation (7.1) states that net investment is determined only by additions or subtractions to current capacity, and that the amount of investment per unit of output is determined as a function of relative prices.

To obtain an estimate of net investment for this model, replacement investment must be estimated, and then subtracted from gross investment. Replacement investment in the putty-clay model is not modeled as replacing depreciated capital stock dollar for dollar, but rather to replace capacity, in the sense of ability to produce output. The capacity of capital to produce output at any given time is assumed to be determined by the optimal capital output ratio, which is in turn a function of relative prices. New capacity installed at time $t-i$ is defined as gross investment divided by the optimal capital output ratio at that time:[57]

$$(7.2) \qquad C_{t-i} = I_{t-i}/(K/Q)^*_{t-i}$$

The total amount of capacity lost in year t due to depreciation is

$$(7.3) \qquad \bar{C}_t = \sum_{i=1}^{t} d_i C_{t-i}$$

Translating this lost capacity into replacement investment requires multiplication by the optimal capital output ratio at time t, which is a function of relative prices:

$$(7.4) \qquad R_t = (K/Q)^* \, \bar{C}_t$$

Since $(K/Q)^*$ is dependent upon the b parameters from the Generalized Leontief cost function, replacement investment is determined during the estimation of these parameters, and then subtracted from gross investment to yield an estimate of net investment. When this

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[57]See Chapter II, section 4.

equation is used for forecasting purposes, replacement investment is considered to be a function of relative prices as well as previous lagged values of investment. The *b* parameters in this model play the same role as in the previous model, and so the same constraints were imposed.

8. A Dynamic Factor Demand Model

The *dynamic factor demand* approach was outlined by Treadway (1971), and is exemplified by studies such as Berndt, Fuss, and Waverman (1980); Berndt and Morrison (1981); or Morrison (1988). In this approach, factors are divided into *variable* and *quasi-fixed*. Quasi-fixed factors impose internal costs of adjustment with a changing in the level of stocks. Treadway's basic contribution was to include an endogenous adjustment matrix for the quasi-fixed factors, derived from solving a basic calculus of variations problem of production with quasi-fixed factors. In the case of one quasi-fixed factor, this method boils down to a flexible accelerator model with an adjustment coefficient determined by the real interest rate and parameters in the cost function.

Many of the studies using the dynamic factor demand approach have relied upon the assumption of a quadratic cost function to represent the underlying technology. This assumption allows for a tractable expression for the adjustment coefficient β, and hence for the investment equation. The dynamic factor demand model I have chosen is related to that in Berndt, Fuss, and Waverman (1980), hereafter referred to as *BFW*. The cost relationships between variable and quasi-fixed factors is assumed to be representable by a Normalized Restricted Cost Function (NRCF) of a quadratic functional form. The variable factors are Labor (L) and Energy (E), and the quasi-fixed factor is the capital stock of equipment (K). The cost function is normalized on the price of one of the variable factors (E) to ensure homogeneity in prices. The form of the NRCF assumed for this model is:

$$
\begin{aligned}
(8.1)\quad G = E + \hat{P}_L L \;=\; & \alpha_0 + \alpha_{0t} t + \alpha_L \hat{P}_L + \alpha_Q Q + \alpha_K K + \alpha_{\dot{K}} \Delta K \\
& + \tfrac{1}{2}\left(\gamma_{LL} \hat{P}_L^2 + \gamma_{QQ} Q^2 + \gamma_{KK} K^2 + \gamma_{\dot{K}\dot{K}} (\Delta K)^2 \right) \\
& + \gamma_{LQ} \hat{P}_L Q + \gamma_{LK} \hat{P}_L K + \gamma_{L\dot{K}} \hat{P}_L (\Delta K) + \gamma_{QK} QK + \gamma_{Q\dot{K}} Q(\Delta K) + \gamma_{K\dot{K}} K(\Delta K) \\
& + \alpha_{Lt} \hat{P}_L t + \alpha_{Kt} Kt + \alpha_{\dot{K}t} (\Delta K) t
\end{aligned}
$$

where:

G = total cost

$\hat{P}_L$ = the price of labor normalized by the price of energy.

E = demand for energy inputs.

L = demand for labor inputs.

K = capital stock of equipment.

$\Delta K = N = K_t - K_{t-1}$ = net investment, or change in capital stock.

Q = gross output.

t = an index of technology, measured by time. $t = 1$ in 1947.

Internal costs of adjustment can be represented by the function:

$$(8.2)\qquad C(\Delta K) = \alpha_{\dot{K}}\Delta K + \frac{1}{2}\gamma_{\dot{K}\dot{K}}\Delta K^2 + \gamma_{L\dot{K}}\hat{P}_L\Delta K + \gamma_{Q\dot{K}}Q\Delta K + \gamma_{K\dot{K}}K\Delta K + \alpha_{\dot{K}t}t\Delta K$$

Marginal adjustment costs with respect to capital are:

$$(8.3)\qquad \frac{\partial G}{\partial(\Delta K)} = C'(\Delta K) = \alpha_{\dot{K}} + \gamma_{\dot{K}\dot{K}}\Delta K + \gamma_{L\dot{K}}\hat{P}_L + \gamma_{Q\dot{K}}Q + \gamma_{K\dot{K}}K + \alpha_{\dot{K}t}t$$

At a stationary point, where firms neither need to increase or decrease their capital stock, $\Delta K = 0$; and $C'(0) = 0$. This is true only if the following restrictions are imposed:

$$(8.4)\qquad \alpha_{\dot{K}} = \gamma_{L\dot{K}} = \gamma_{Q\dot{K}} = \gamma_{K\dot{K}} = \alpha_{\dot{K}t} = 0$$

With these restrictions the cost function simplifies to:

$$(8.5)\qquad G = \alpha_0 + \alpha_{0t}t + \alpha_L\hat{P}_L + \alpha_Q Q + \alpha_K K + \frac{1}{2}\left(\gamma_{LL}\hat{P}_L^2 + \gamma_{QQ}Q^2 + \gamma_{KK}K^2 + \gamma_{\dot{K}\dot{K}}(\Delta K)^2\right) + \gamma_{LQ}\hat{P}_L Q + \gamma_{LK}\hat{P}_L K + \gamma_{QK}QK + \alpha_{Lt}\hat{P}_L t + \alpha_{Kt}Kt$$

Shephard's Lemma can be used to derive the short-run cost minimizing demand for labor:

$$(8.6)\qquad \partial G/\partial\hat{P}_L = L = \alpha_L + \gamma_{LL}\hat{P}_L + \gamma_{LQ}Q + \gamma_{LK}K + \alpha_{Lt}t$$

Since $G = E + \hat{P}_L L$, E can be expressed using (1.5) and (1.6) as:

$$(8.7)\qquad E = \alpha_0 + \alpha_{0t}t - \frac{1}{2}\gamma_{LL}\hat{P}_L^2 + \gamma_{KQ}QK + \alpha_Q Q + \frac{1}{2}\gamma_{QQ}Q^2 + \alpha_K K + \alpha_{Kt}Kt + \frac{1}{2}\gamma_{KK}K^2 + \frac{1}{2}(\Delta K)^2$$

The derivation of the net investment function draws heavily on the theory developed in Treadway (1971). In the special case of only one quasi-fixed input K, Treadway derived the following multiplier formula:

(8.8) $$\Delta K = \beta^{*}\left(K^{*} - K_{t-1}\right)$$

where K is a single quasi-fixed factor, and β^{*} is an adjustment coefficient that is a function both of parameters of the cost function and of the real interest rate r. At the stationary point, where $G_{\dot{K}\dot{K}} = 0$, Treadway derived the following formula for the adjustment parameter:

(8.9) $$\beta^{*} = -\frac{1}{2}\left[r - \left(r^{2} + \frac{4\gamma_{KK}}{\gamma_{\dot{K}\dot{K}}}\right)^{\frac{1}{2}}\right]$$

To get an expression for the equilibrium capital stock, K^{*}, set the price of capital equal to the marginal savings in variable costs of a extra unit of capital, as follows:

(8.10) $$G_{K} = \delta G/\delta K = -\hat{P}_{K}$$

or,

(8.11) $$-\hat{P}_{K} = \alpha_{K} + \gamma_{KK}K + \gamma_{LK}\hat{P}_{L} + \gamma_{QK}Q + \alpha_{Kt}t$$

where $\hat{P}_{K}$= the user cost of capital normalized by the price of energy. Solving for optimal K:

$$(8.12) \qquad K^{*} = \frac{-1}{\gamma_{KK}} \left\{ \alpha_{K} + \gamma_{LK}\hat{P}_{L} + \gamma_{QK}Q + \alpha_{Kt}t + P_{K} \right\}$$

Equations (8.8), (8.9) and (8.12) are then combined to obtain an estimable equation for net investment:

$$(8.13) \qquad N = \frac{1}{2}\left[r - \left(r^{2} + \frac{4\gamma_{KK}}{\ddot{\gamma}_{KK}} \right)^{\frac{1}{2}} \right]$$

$$\cdot \left[\frac{-1}{\gamma_{KK}} \left\{ \alpha_{K} + \gamma_{LK}\hat{P}_{L} + \gamma_{QK}Q + \alpha_{Kt}t + P_{K} \right\} - K_{t-1} \right]$$

The equations (8.6), (8.7) and (8.13) form a simultaneous system of equations which can be estimated using nonlinear system techniques.

There are some restrictions on the parameters in this model implied by economic theory. For the short-run own price elasticities of the variable factors to be negative, it is necessary and sufficient for γ_{LL} to be negative. For the long-run own price elasticity of capital to be negative, it is necessary that γ_{KK} be positive. Also, for marginal costs of adjustment to be increasing, it is necessary that $\ddot{\gamma}_{KK}$ be positive. For the adjustment parameter β^{*} to be in the range $0 < \beta^{*} < 1$, it is sufficient that $0 < \gamma_{KK} < \ddot{\gamma}_{KK}$ Finally, for output elasticities to be positive, it is necessary that γ_{LQ} be positive and that γ_{QK} be negative. In summary, the parameter restrictions implied by economic theory are:

$$(8.14) \qquad \gamma_{LL},\ \gamma_{QK} < 0, \quad \gamma_{LQ} > 0, \quad \text{and } 0 < \gamma_{KK} < \ddot{\gamma}_{KK}$$

It may be useful to compare the form of the net investment equation in this model to some of the other models. Note that although the basic form of the equation is the familiar stock adjustment model, the formulas for β, the adjustment parameter, and K^*, the optimal capital stock, are unusual. What effect do we expect r to have on the speed of adjustment? Treadway notes that we would expect adjustment to be faster for lower rates of interest, according to intuition, but admits there are no strict theoretical or empirical grounds for believing this hypothesis.[58] The optimal capital stock is based on current output, a time trend, and the prices of labor and capital normalized by the price of energy. This expression was derived by setting the normalized cost of capital equal to the savings in variable cost realized by adding an extra unit of capital, as measured by the variable cost function. As such, it is valid locally, but doesn't appear to have good asymptotic properties. For example, if the level of output were to fall to zero, there could still be a positive level of desired capital stock. Alternatively, if the price of capital fell to zero, there would still be only a finite amount of capital demanded. This asymptotic behavior doesn't seem reasonable. However, this model will be included in the present study as a representative of the dynamic factor demand approach.

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[58] Treadway [1974, p 26].

CHAPTER IV

ESTIMATION RESULTS

In this chapter, the results of the estimation of each of the models introduced in Chapter III are presented. In most cases, the first attempt at model estimation was not acceptable and the model was subsequently altered, either through a change in the specification, or through the imposition of constraints. In addition to a presentation of the parameter estimates and their economic significance, this chapter will include some discussion of the path that led to the final equation, and review the subjectively imposed constraints embodied in the final equations.

The estimated parameters in each model should be examined in terms of their economic significance and their stability over time. Each set of estimation results will be evaluated not only in terms of the fit to historical data, but also in terms of economic "reasonableness". Two sets of estimation results are presented for each model: the first estimation period being from 1953 to 1977, and the second from 1953 to 1985. If estimated parameters differ greatly between the two regression intervals, caution should be exercised in extrapolating these results in a forecast extending out five to ten years. Of course, the degree of difference that should be considered 'significant' is also a subjective matter, and will be treated as such in this study, as opposed to relying on the customary Chow tests, *F*-tests, or other tests based on assumed statistical distributions. Instead, models will be viewed with an eye as to how well they perform in a long-term forecast, or in a dynamic historical simulation. If model parameters appear to be unstable between the two estimation periods, then the validity of the model may be doubted, and it should be expected to perform poorly in a dynamic historical simulation. Whether or not this is indeed the case will be examined in Chapter V.

I will also compare estimation results across models, in order to determine to what extent the different models are yielding different views of the same overall picture. Are the output responses implied by the models consistent with each other? Where price effects are important, are the models giving similar notions of price responsiveness? In the factor demand models, are the cross- and own-price elasticities in the different models of comparable magnitude? In attempting to answer these questions, the data must also be evaluated. Are the data informative enough to really tell a clear story? Comparing the results of a battery of models such as this should provide a better answer to this question than the results of any single model.

In the sections that follow, the results of each model estimation will be discussed in turn for both estimation intervals. The regression tables are missing the traditional reported standard errors and *T*-Statistics. This is partly in the interest of brevity, but also because of the nature of the estimation procedures used. For instance, many of the models embody "soft constraints"[59], where some degree of goodness of fit is sacrificed to obtain sensible parameter values. The Diewert models were estimated using a quadratic programming algorithm that embodied nonlinear inequality constraints. Many of the other models were estimated with nonlinear techniques. For all three such kinds of models, reported standard errors are questionable and difficult to interpret.

Since graphical results are a welcome addition to tables of parameters, the reader is referred to the regression plots which can be found roughly at the end of each section, after the tables of estimated parameter results. The actual estimated equations originally presented in Chapter III will be reproduced in each section for reference.

1. The Autoregressive Model

This model is the simplest of the group, basing its prediction of gross investment simply on an intercept term and five lagged

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[59] A regression using "soft constraints" is equivalent to a "mixed estimation procedure", where an implicit tradeoff between goodness of fit and satisfaction of the constraint is implemented by expressing the objective function as a weighted average of actual squared errors and a sum of artificial observations consisting of squared differences of the value of the constrained expression from the value of the constraint.

values of gross investment:

$$(1.1) \qquad I_t = a_0 + \sum_{i=1}^{4} a_i I_{t-i}$$

The model was estimated with no parameter constraints, the objective being simply to obtain the best fit to the data. Both the regression tables and the plots bear out the fact that this was indeed the model that gave, on average, the best fits. Tables 4.1 and 4.2 show the regression results for both estimation intervals. Each table shows the values for the intercept (*INTCP*), lagged investment (*V[1]* to *V[4]*), R^2 (*RSQUARE*), the average absolute percentage error (*AAPE*), the standard error of the estimate (*SEE*), and the value of ρ, the autocorrelation coefficient for the residuals (*RHO*). Viewing thesetables we find that of 53 equations, only 3 had an R^2 below .6 in the 53 to 77 estimation: Crude Oil and Gas(2), Iron and Steel(19), and Special Industry Machinery(27). Four industries had a value of R^2 less than .6 in the 53 to 85 estimation: Iron and Steel(19), Special Industry Machinery(27), Motor Vehicles(36), and Miscellaneous Manufacturing(41). About a third of the equations for both estimation periods had a value of R^2. over .9.

The graphs making up Figures 4.1.a to 4.2.d show the total of actual and fitted investment for the aggregate of all 53 industries, in addition to regression fits for 15 selected industries. Figures 4.1 contain the regression plots for the 53 to 77 estimations, and figures 4.2 contain the plots for the 53 to 85 estimations. Judging by these graphs the fits are indeed tight, but this is to be expected of an autoregressive model for fairly aggregate time series. It is also typical that the turning points for the fitted values tend to lag the actual turning points, usually by one year. For the most part, the coefficient on the one year lag was positive and close to one, whereas the coefficient on the two year lag was negative, and generally lying between -.1 and -1.0. The results on the three and four year lagged coefficients are mixed, but the results show that there strong positive serial correlation in the gross investment data at a one year lag, strong negative correlation at a two year lag, and a mixed pattern in lags beyond this length. This alteration in sign is characteristic of the cyclical nature of equipment investment.

Comparing parameters between the two sets of regressions, one notices that the general pattern of signs is similar, but individual regression parameters diverge by a factor of two or more. Of course, the period of data added in the second set of regressions (1978 to 1985) includes an energy price hike, followed by a recession, followed by the beginning of a long expansion. One might reasonably expect the autocorrelations of a time series like equipment investment to change over such a period.

Of course, the ability of a regression equation to fit the data should not be measured entirely by R^2. For instance, turning to the plots in Figure 4.1, the equation for Iron and Steel(19) has a low R^2, but this is due mostly to the fact that the series we are trying to fit does not have much of a trend. The equations for Agriculture, Forestry, and Fisheries(1) and Construction(4) both fit fairly well,

Table 4.1

The Autoregressive Model. Estimated from 53 to 77.

	Sector Title	INTCP	V[1]	V[2]	V[3]	V[4]	RSQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	1527.88	0.9876	-0.3037	0.4369	-0.2846	0.716	8.020	925.500	0.003
2	Crude Petroleum, Natural Gas	951.35	0.4915	-0.0866	0.0400	-0.0195	0.103	7.771	209.600	-0.001
3	Mining	407.16	1.0231	-0.2990	0.2939	-0.2014	0.602	9.847	306.200	-0.005
4	Construction	195.44	1.0930	-0.5768	0.3892	0.1865	0.949	13.833	869.200	-0.004
5	Food, Tobacco	107.54	0.8968	-0.2031	0.1673	0.1696	0.984	4.068	110.700	-0.219
6	Textiles	123.11	0.9090	-0.1182	0.1266	-0.0433	0.766	11.386	117.300	-0.111
7	Knitting, Hosiery	19.75	0.9538	-0.2724	0.2067	-0.0281	0.733	30.380	44.257	-0.007
8	Apparel and Household Textile	50.56	0.9720	-0.0178	0.4080	-0.4704	0.924	12.129	57.548	0.083
9	Paper	180.37	1.0016	-0.1692	0.1114	0.0051	0.868	8.423	206.600	-0.011
10	Printing	48.82	1.2244	-0.7174	0.5563	-0.0580	0.971	5.815	63.874	-0.072
11	Agricultural Fertilizers	23.25	1.0450	0.0095	-0.1242	0.1462	0.817	32.200	116.900	-0.020
12	Other Chemicals	96.02	1.0122	-0.2498	0.1471	0.1098	0.936	7.927	271.300	0.047
13	Petroleum Refining and Fuel	127.47	1.1128	-0.3751	0.1371	-0.0150	0.767	18.734	191.800	-0.016
14	Rubber and Plastics	129.03	0.8455	-0.5187	0.3020	0.3179	0.872	12.054	139.700	0.044
15	Footwear and Leather	63.01	0.8283	-0.1055	-0.0483	-0.1752	0.614	11.253	18.682	0.033
16	Lumber	55.96	0.7492	0.0474	0.5692	-0.4011	0.916	13.520	101.200	0.093
17	Furniture	25.94	0.6326	0.0519	-0.1185	0.3963	0.738	14.793	42.805	0.024
18	Stone, Clay and Glass	156.98	0.9830	-0.4226	0.1836	0.1741	0.845	11.600	153.600	-0.068
19	Iron and Steel	2008.91	0.4159	-0.2870	-0.0385	0.1517	0.251	13.917	410.300	0.118
20	Non Ferrous Metals	64.34	0.8905	-0.1137	-0.3995	0.6051	0.779	16.263	148.700	0.159
21	Metal Products	234.26	0.7838	-0.0509	-0.0119	0.1836	0.789	9.948	220.400	0.046
22	Engines and Turbines	18.35	1.1513	-0.7131	0.2795	0.2684	0.921	17.131	28.463	0.077
23	Agricultural Machinery	12.63	0.5031	0.1339	0.7447	-0.3867	0.783	18.259	30.480	0.074
25	Metalworking Machinery	255.32	0.7536	-0.2361	0.2806	-0.4321	0.610	14.335	77.732	-0.112
27	Special Industry Machinery	170.14	0.6595	-0.2518	-0.0714	-0.0511	0.358	12.077	33.787	0.029
28	Miscellaneous Non-Electrical	62.36	0.9987	0.0276	-0.3449	0.3053	0.892	10.230	105.800	-0.063
29	Computers	31.14	1.1259	-0.3959	0.2311	0.0210	0.813	18.220	74.871	-0.000
30	Service Industry Machinery	24.09	1.1716	-0.3376	-0.3563	0.4362	0.781	20.699	38.882	-0.122
31	Communications Machinery	110.46	0.8523	-0.2922	0.3083	0.0764	0.873	15.356	164.500	0.016
32	Heavy Electrical Machinery	46.08	1.0372	-0.2388	0.2170	-0.1166	0.809	12.581	56.621	-0.006
33	Household Appliances	39.71	0.8138	0.0467	-0.1697	0.0909	0.626	17.320	37.866	0.012
34	Electrical Lighting and wiri	30.62	0.8840	-0.3538	0.0841	0.3768	0.804	17.960	66.116	0.031
35	Radio, T.V. Phonographs	15.41	0.8415	-0.4446	0.5961	-0.1369	0.716	27.893	25.852	-0.012
36	Motor Vehicles	240.65	0.6707	-0.0327	-0.0573	0.3698	0.668	19.199	423.400	-0.074
37	Aerospace	167.49	1.0635	-0.3121	0.0003	-0.0505	0.696	15.301	137.300	-0.012
38	Ships and Boats	-3.95	-0.9954	-0.4632	1.6422	2.7750	0.800	61.757	50.536	0.293
39	Other Transportation Equipme	2.27	0.8400	0.4949	-0.1060	-0.1792	0.960	20.305	11.118	0.052
40	Instruments	43.88	0.9960	-0.1978	-0.1480	0.3258	0.926	10.737	56.340	-0.006
41	Miscellaneous Manufacturing	63.48	0.3035	0.0154	0.5879	-0.0282	0.690	11.516	52.714	-0.009
42	Railroads	1487.13	0.8113	-0.0236	-0.1341	-0.1834	0.609	18.787	596.000	0.017
43	Air Transport	613.21	1.1253	-0.2694	-0.3112	0.3123	0.769	26.672	911.000	0.077
44	Trucking and Other Transport	180.73	1.3568	-0.8558	0.6924	-0.1839	0.952	12.717	451.500	-0.015
45	Communications Services	325.92	1.5162	-1.0799	0.8249	-0.2803	0.966	7.532	526.400	0.041
46	Electric Utilities	448.79	0.6873	-0.1447	0.3124	0.1057	0.787	12.459	729.800	-0.002
47	Gas, Water and Sanitation	-127.51	0.8889	0.0592	0.1372	0.0961	0.627	16.607	300.100	-0.013
48	Wholesale and Retail Trade	-437.59	0.4144	-0.0809	0.4061	0.4463	0.912	10.012	1198.800	-0.060
49	Finance and Insurance	142.55	0.7163	0.1270	0.2148	-0.0433	0.918	13.198	325.200	0.003
50	Real Estate	97.74	1.6100	-1.0539	0.4394	0.0574	0.956	22.391	357.800	0.022
51	Hotels and repairs Minus Aut	228.04	1.0578	-0.1745	0.2851	-0.2720	0.910	8.088	216.400	0.025
52	Business Services	147.09	1.3086	-0.9150	0.3108	0.3344	0.905	17.151	395.300	0.089
53	Auto repair	281.54	0.6575	-0.0131	0.3212	-0.0371	0.750	19.389	446.800	-0.000
54	Movies and Amusements	56.21	1.1612	-0.1294	-0.4544	0.4200	0.956	6.279	79.766	0.078
55	Medical and Educational Serv	184.03	0.9871	-0.0329	-0.1197	0.1996	0.948	8.758	412.000	0.020

Table 4.2

The Autoregressive Model. Estimated from 53 to 85.

	Sector Title	INTCP	V[1]	V[2]	V[3]	V[4]	RSQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	2102.52	1.0958	-0.2722	0.1711	-0.2330	0.765	9.103	1049.000	0.015
2	Crude Petroleum, Natural Gas	463.17	1.1576	-0.5308	0.3486	-0.2152	0.738	11.772	417.500	-0.035
3	Mining	463.94	1.2393	-0.6016	0.1318	0.0329	0.713	11.776	342.700	-0.006
4	Construction	768.82	1.3850	-0.7257	0.0807	0.2101	0.908	15.074	1368.700	-0.041
5	Food, Tobacco	178.53	1.1215	-0.4168	0.1207	0.1538	0.959	5.174	190.300	-0.023
6	Textiles	149.43	0.9217	-0.2241	0.2559	-0.1149	0.731	10.693	111.600	-0.104
7	Knitting, Hosiery	20.93	0.9325	-0.2121	0.1083	0.0260	0.739	27.805	41.772	-0.014
8	Apparel and Household Textile	58.68	1.0033	-0.1761	0.5215	-0.4829	0.886	13.222	63.255	-0.061
9	Paper	91.72	1.0532	-0.2028	-0.1310	0.2995	0.885	9.541	271.800	-0.081
10	Printing	-17.09	1.4804	-1.0126	0.5681	0.0445	0.973	5.888	93.556	-0.007
11	Agricultural Fertilizers	67.86	1.0124	-0.2490	-0.0940	0.1395	0.706	38.461	139.500	0.006
12	Other Chemicals	257.10	0.8874	-0.3302	0.2901	0.1206	0.898	8.544	352.700	0.003
13	Petroleum Refining and Fuel	10.48	0.8982	-0.0442	0.1125	0.0738	0.844	19.999	257.900	-0.037
14	Rubber and Plastics	152.79	1.0436	-0.7141	0.4359	0.1299	0.833	12.734	155.800	-0.001
15	Footwear and Leather	29.87	0.9708	-0.2290	0.0571	-0.0594	0.667	12.668	19.120	0.021
16	Lumber	93.89	1.0663	-0.2835	0.2522	-0.1331	0.866	14.287	130.100	0.036
17	Furniture	37.50	0.7596	-0.0353	-0.1391	0.3102	0.728	13.968	43.738	0.021
18	Stone, Clay and Glass	202.57	0.9922	-0.2127	-0.1832	0.2576	0.809	12.244	176.200	-0.069
19	Iron and Steel	1174.32	0.6155	-0.2756	0.0352	0.1565	0.323	13.488	413.100	0.121
20	Non Ferrous Metals	134.05	0.6949	-0.0591	-0.0329	0.2807	0.710	16.199	168.200	-0.005
21	Metal Products	309.86	0.8284	-0.2596	0.1970	0.0808	0.736	10.069	234.400	0.021
22	Engines and Turbines	23.07	0.6702	-0.0338	0.1116	0.2304	0.860	19.629	43.978	-0.012
23	Agricultural Machinery	31.59	0.6688	0.0152	0.2053	-0.0704	0.657	20.780	40.717	0.008
25	Metalworking Machinery	271.49	0.7469	-0.2390	0.2108	-0.3901	0.591	13.922	72.528	-0.075
27	Special Industry Machinery	122.52	0.7330	-0.2138	-0.0872	0.0346	0.399	11.969	32.562	0.040
28	Miscellaneous Non-Electrical	110.01	0.9520	-0.1551	-0.2150	0.3614	0.885	10.359	135.900	-0.051
29	Computers	-8.68	1.2573	-0.3689	0.5422	-0.2757	0.981	16.002	92.025	-0.039
30	Service Industry Machinery	31.00	1.0695	-0.3245	-0.0309	0.1467	0.771	18.680	37.582	-0.022
31	Communications Machinery	-49.02	1.0492	-0.1495	0.2831	-0.0232	0.944	14.171	231.800	0.003
32	Heavy Electrical Machinery	25.39	0.9826	-0.3123	0.4675	-0.1557	0.846	12.399	64.153	-0.023
33	Household Appliances	42.33	0.8154	0.0353	-0.1339	0.0529	0.612	15.466	34.501	0.006
34	Electrical Lighting and wiri	41.06	0.8681	-0.3746	0.3521	0.0899	0.823	15.613	63.986	-0.007
35	Radio, T.V. Phonographs	13.39	0.8152	-0.3441	0.4065	0.0540	0.767	25.038	25.417	-0.009
36	Motor Vehicles	510.42	0.6590	-0.1459	0.1192	0.1544	0.550	23.633	681.100	0.011
37	Aerospace	127.43	1.1327	-0.2623	0.0163	-0.0633	0.777	16.778	149.700	-0.006
38	Ships and Boats	19.76	0.7790	0.1100	-0.0951	0.1115	0.752	51.630	54.664	0.002
39	Other Transportation Equipme	3.94	1.1102	0.0855	-0.2906	0.1236	0.928	22.245	19.364	-0.051
40	Instruments	13.29	1.0967	-0.3950	0.3980	-0.0507	0.904	11.182	85.419	0.005
41	Miscellaneous Manufacturing	84.96	0.5081	-0.0443	0.3724	-0.0608	0.588	11.897	54.636	-0.004
42	Railroads	913.50	1.2006	-0.5338	-0.0907	0.1296	0.710	22.005	797.500	0.003
43	Air Transport	638.58	1.0599	-0.0933	-0.4445	0.3590	0.773	24.330	972.000	0.009
44	Trucking and Other Transport	355.72	1.0180	-0.4082	0.2738	0.0984	0.932	13.331	723.900	-0.028
45	Communications Services	21.00	1.3048	-0.4600	-0.0651	0.2967	0.976	8.088	783.700	-0.068
46	Electric Utilities	-230.62	1.1341	-0.0004	0.3546	-0.3780	0.737	13.055	1133.500	0.059
47	Gas, Water and Sanitation	163.91	1.1300	-0.5033	0.2626	0.0798	0.857	18.447	451.400	0.015
48	Wholesale and Retail Trade	-1005.62	0.9088	-0.2512	0.0764	0.4927	0.950	11.227	2036.200	-0.236
49	Finance and Insurance	-286.27	1.3137	-0.1623	-0.0027	0.0520	0.970	15.127	478.700	-0.008
50	Real Estate	237.26	1.1184	-0.3628	-0.1430	0.4347	0.958	20.148	608.600	-0.093
51	Hotels and repairs Minus Aut	178.61	1.2076	-0.3137	-0.0357	0.0949	0.901	8.071	245.900	-0.022
52	Business Services	-22.80	1.2098	-0.5731	0.1948	0.3347	0.967	14.896	528.800	0.019
53	Auto repair	73.21	0.9427	-0.1968	0.2649	0.0729	0.850	19.189	608.300	-0.014
54	Movies and Amusements	60.67	1.3029	-0.4695	-0.4226	0.5925	0.957	6.350	97.432	-0.085
55	Medical and Educational Serv	173.90	1.1698	-0.3260	-0.1116	0.3145	0.959	9.668	616.800	-0.023

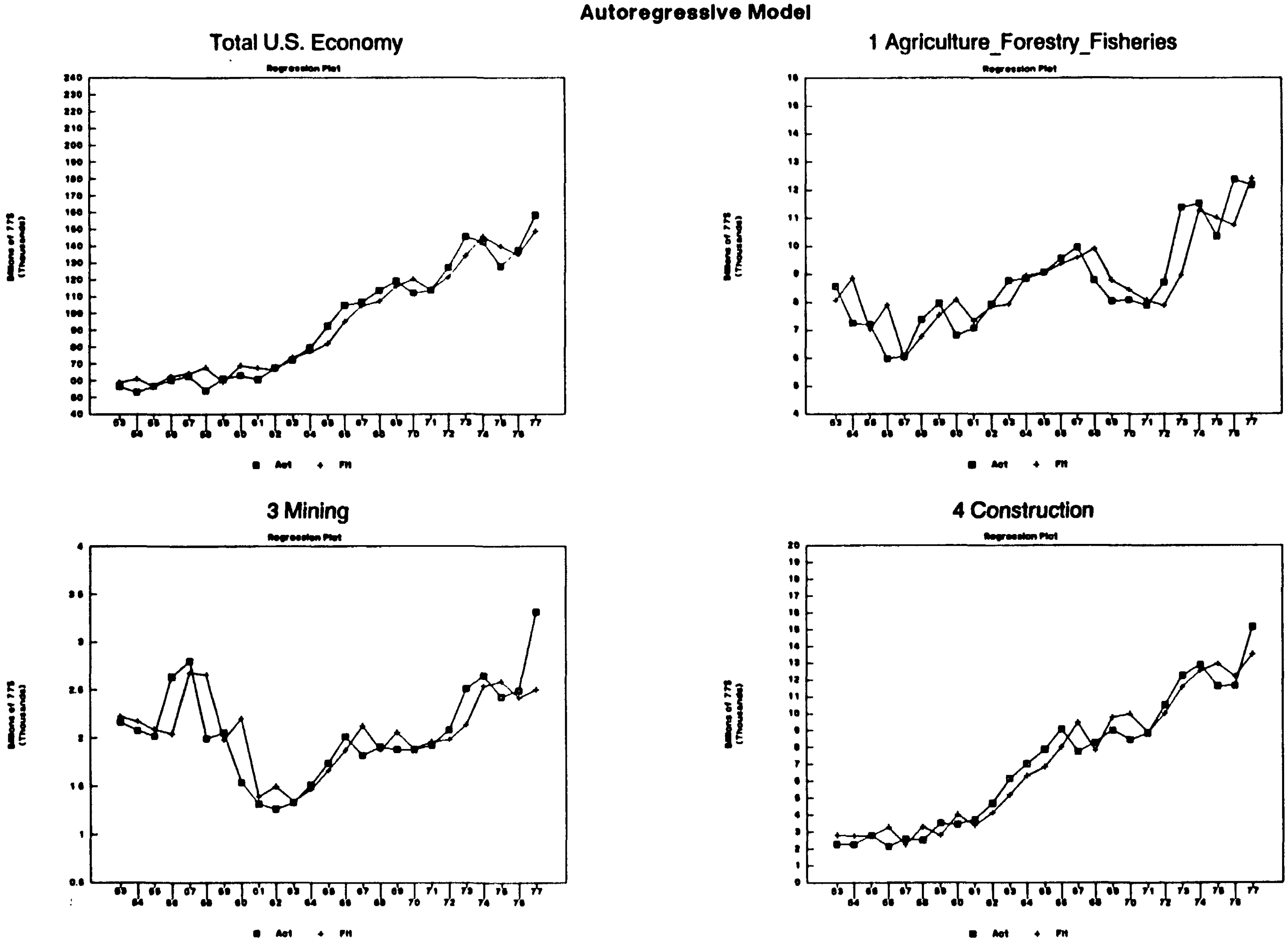


Figure 4.1.a - 1953 to 1977 Estimation

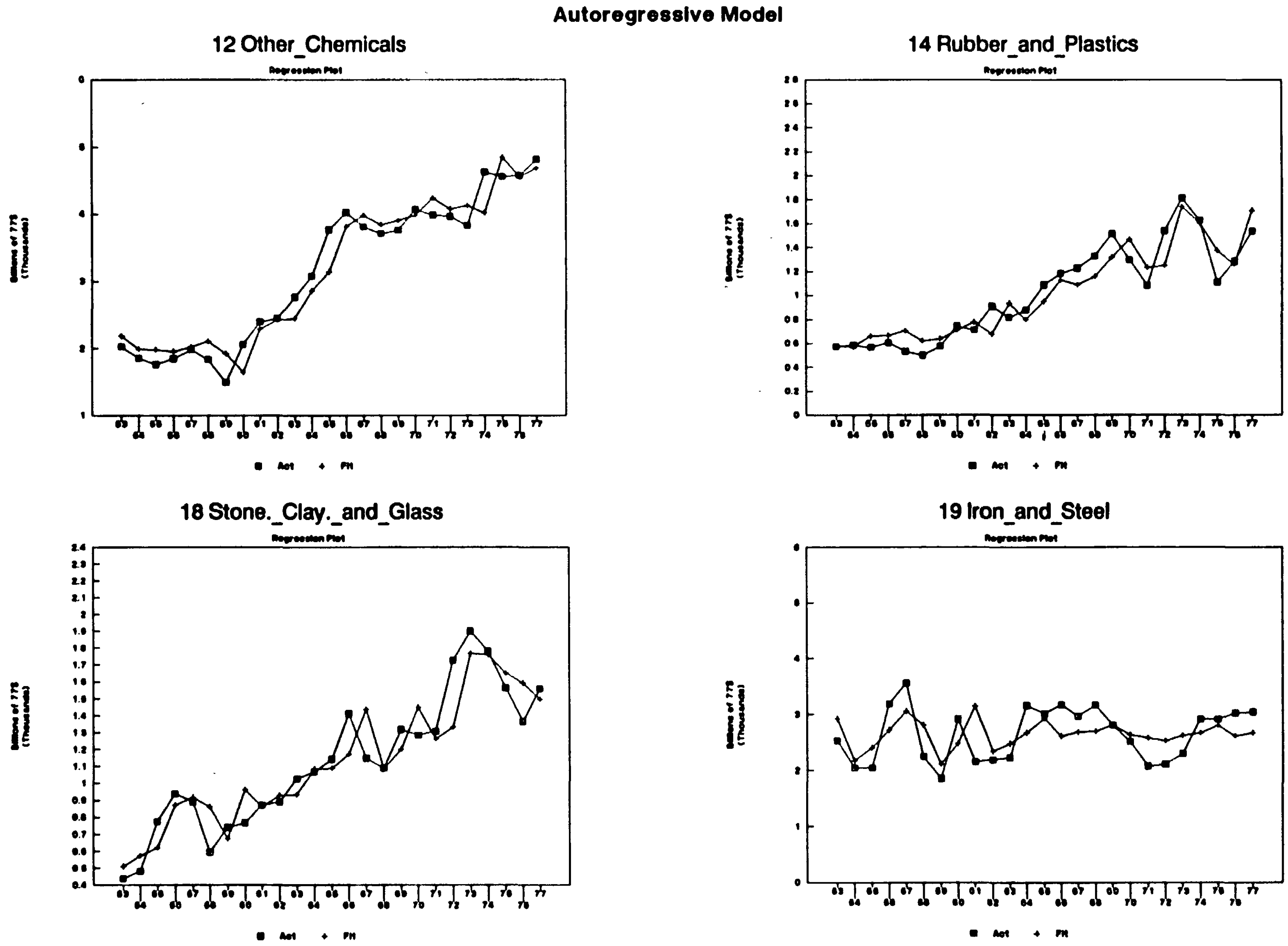
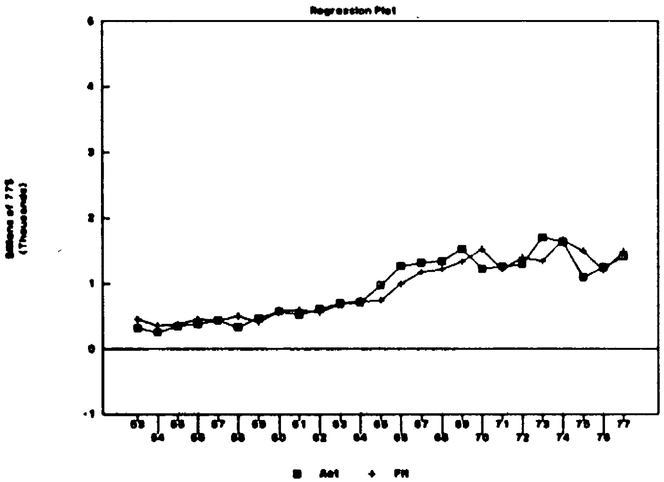


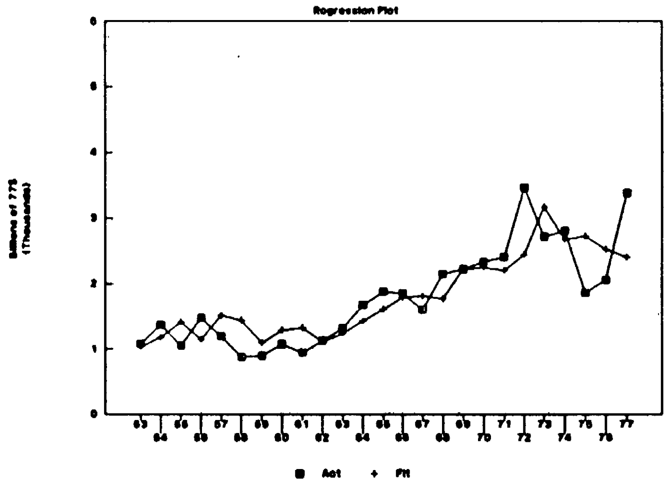
Figure 4.1.b - 1953 to 1977 Estimation

Autoregressive Model

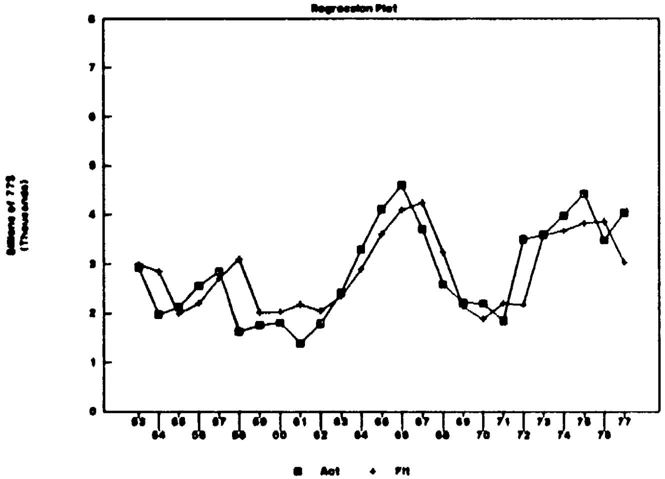
31 Communications_Machinery



36 Motor_Vehicles



42 Railroads



43 Air_Transport

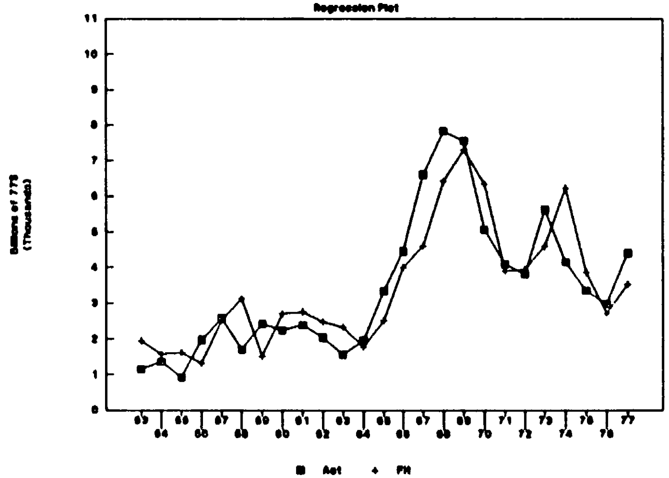


Figure 4.1.c - 1953 to 1977 Estimation

Autoregressive Model

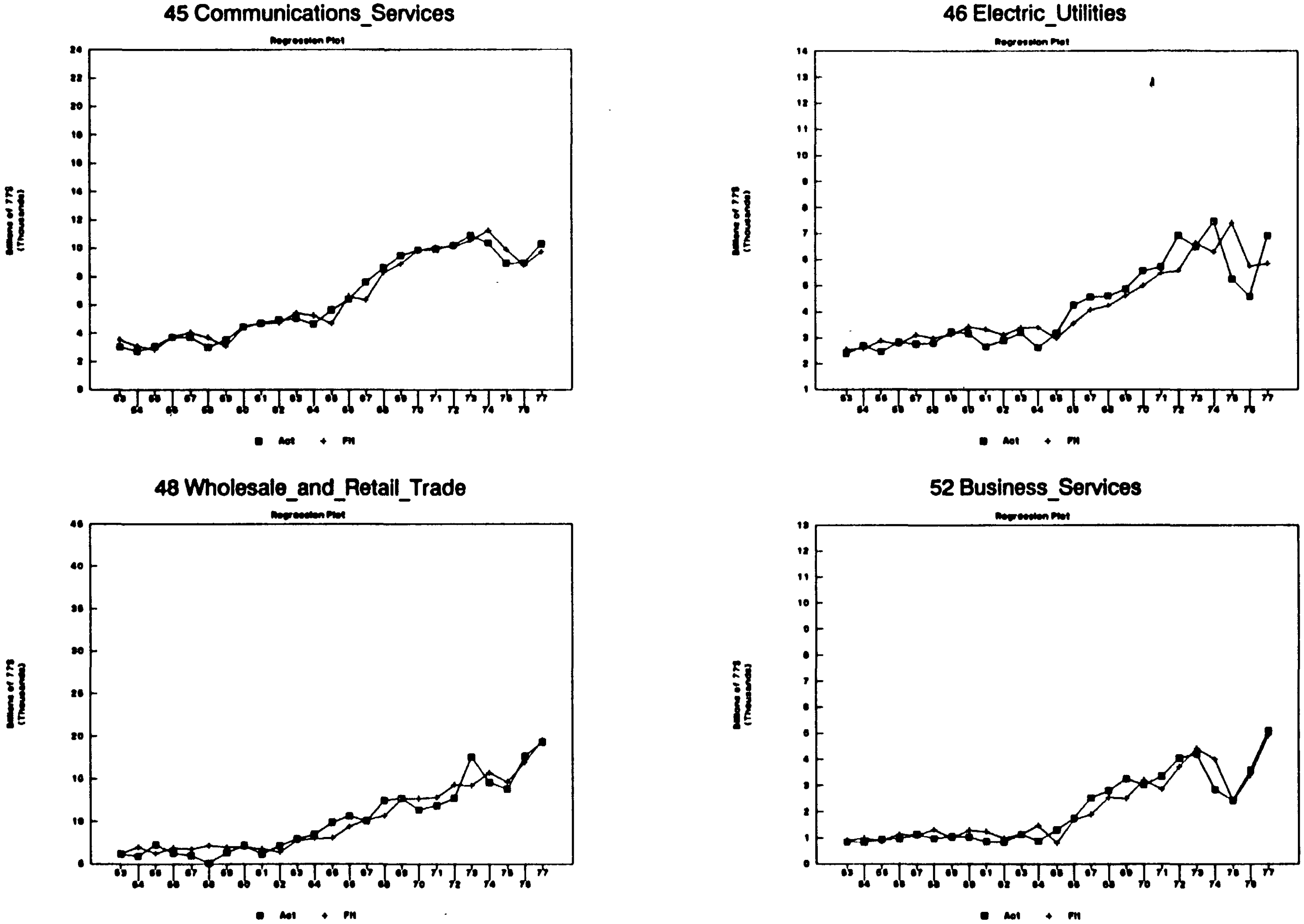


Figure 4.1.d - 1953 to 1977 Estimation

Autoregressive Model

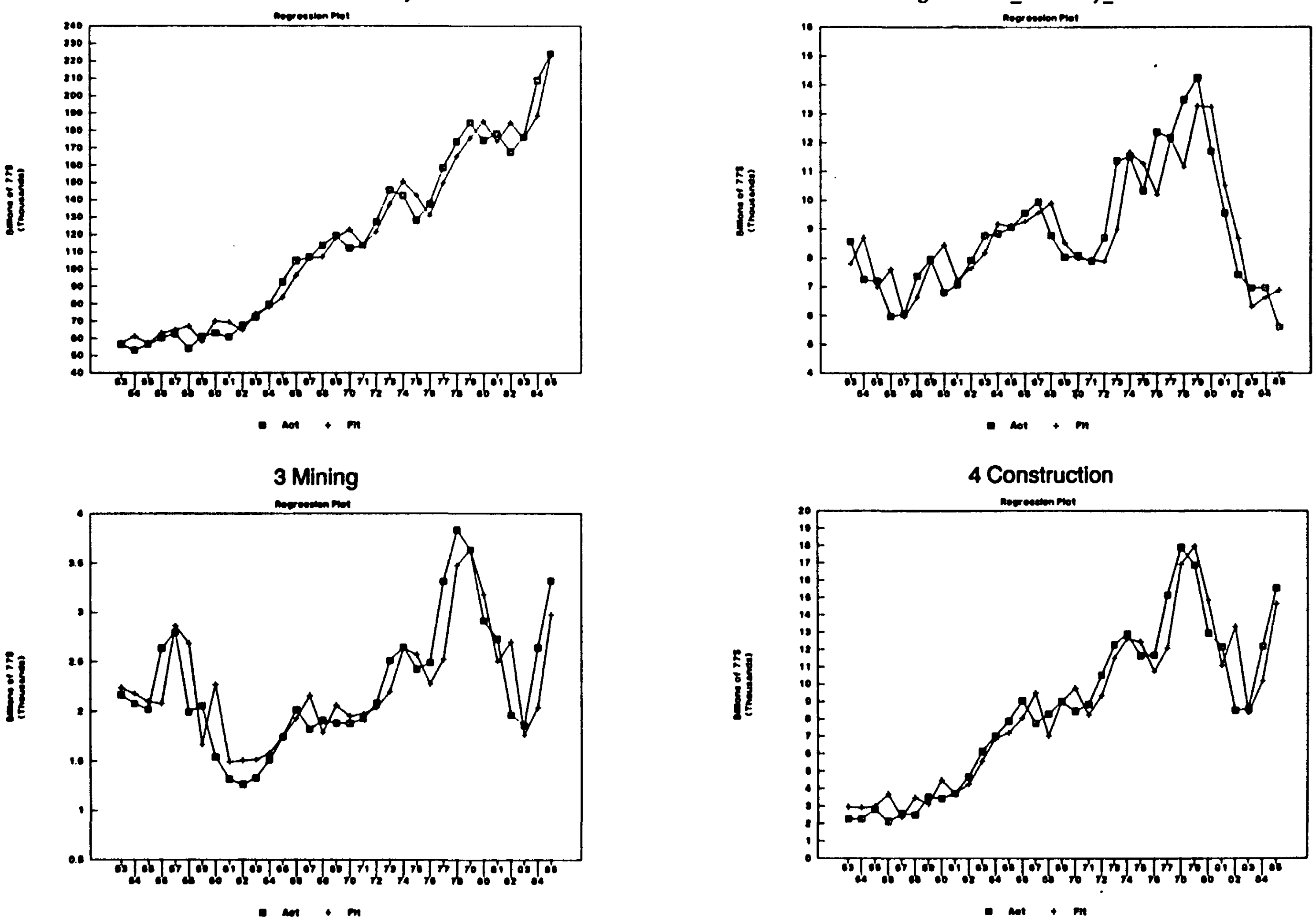


Figure 4.2.a - 1953 to 1985 Estimation

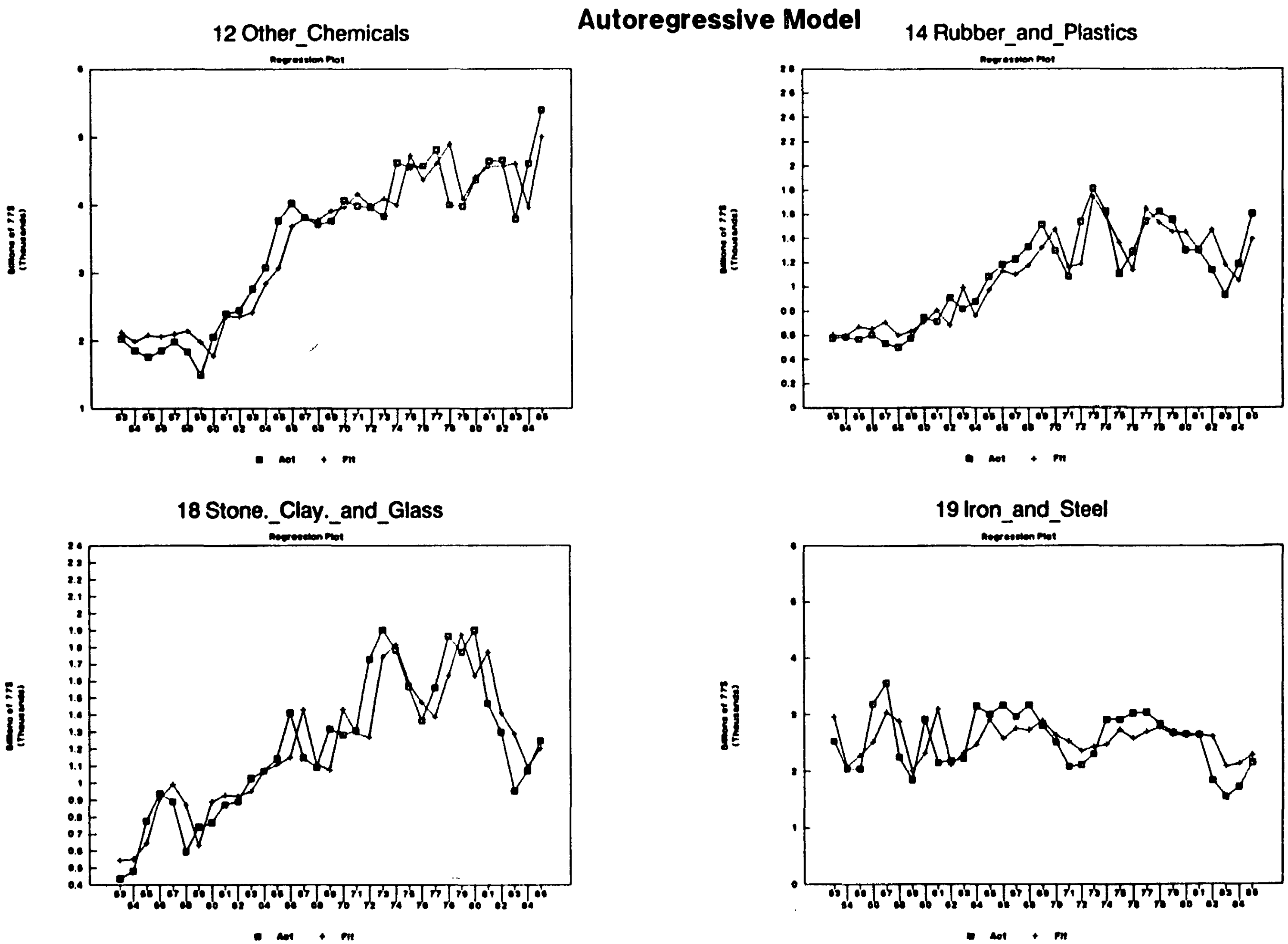


Figure 4.2.b - 1953 to 1985 Estimation

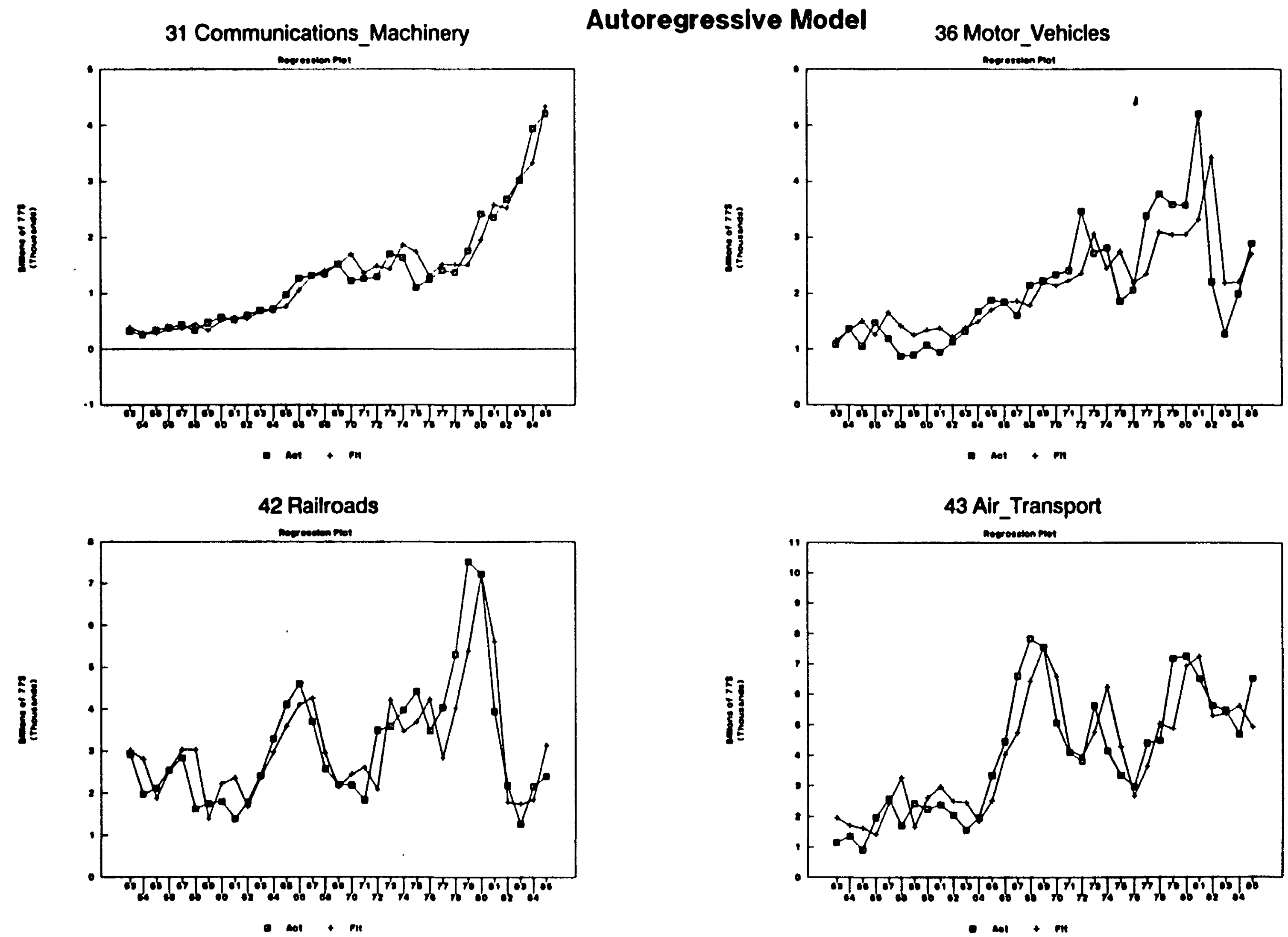


Figure 4.2.c - 1953 to 1985 Estimation

Autoregressive Model

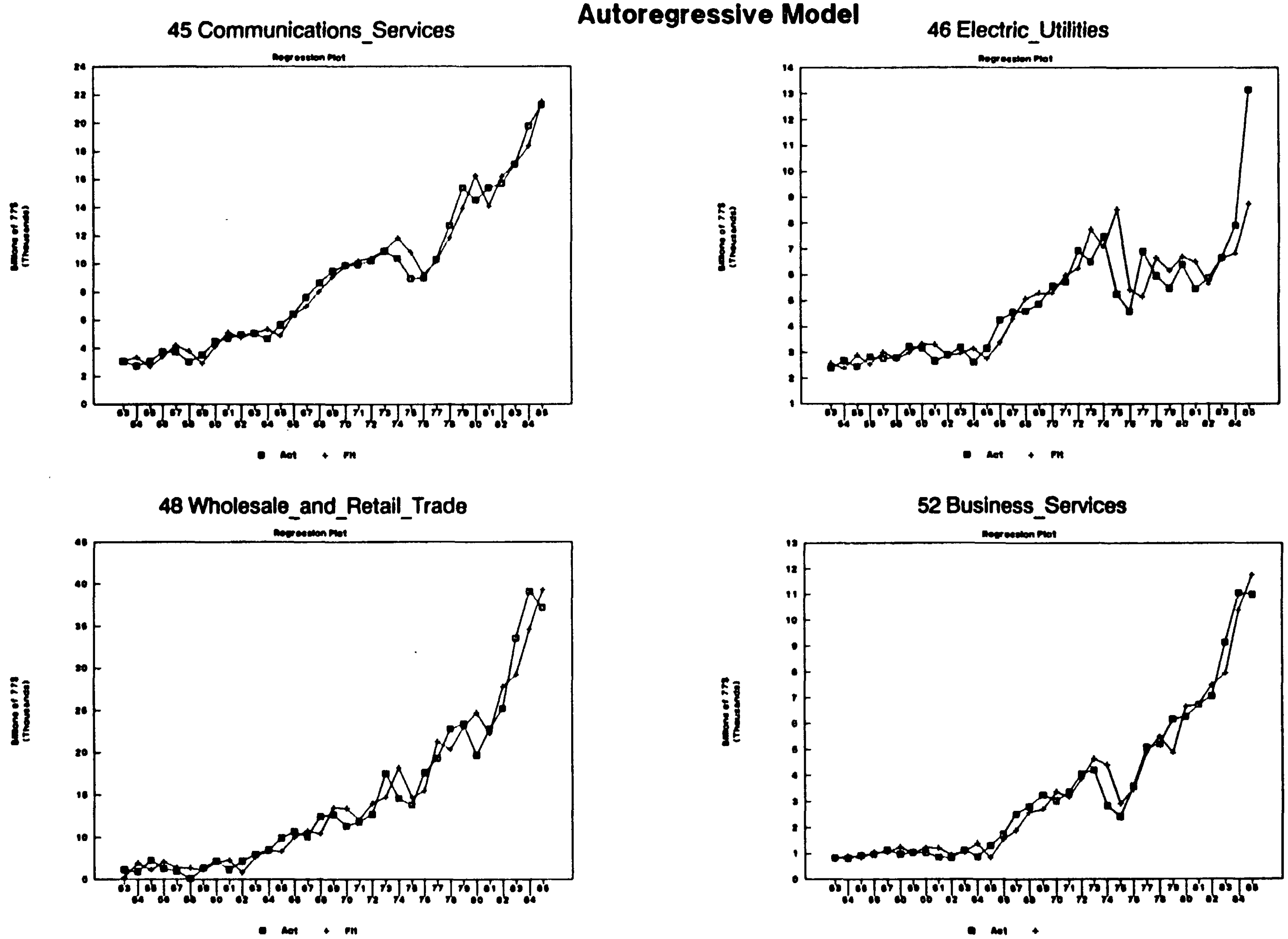


Figure 4.2.d - 1953 to 1985 Estimation

but both catch turning points only with a lag. In general, although the autoregressive model fits the data fairly well, it will encounter stiff competition from the accelerator and Cobb-Douglas based models, as will be seen in the following sections.

2. The Accelerator Model

This model expresses gross investment as a function of a four-year distributed lag on past changes in output, a "wear" variable representing replacement investment, and a constant term. The equation from Chapter III is reproduced below:

$$(2.1) \qquad I_t = a_0 + \sum_{i=0}^{3} b_i \, \Delta Q_{t-i} + cW_t$$

where W is the value for "wear". Upon first estimating this equation, the lag weights on ΔQ were found to jump around wildly, and to be quite different in the two estimation periods. Therefore a softly constrained second order Almon lag was imposed on the b_i's and the equation was re-estimated. Tables 4.3 and 4.4 show the estimated parameters and regression statistics for both the 1953 to 1977 regressions and the 1953 to 1985 regressions. The estimated parameters are the intercept (*INTCP*), four lagged values of the change in industry output (*DIF* to *DIF[3]*), and the wear, or replacement variable (*FB2*).

It is quickly apparent from examining these tables that the lag weights still have a tendency to jump around, and many are negative, which does not make economic sense. The R^2s are still quite high, although of course lower than those in the unconstrained estimation. Only 10 of the 53 equations have R^2s less than .6 in the 53-77 estimation, and 14 in the 53-85 estimation. However, the results for the two estimation periods are quite different, whether one considers the intercept, the replacement term coefficient, or the distributed lag weights on changes in output. It is also notable that the ability of this model to fit the data is quite sensitive to the addition of the extra data points. This suggests that this model is not picking up the underlying structural relationship between investment and output, or that the relationship has changed between the two periods. This tends to throw doubt upon the forecasting ability of the model. The negative coefficients on changes in output in some of the industries also could lead to perverse behavior in a simulation. In many cases these negative coefficients are swamped by a large intercept or a strong replacement term coefficient, so that forecasted investment can be expected to keep rising in the forecast, but to respond perversely to changes in output. The final notable feature of the estimation results is the value of the coefficient on the replacement variable. I suggested in the previous chapter that for this term to actually represent replacement, the value of the coefficient should be close to unity. However, it is obvious from both parts of Table 4.1 that the value of this variable lies between .1 and .3 for most industries. This suggests that either there is high multicollinearity between changes in output and the replacement variable, or that changes in current output actually stimulate replacement investment, so that the output terms are capturing part of the replacement investment in the equation.

Plots for the total economy and for the same 15 sectors in the previous section are displayed in Figure 4.3.a to 4.4.d, again with the results in figures 4.3 containing results for the 53 to 77 estimations, and figures 4.4 containing the results for the 53 to 85 estimations. These graphs tell a story similar to that of the regression results. Although the sum of the results for the total economy fits very well, certain individual sectors fit demonstrably more poorly than in the autoregressive model. The accelerator model fails to track the large dips in investment in both Agriculture, Forestry, and Fisheries(1) and Mining(3), and the model fails to track most of the variation in the Iron and Steel(19) sector. For the most part, however, the fits appear close and the model is good at capturing the turning points.

Other versions of this basic equation were tried, and will be briefly discussed. An equation without an intercept was also estimated, as an attempt to get more sensible output coefficients: The fits were significantly poorer, and there was little improvement in the pattern of the lag weights. Another version was estimated using a time trend instead of a replacement investment term, but this led to even less sensible lagged output coefficients. In yet another version the lag weights were rather strongly constrained to be positive, but this led to a drastic reduction in R^2.

Table 4.3

The Accelerator Model. Estimated 53 to 77.

	Sector Title	INTCP	DIF	DIF[1]	DIF[2]	DIF[3]	FB2	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	-1733.26	-0.0240	-0.0625	-0.0510	-0.0288	0.1808	0.642	10.6320	1038.700	0.578
2	Crude Petroleum, Natural Gas	1521.83	0.0732	-0.0150	-0.0325	-0.0378	0.0176	0.327	8.7430	181.500	0.040
3	Mining	1918.55	-0.0374	0.0422	0.0092	-0.0018	0.0118	0.030	20.5050	478.200	0.652
4	Construction	-1667.58	0.1163	0.1874	0.1381	0.0961	0.3252	0.969	10.3170	672.900	0.638
5	Food, Tobacco	-137.29	0.0032	-0.0141	-0.0084	0.0011	0.2323	0.974	4.8970	142.700	0.716
6	Textiles	-392.11	0.0317	0.0693	0.0934	0.0592	0.2073	0.790	9.2690	111.200	0.092
7	Knitting, Hosiery	-82.03	0.0902	0.0529	0.0502	0.0445	0.2626	0.919	21.3460	24.409	-0.455
8	Apparel and Household Textile	-224.94	0.0555	0.0567	0.0536	0.0762	0.2435	0.782	15.7650	97.404	0.417
9	Paper	243.74	0.0136	0.0411	0.0282	0.0635	0.1654	0.851	10.4980	219.500	0.510
10	Printing	-112.50	0.0519	0.0371	0.0400	0.0407	0.2196	0.953	7.4250	82.066	0.558
11	Agricultural Fertilizers	-115.51	0.0045	0.0775	0.0889	0.1959	0.3800	0.848	46.7040	106.500	0.721
12	Other Chemicals	246.67	0.0236	0.0422	0.0377	0.0604	0.1697	0.900	9.9650	338.900	0.647
13	Petroleum Refining and Fuel	-27.53	0.0440	0.0109	0.0200	0.0384	0.1461	0.260	39.6220	341.800	0.728
14	Rubber and Plastics	98.33	0.0599	0.0574	0.0460	0.0334	0.1582	0.939	7.9850	96.238	0.292
15	Footwear and Leather	41.46	0.0161	0.0380	0.0381	0.0585	0.0975	0.448	14.4470	22.332	0.479
16	Lumber	-87.71	0.0174	0.0230	0.0435	0.0234	0.2629	0.947	11.5580	80.224	0.029
17	Furniture	-98.43	0.0238	0.0337	0.0251	0.0156	0.2587	0.872	10.3920	29.907	0.238
18	Stone, Clay and Glass	47.45	0.0630	0.0766	0.0672	0.0199	0.2065	0.936	8.4450	98.970	0.225
19	Iron and Steel	2315.76	0.0075	0.0220	0.0066	-0.0007	0.0218	0.159	14.6140	434.700	0.403
20	Non Ferrous Metals	-10.47	-0.0043	0.0175	0.0244	0.0412	0.2140	0.774	16.1410	150.300	0.372
21	Metal Products	-60.61	0.0240	0.0357	0.0259	0.0212	0.1846	0.909	7.3080	144.900	0.242
22	Engines and Turbines	-0.17	0.0446	0.0469	0.0503	0.0074	0.2386	0.932	24.3360	26.460	0.486
23	Agricultural Machinery	-19.78	0.0011	0.0161	0.0127	0.0168	0.2472	0.839	15.8410	26.279	0.081
25	Metalworking Machinery	552.14	0.0107	0.0383	0.0054	0.0285	-0.0636	0.388	21.8360	97.315	0.533
27	Special Industry Machinery	303.21	0.0051	0.0139	0.0091	-0.0118	-0.0391	0.217	13.9410	37.307	0.656
28	Miscellaneous Non-Electrical	59.96	0.0181	0.0352	0.0146	0.0295	0.1935	0.956	7.3720	67.882	0.250
29	Computers	70.67	0.0229	0.0534	0.0155	0.0757	0.1606	0.765	27.5790	83.968	0.685
30	Service Industry Machinery	-95.50	0.0332	0.0470	0.0413	0.0387	0.2778	0.786	20.8510	38.472	0.622
31	Communications Machinery	1.04	0.0487	0.0606	0.0507	0.0314	0.2069	0.861	18.4010	171.700	0.542
32	Heavy Electrical Machinery	7.03	0.0264	0.0465	0.0187	0.0482	0.1777	0.774	14.2850	61.532	0.636
33	Household Appliances	2.68	0.0530	0.0464	0.0501	0.0487	0.1172	0.470	24.5120	45.067	0.609
34	Electrical Lighting and wiri	-78.42	0.0414	0.0678	0.0592	0.0463	0.2519	0.897	14.6290	47.870	0.561
35	Radio, T.V. Phonographs	-6.52	0.0248	0.0654	0.0384	0.0291	0.2055	0.818	24.1960	20.691	0.301
36	Motor Vehicles	121.34	0.0127	0.0286	0.0102	0.0057	0.1959	0.801	16.1040	327.800	0.490
37	Aerospace	114.37	0.0221	0.0154	0.0078	0.0220	0.1570	0.307	33.1780	207.400	0.780
38	Ships and Boats	-24.11	0.0318	0.0323	-0.0057	0.0560	0.4960	0.837	68.1490	45.698	0.024
39	Other Transportation Equipme	-18.91	0.0071	0.0048	0.0020	0.0026	0.4606	0.897	43.5480	17.798	0.783
40	Instruments	61.82	0.0446	0.0444	0.0506	0.0094	0.1730	0.910	11.0330	62.210	0.646
41	Miscellaneous Manufacturing	72.32	0.0264	-0.0008	0.0113	-0.0105	0.1667	0.770	11.9700	45.474	0.368
42	Railroads	-1915.93	0.2248	0.3774	0.2803	0.3217	0.1666	0.585	21.0940	613.900	0.415
43	Air Transport	561.23	0.9674	1.0131	0.8018	0.1846	0.0260	0.914	20.3110	555.500	0.318
44	Trucking and Other Transport	-1187.34	0.2421	0.1894	0.2955	0.0532	0.3119	0.963	13.2050	398.600	0.455
45	Communications Services	920.03	-0.5889	0.0179	-0.0190	0.0005	0.2611	0.855	12.9520	1085.100	0.722
46	Electric Utilities	-136.10	-0.0083	0.5545	0.2376	0.2561	0.1200	0.901	10.6740	496.000	0.232
47	Gas, Water and Sanitation	1537.85	-0.1024	-0.0537	-0.0645	-0.0744	0.0494	0.752	15.8890	244.800	0.201
48	Wholesale and Retail Trade	-2239.31	0.0770	0.0767	0.0018	0.0206	0.3298	0.966	6.2750	740.500	0.134
49	Finance and Insurance	-695.89	0.1285	0.0424	0.1077	0.0206	0.2972	0.941	10.6690	275.700	0.194
50	Real Estate	-858.12	0.0064	0.0763	0.0838	0.0056	0.4039	0.858	38.0970	642.200	0.819
51	Hotels and repairs Minus Aut	509.72	-0.0719	0.0820	0.0513	0.0981	0.1923	0.769	11.1880	347.400	0.662
52	Business Services	-249.45	0.1016	0.0519	-0.0302	0.0726	0.2493	0.852	26.2110	493.900	0.693
53	Auto repair	322.34	0.1094	0.1385	0.0708	0.0446	0.2350	0.798	20.2870	401.500	0.535
54	Movies and Amusements	0.41	-0.0137	0.0013	-0.0728	-0.0546	0.2745	0.910	8.6360	113.600	0.643
55	Medical and Educational Serv	516.43	0.1003	0.1456	0.0132	0.0229	0.1671	0.940	10.3110	441.700	0.616

Table 4.4

The Accelerator Model. Estimated 53 to 85.

	Sector Title	INTCP	DIF	DIF[1]	DIF[2]	DIF[3]	FB2	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	4083.33	0.0833	0.0999	0.1527	0.0846	0.0606	0.286	18.1610	1830.600	0.706
2	Crude Petroleum, Natural Gas	868.32	0.0159	-0.0192	0.0220	-0.0327	0.1251	0.288	23.3200	687.800	0.716
3	Mining	472.58	0.0708	0.0938	0.0563	0.0161	0.1380	0.243	22.7480	556.400	0.816
4	Construction	-1382.58	0.2019	0.2688	0.2436	0.2053	0.2563	0.881	16.8800	1558.900	0.757
5	Food, Tobacco	606.00	0.0150	-0.0052	-0.0111	0.0023	0.1539	0.853	12.4530	357.800	0.879
6	Textiles	336.31	0.0217	0.0297	0.0087	-0.0042	0.0840	0.346	17.7880	173.800	0.855
7	Knitting, Hosiery	-59.38	0.0795	0.0579	0.0473	0.0573	0.2099	0.846	23.2990	32.062	0.004
8	Apparel and Household Textile	93.91	0.0423	0.0301	0.0239	0.0415	0.0940	0.243	34.9320	163.100	0.751
9	Paper	278.03	-0.0046	0.0471	0.0450	0.0344	0.1653	0.895	9.8030	260.000	0.361
10	Printing	26.23	0.0312	0.0342	0.0105	0.0290	0.1990	0.956	8.9120	119.800	0.448
11	Agricultural Fertilizers	-40.97	0.0105	0.1576	0.1047	0.2465	0.1873	0.613	44.1080	160.000	0.570
12	Other Chemicals	816.70	0.0134	0.0291	0.0197	0.0336	0.1378	0.825	12.1970	462.400	0.578
13	Petroleum Refining and Fuel	-444.13	0.0116	-0.0172	-0.0171	0.0231	0.3281	0.740	35.1410	332.300	0.919
14	Rubber and Plastics	452.69	0.0242	0.0399	0.0186	0.0190	0.0909	0.623	18.8040	234.500	0.762
15	Footwear and Leather	77.26	0.0308	0.0371	0.0328	0.0383	0.0495	0.402	19.4360	25.600	0.643
16	Lumber	139.18	0.0474	0.0474	0.0680	0.0669	0.1451	0.736	19.9450	182.300	0.586
17	Furniture	33.49	0.0181	0.0292	0.0150	0.0081	0.1464	0.714	15.9230	44.841	0.652
18	Stone, Clay and Glass	188.96	0.0474	0.0853	0.0595	0.0748	0.1606	0.787	14.3310	186.300	0.412
19	Iron and Steel	2540.48	0.0160	0.0311	0.0205	0.0102	0.0047	0.290	14.3940	423.100	0.441
20	Non Ferrous Metals	182.69	0.0099	0.0183	0.0261	0.0338	0.1530	0.692	16.4770	173.500	0.541
21	Metal Products	437.61	0.0195	0.0336	0.0213	0.0298	0.1219	0.674	11.6220	260.800	0.506
22	Engines and Turbines	18.57	0.0137	0.0289	0.0141	0.0220	0.2328	0.850	22.2060	45.554	0.557
23	Agricultural Machinery	7.14	0.0054	0.0168	0.0275	0.0289	0.1911	0.815	16.3290	29.939	0.176
25	Metalworking Machinery	516.18	0.0102	0.0325	0.0064	0.0284	-0.0458	0.405	18.7800	87.514	0.520
27	Special Industry Machinery	353.50	0.0090	0.0168	0.0138	-0.0038	-0.0732	0.261	14.1100	36.090	0.674
28	Miscellaneous Non-Electrical	74.91	0.0093	0.0362	0.0089	0.0325	0.1916	0.966	6.5360	73.358	0.123
29	Computers	-29.19	0.0204	0.0804	0.0089	0.0606	0.2711	0.968	22.8470	120.200	0.616
30	Service Industry Machinery	17.57	0.0165	0.0251	0.0175	0.0244	0.1530	0.568	24.4050	51.630	0.646
31	Communications Machinery	-28.82	0.0201	0.0725	-0.0301	0.0649	0.2296	0.902	18.2830	307.500	0.666
32	Heavy Electrical Machinery	21.45	0.0074	0.0325	-0.0067	0.0316	0.1859	0.787	15.3500	75.494	0.672
33	Household Appliances	81.08	0.0244	0.0276	0.0148	0.0216	0.0668	0.208	27.7270	49.292	0.714
34	Electrical Lighting and wiri	54.46	0.0203	0.0420	0.0204	0.0286	0.1659	0.778	18.4010	71.705	0.660
35	Radio, T.V. Phonographs	16.46	0.0169	0.0399	0.0119	0.0252	0.1472	0.785	30.4140	24.435	0.606
36	Motor Vehicles	515.64	-0.0065	0.0024	0.0074	0.0192	0.1559	0.523	25.7390	701.500	0.327
37	Aerospace	-8.61	0.0226	0.0199	0.0116	0.0273	0.2054	0.543	33.2810	214.100	0.735
38	Ships and Boats	-21.41	0.0753	0.0661	0.0121	0.0885	0.2531	0.726	81.2580	57.453	0.525
39	Other Transportation Equipme	3.52	0.0172	0.0118	0.0082	0.0123	0.2848	0.866	53.3690	26.432	0.786
40	Instruments	78.58	0.0004	0.0231	-0.0271	0.0224	0.2065	0.846	14.6100	108.200	0.661
41	Miscellaneous Manufacturing	134.16	0.0382	0.0163	0.0073	0.0173	0.1042	0.515	14.0870	59.258	0.424
42	Railroads	-524.13	0.5342	0.5538	0.5905	0.4038	0.1136	0.602	27.4920	933.600	0.597
43	Air Transport	1064.81	0.4310	0.6452	0.3048	0.7429	0.0424	0.782	23.4330	951.900	0.326
44	Trucking and Other Transport	-557.95	0.2409	0.1304	0.1565	0.1945	0.2528	0.944	14.2780	658.000	0.274
45	Communications Services	417.06	-0.0551	0.0563	-0.1133	-0.1208	0.2538	0.951	9.8260	1127.900	0.690
46	Electric Utilities	-31.35	0.1689	0.3802	0.3161	-0.4597	0.1746	0.827	14.5110	920.300	0.260
47	Gas, Water and Sanitation	435.89	-0.1138	-0.0146	0.0959	-0.1354	0.1986	0.677	29.2520	678.400	0.593
48	Wholesale and Retail Trade	-2928.00	0.1025	0.0228	-0.0272	-0.0419	0.3930	0.980	7.4170	1280.300	0.286
49	Finance and Insurance	-540.44	0.0568	-0.0742	-0.0278	-0.0275	0.4366	0.950	15.8440	620.700	0.526
50	Real Estate	-359.80	0.0295	0.0540	0.0305	0.0685	0.3101	0.922	34.5960	831.600	0.662
51	Hotels and repairs Minus Aut	600.65	0.0558	0.0818	0.0554	-0.0124	0.1696	0.754	12.9850	387.000	0.798
52	Business Services	-353.20	0.0823	0.0238	-0.0388	0.0215	0.3393	0.966	21.7760	535.900	0.752
53	Auto repair	55.46	0.1483	0.1005	0.0164	-0.0226	0.3191	0.898	18.0420	501.800	0.499
54	Movies and Amusements	170.89	-0.0007	-0.0194	-0.0450	-0.0233	0.2195	0.882	11.0200	162.200	0.673
55	Medical and Educational Serv	196.01	0.0830	0.1176	-0.0748	-0.0274	0.2439	0.933	11.3170	791.000	0.727

Accelerator Model

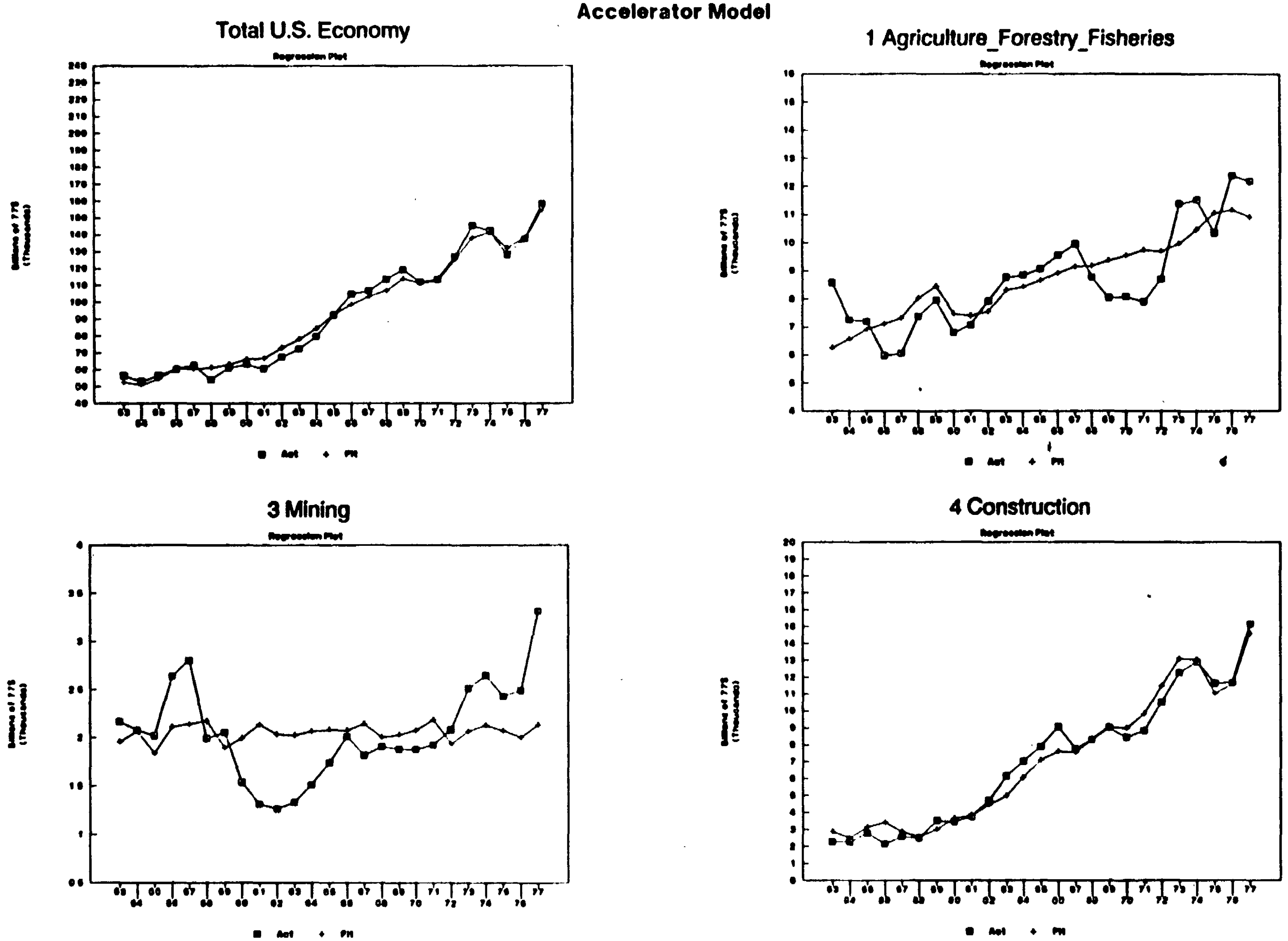


Figure 4.3.a - 1953 to 1977 Estimation

Accelerator Model

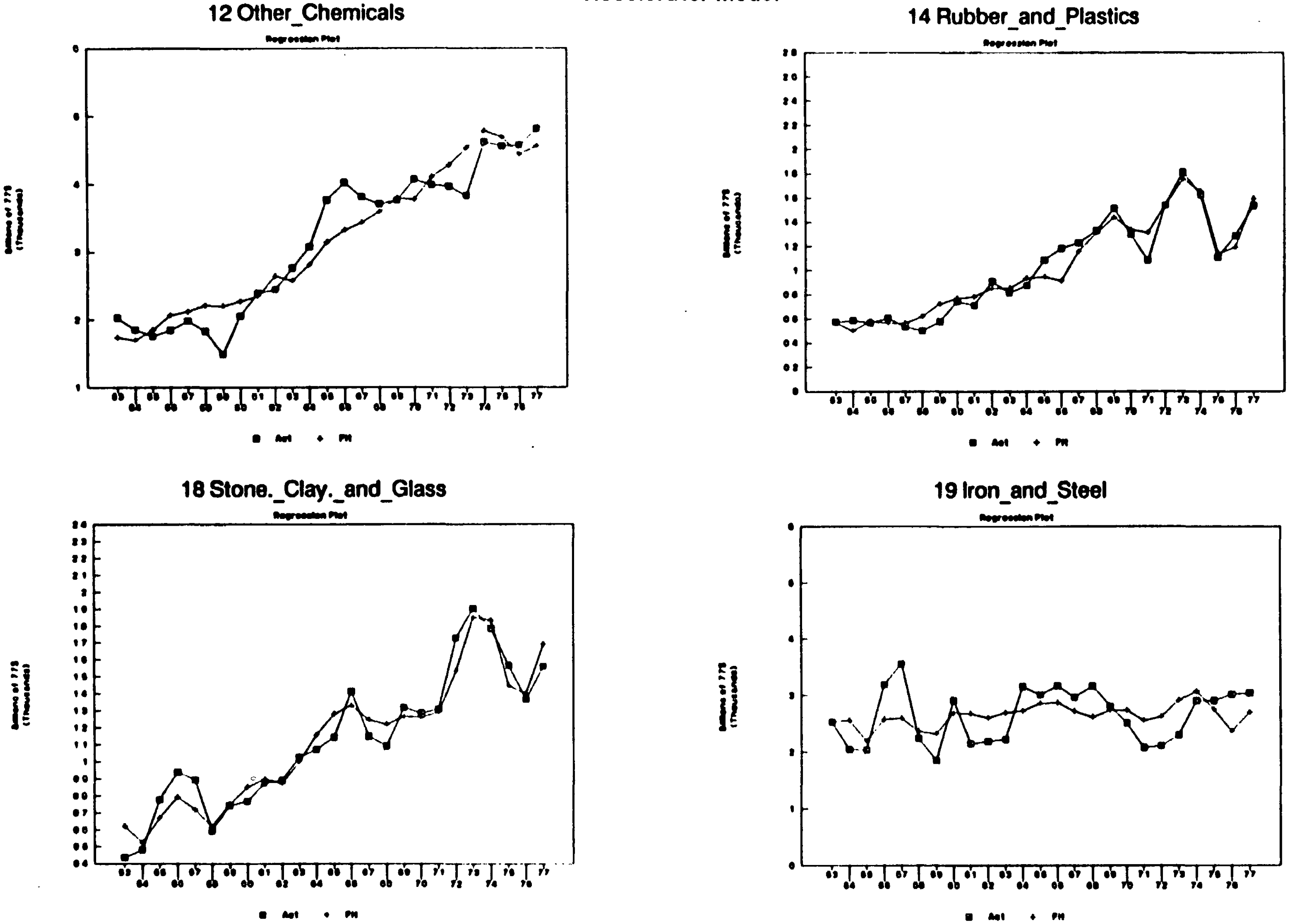


Figure 4.3.b - 1953 to 1977 Estimation

Accelerator Model

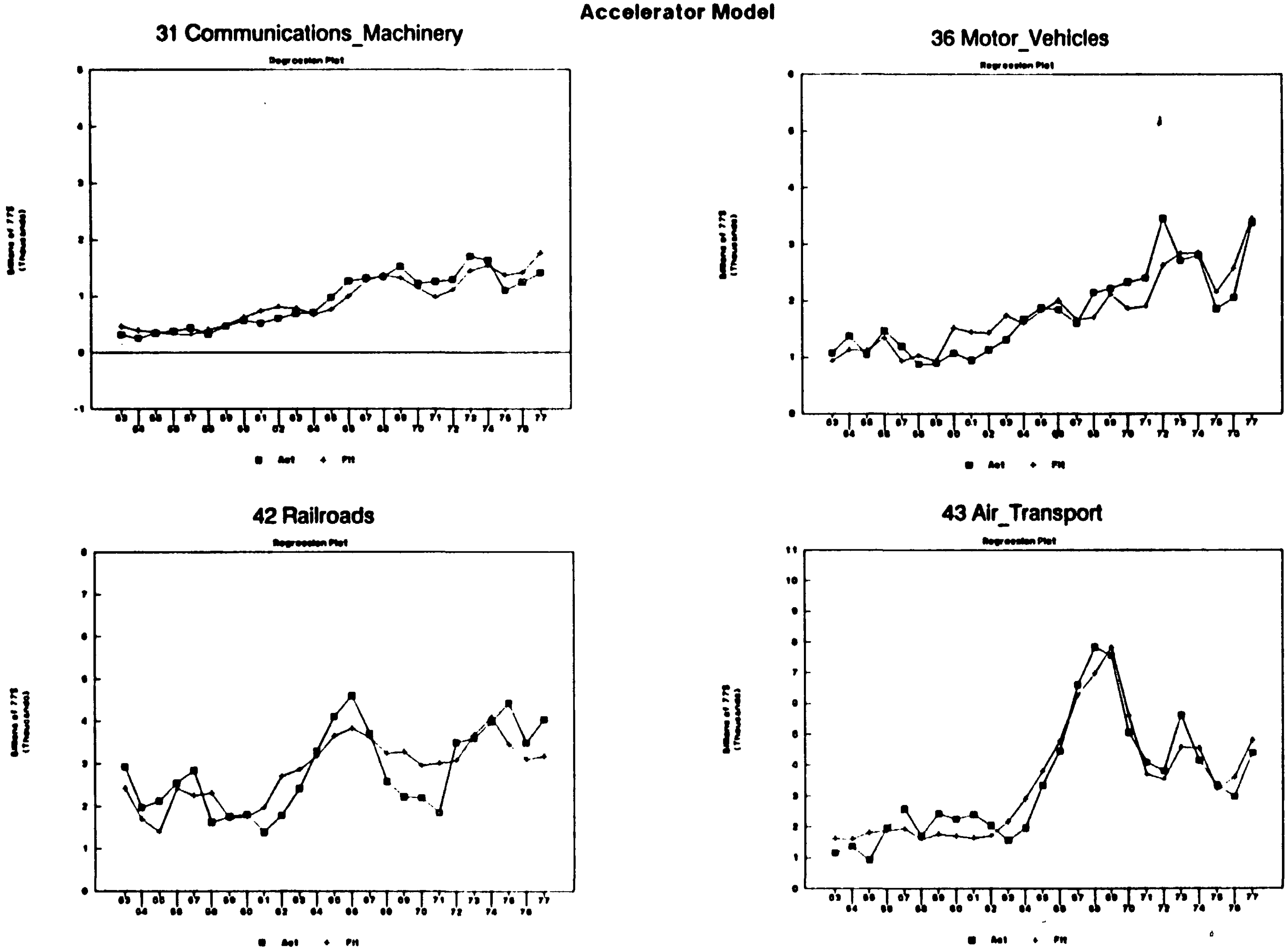


Figure 4.3.c - 1953 to 1977 Estimation

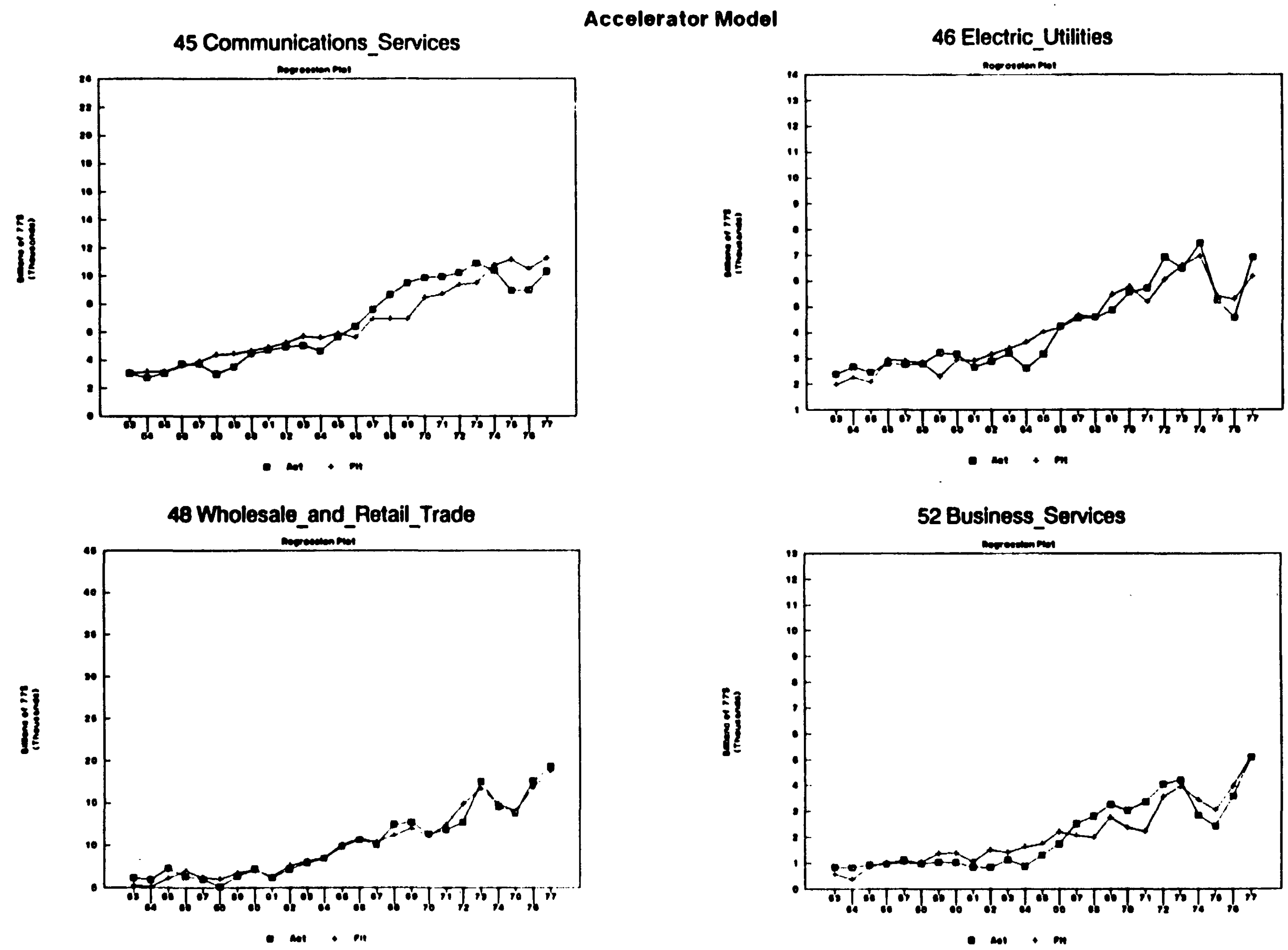


Figure 4.3.d - 1953 to 1977 Estimation

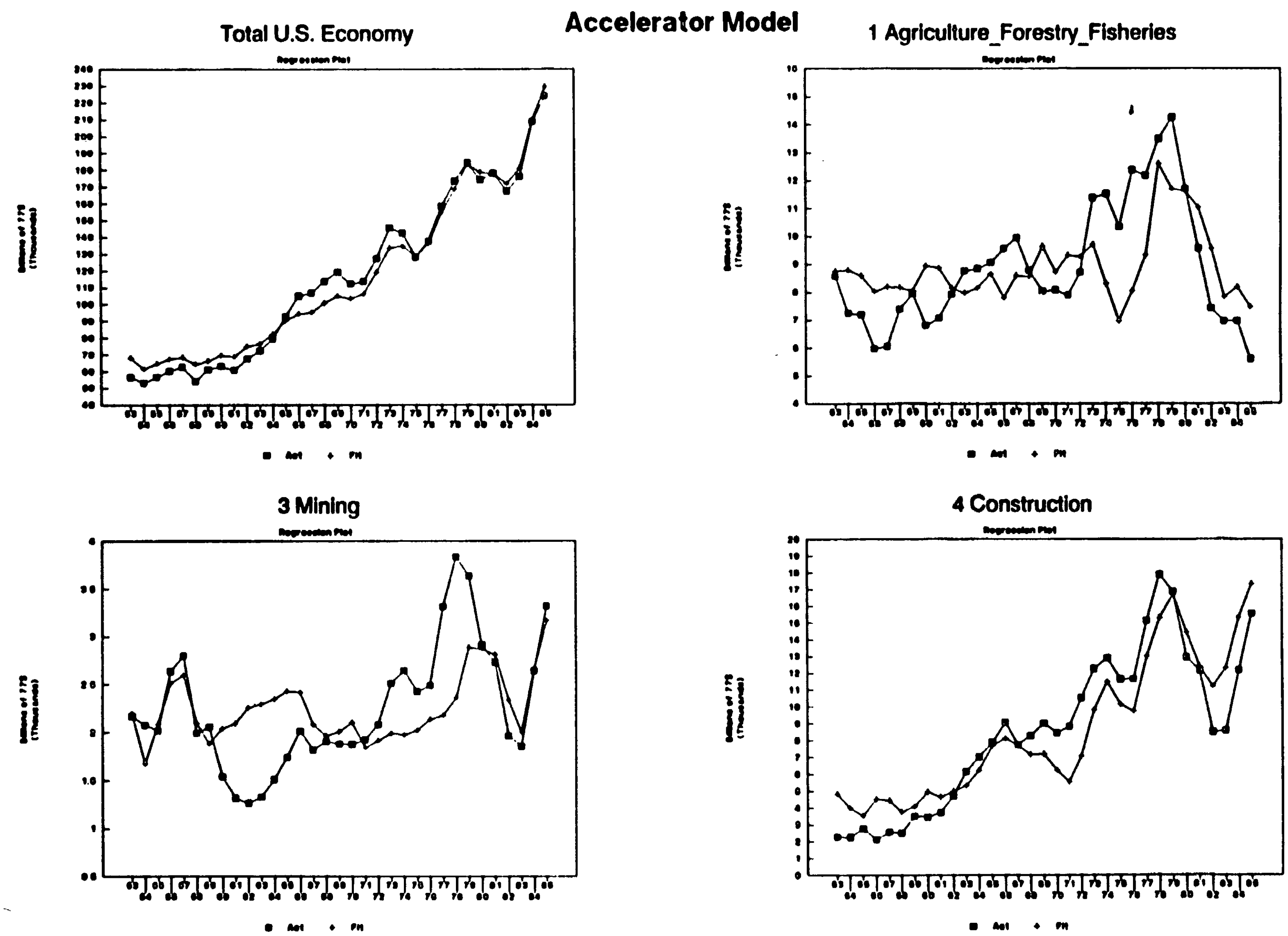


Figure 4.4.a - 1953 to 1985 Estimation

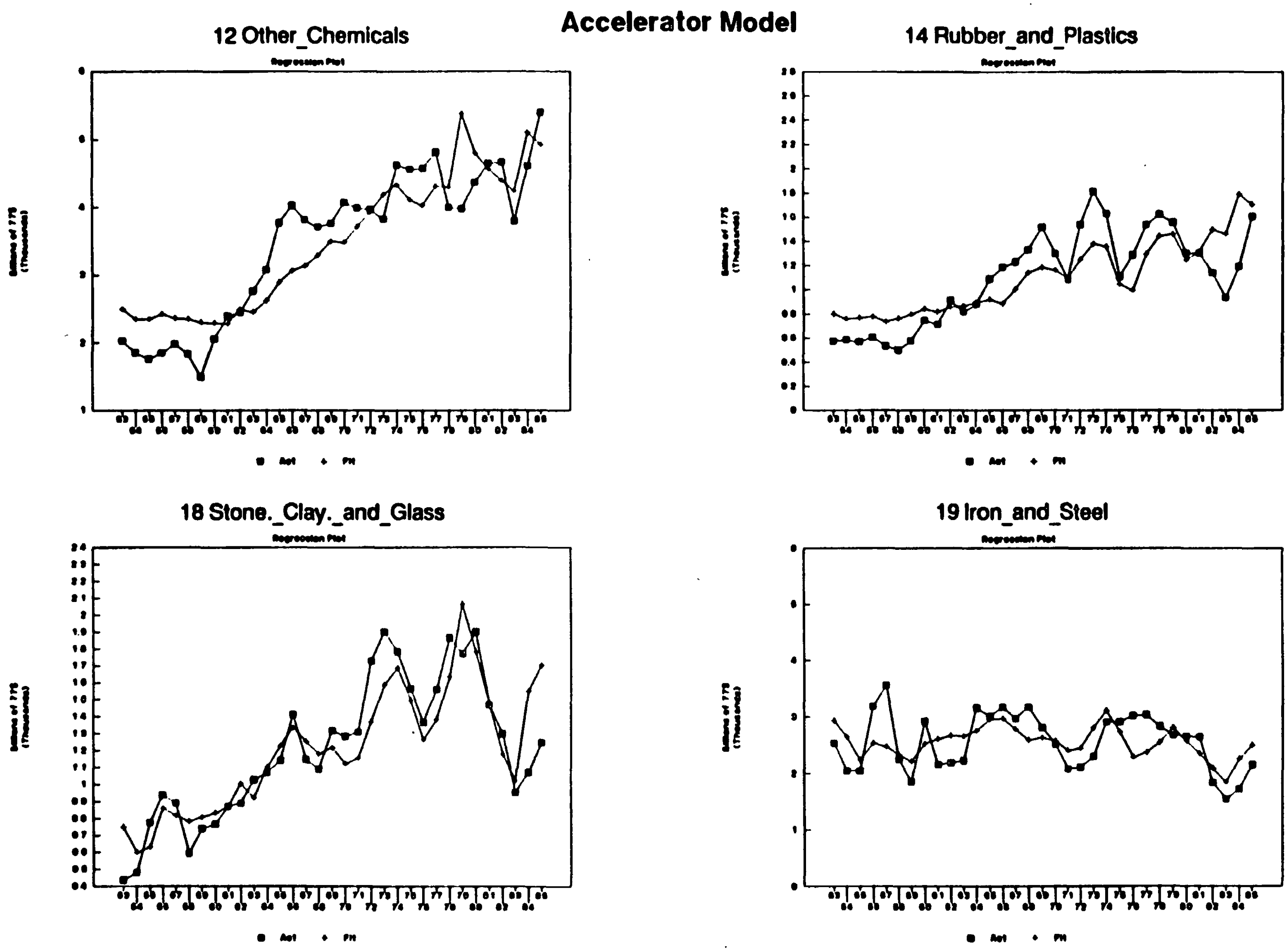


Figure 4.4.b - 1953 to 1985 Estimation

Accelerator Model

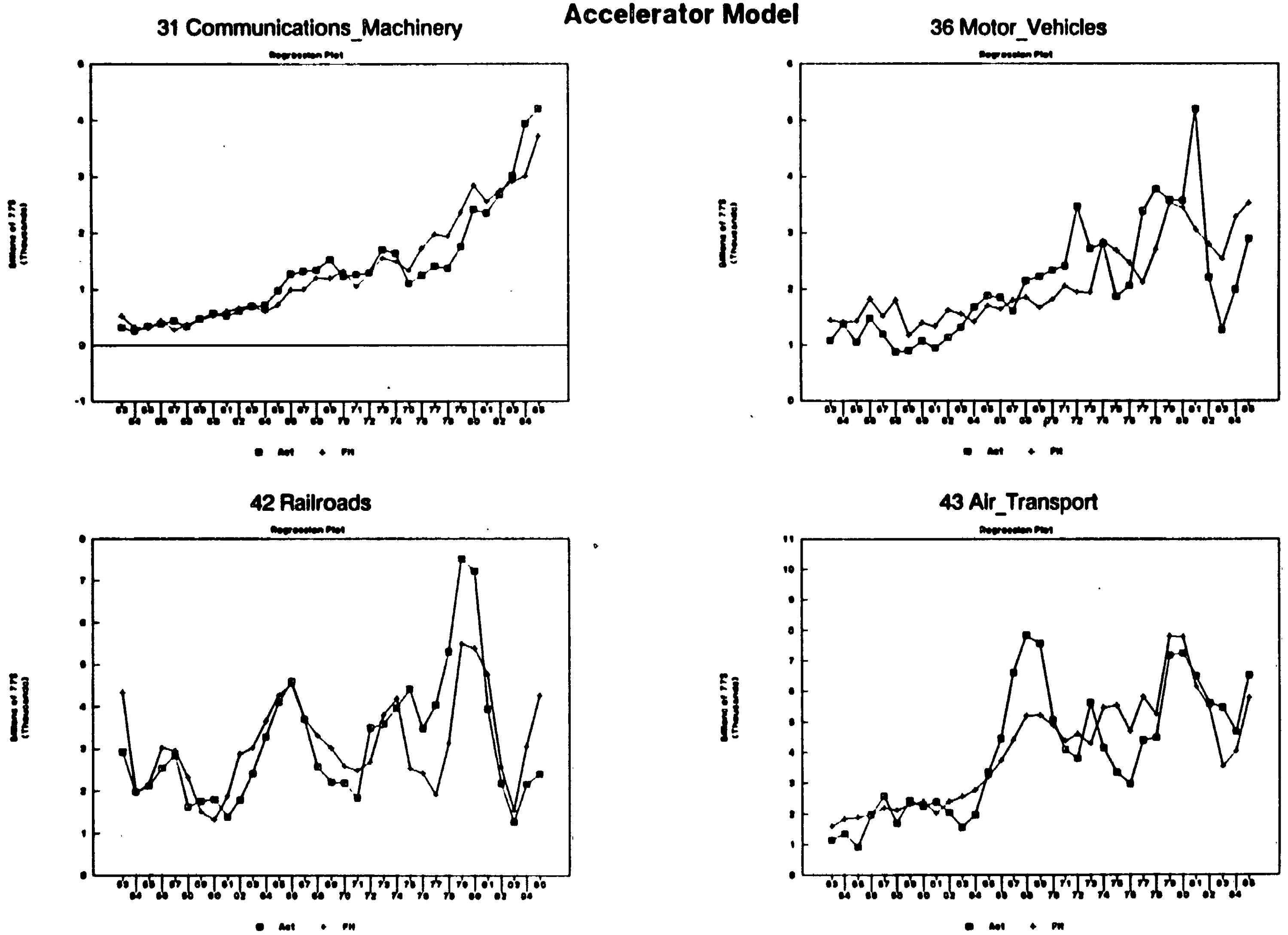


Figure 4.4.c - 1953 to 1985 Estimation

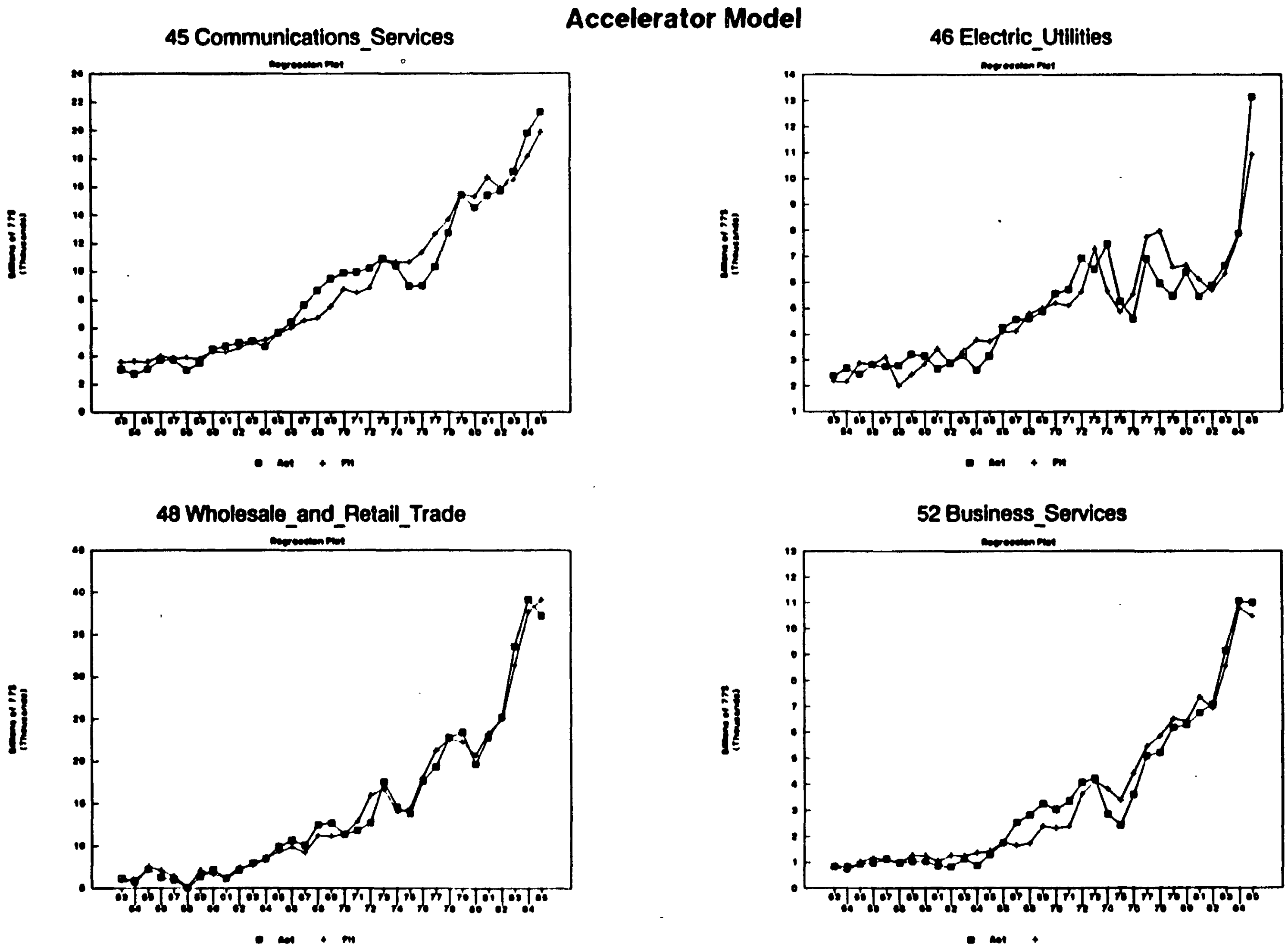


Figure 4.4.d - 1953 to 1985 Estimation

In summary, the regression fits for the accelerator model are fairly good, and the model is better than the autoregressive model at predicting turning points. This finding agrees with the conventional wisdom that output is a good indicator of the dynamic movements of investment. However, the accelerator model leaves much room for improvement. It allows for no price effects, particularly of tax policies operating through changing the cost of capital. In the next few sections, various models will be investigated in which relative prices are introduced into the investment model, to see what contribution this makes to explanatory power and sensible results.

3. The Jorgenson Cobb-Douglas Model

This model, which is essentially the same as Jorgenson's Neoclassical model, combines output and price effects into a composite variable, and expresses gross investment as a function of an intercept, a three-year distributed lag on first differences of the composite variable, lagged net investment, and lagged capital stock. The estimated equation is reproduced below:

$$(3.1) \qquad I_t = a_0 + \sum_{i=0}^{3} b_i \left[\Delta \frac{pQ}{c}\right]_{t-i} + \delta K_{t-1}$$

The b's are expected to be positive in sign, because investment should respond positively to changes in output, negatively to increases in user cost c, and positively to changes in output price p. The coefficient on the lagged capital stock is expected to be a small fraction which can be interpreted as an estimate of the geometric depreciation rate.

The equation has been formulated in this manner to follow roughly the form of the Jorgenson model, although his model was estimated with quarterly data, using the rational lag distribution he developed. The use of the composite variable *pQ/c* makes the interpretation of price response ambiguous, since *p/c* is constrained to have the same distributed lag coefficients as *Q*. In other words, if the change in output has a strong effect on investment, then the change in the real cost of capital is also bound to have a strong effect. This can lead to the inference that various tax and depreciation policies that act through the cost of capital have a significant impact on investment in a given industry, when in fact, they may have little effect. Unlike the Jorgenson model, this model does not include a lagged net investment term. Thus, although this model will probably provide a poorer fit to the data than the Jorgenson model, it is more of a structural model, and doesn't rely so much on lagged investment[60]. The coefficient on the capital stock term may be interpreted as the geometric depreciation rate, assuming that depreciation does in fact follow a simple geometric pattern.

The regression results for this model are displayed in Tables 4.5 and 4.6. In these tables the intercept is in the first column

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[60] Actually, the model was first estimated with the lagged net investment term included, and this term contributed greatly to R^2. However, this version of the model displayed perverse behavior in the forecasting model.

(*INTCP*), followed by the distributed lag weights on $\Delta\frac{pQ}{c}$ (*DIF* to *DIF[3]*), followed by the coefficient on the capital stock (K) and the four regression statistics. An examination of the values of R^2 reveals that the fits of this model are about the same as the accelerator model, on average, although slightly worse in the 53-85 estimation period. Of the 53 industries estimated, 10 have a value of R^2 below .6 in the 53-77 estimation, and 17 in the 53-85 estimation. Note that all three of the models discussed so far do significantly worse in the 53-85 period. This is partly because there are more points of data to fit with the same parameters. However, it also suggests that there was a change in the behavior of investment during the period from 78 to 85, enough to strain the equations' capacity to fit well over the whole period from 53 to 85. This supposition is borne out by comparing the parameters from the two estimations. Neither the intercept terms nor the capital stock coefficients show much resemblance to each other between the two periods.

As in the previous model, a softly constrained second order Almon lag was imposed on the distributed lag coefficients to give them a more reasonable pattern. Nevertheless, many of these coefficients are negative, which is contrary to common sense (although agreeing with the accelerator results). The coefficient on the lagged capital stock seems reasonable, and is negative in only a handful of cases. Table 4.7 below compares the depreciation rates calculated for this model for both estimation periods with geometric depreciation rates calculated using average service lives[61].

Most of the estimated values of δ fall within an acceptable range, except of course those which are negative. It is heartening that so many of the estimated values tally so closely with what average service lives would lead us to expect. Curiously enough, the estimated values of δ in the 53 to 85 estimation are on average even closer to the calculated values for most industries, than in the 53 to 77 estimation. It is also notable that estimated depreciation rates are much higher than calculated rates in Computers (29), Communications Machinery (31), Finance and Insurance (49), and Business Services (52), which are all industries that invest heavily in computers.

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[61] Assuming geometric depreciation, the formula for the depreciation rate is $\delta = 1/(1+L)$, where L is the average service life.

Table 4.5

The Cobb-Douglas Neo-classical Model. Estimated 53 to 77.

	Sector Title	INTCP	DIF	DIF[1]	DIF[2]	DIF[3]	K	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	-2866.05	0.0032	0.0066	0.0001	0.0084	0.0903	0.760	8.2940	851.000	0.357
2	Crude Petroleum, Natural Gas	1430.53	-0.0039	-0.0049	-0.0009	0.0076	0.0125	0.568	7.5910	145.500	-0.184
3	Mining	940.91	-0.0060	0.0071	0.0077	0.0177	0.0463	0.208	18.4860	432.300	0.607
4	Construction	-362.59	0.0103	0.0168	0.0174	0.0054	0.1574	0.964	11.7080	732.800	0.480
5	Food, Tobacco	-344.19	0.0005	-0.0001	-0.0001	0.0001	0.1123	0.972	5.4730	147.100	0.586
6	Textiles	-160.73	0.0013	0.0025	0.0029	0.0001	0.0868	0.685	12.1260	136.200	0.653
7	Knitting, Hosiery	-56.60	0.0088	0.0041	0.0026	0.0015	0.1466	0.661	46.2790	49.797	0.633
8	Apparel and Household Textile	34.69	-0.0015	0.0017	-0.0008	0.0006	0.0982	0.632	26.4550	126.600	0.827
9	Paper	87.62	-0.0008	0.0055	0.0038	0.0075	0.0913	0.896	8.9810	183.000	0.317
10	Printing	26.38	0.0017	0.0014	0.0023	-0.0013	0.1042	0.932	9.2980	98.589	0.827
11	Agricultural Fertilizers	-78.37	0.0047	0.0217	0.0007	0.0242	0.2168	0.891	39.7340	90.472	0.373
12	Other Chemicals	114.56	0.0003	-0.0000	0.0029	0.0061	0.0964	0.908	9.1880	324.700	0.697
13	Petroleum Refining and Fuel	205.64	0.0020	0.0044	0.0027	0.0022	0.0686	0.405	39.9650	306.500	0.840
14	Rubber and Plastics	63.76	0.0030	0.0077	0.0053	-0.0002	0.0945	0.880	11.6060	135.000	0.563
15	Footwear and Leather	123.35	0.0003	0.0011	0.0007	0.0006	0.0028	0.038	19.4740	29.487	0.729
16	Lumber	-71.09	0.0009	0.0043	0.0023	0.0032	0.1291	0.926	12.5690	94.560	0.292
17	Furniture	-71.85	-0.0006	0.0034	0.0011	-0.0013	0.1230	0.769	14.2190	40.214	0.488
18	Stone, Clay and Glass	123.48	0.0014	0.0087	0.0094	-0.0021	0.1037	0.908	9.1680	118.400	0.344
19	Iron and Steel	2101.85	-0.0022	0.0023	0.0027	0.0018	0.0169	0.163	14.9850	433.800	0.197
20	Non Ferrous Metals	-19.77	-0.0024	0.0020	0.0048	0.0040	0.1074	0.793	16.0950	144.000	0.249
21	Metal Products	23.08	0.0002	0.0036	0.0032	0.0010	0.0916	0.765	11.0120	232.600	0.609
22	Engines and Turbines	8.19	0.0028	0.0063	0.0118	0.0005	0.1299	0.830	28.6030	41.926	0.733
23	Agricultural Machinery	-37.59	0.0015	0.0018	0.0032	0.0032	0.1354	0.829	14.9100	27.102	-0.102
25	Metalworking Machinery	488.88	-0.0020	0.0067	0.0004	0.0047	-0.0153	0.283	23.7820	105.300	0.519
27	Special Industry Machinery	342.94	-0.0035	0.0018	0.0021	-0.0036	-0.0291	0.229	13.1440	37.024	0.452
28	Miscellaneous Non-Electrical	-30.65	-0.0005	0.0061	0.0019	0.0045	0.1110	0.928	8.2830	86.656	0.306
29	Computers	36.45	-0.0000	0.0120	-0.0102	0.0250	0.1185	0.778	24.6040	81.624	0.434
30	Service Industry Machinery	-77.17	0.0043	0.0061	0.0045	0.0025	0.1405	0.627	28.5700	50.746	0.729
31	Communications Machinery	38.11	-0.0003	0.0083	0.0026	0.0018	0.1122	0.815	20.9060	198.300	0.653
32	Heavy Electrical Machinery	-4.44	-0.0011	0.0057	-0.0002	0.0046	0.1000	0.640	16.2960	77.748	0.691
33	Household Appliances	-27.30	0.0004	0.0043	0.0007	0.0020	0.0881	0.266	30.4720	53.027	0.687
34	Electrical Lighting and wiri	-56.83	-0.0025	0.0090	0.0052	0.0012	0.1338	0.821	19.4940	63.193	0.574
35	Radio, T.V. Phonographs	-10.92	0.0004	0.0058	0.0014	0.0017	0.1351	0.755	27.4700	24.005	0.448
36	Motor Vehicles	4.13	0.0009	0.0028	0.0004	-0.0005	0.1049	0.763	18.6500	358.100	0.423
37	Aerospace	188.49	0.0005	0.0021	0.0012	0.0028	0.0673	0.172	30.8810	226.800	0.760
38	Ships and Boats	-11.59	0.0016	0.0074	-0.0044	0.0136	0.2354	0.810	77.7910	49.267	0.076
39	Other Transportation Equipme	-17.80	0.0010	0.0003	-0.0003	-0.0000	0.2160	0.901	44.3570	17.478	0.747
40	Instruments	24.10	-0.0060	0.0064	0.0014	-0.0029	0.1202	0.887	12.8800	69.857	0.539
41	Miscellaneous Manufacturing	70.69	-0.0020	0.0015	-0.0047	-0.0014	0.0832	0.761	10.7290	46.310	0.050
42	Railroads	-900.09	0.0076	0.0118	0.0133	0.0189	0.0641	0.595	19.1450	606.500	0.407
43	Air Transport	1291.51	-0.0095	-0.0005	0.0386	0.0099	0.0767	0.361	35.9900	1516.300	0.782
44	Trucking and Other Transport	-634.58	0.0091	0.0107	0.0156	-0.0035	0.1690	0.957	10.2260	428.600	0.652
45	Communications Services	653.17	0.0050	0.0021	0.0177	-0.0063	0.0985	0.866	12.0990	1043.200	0.810
46	Electric Utilities	203.36	0.0040	0.0048	0.0072	-0.0038	0.0913	0.774	13.8060	751.500	0.373
47	Gas, Water and Sanitation	272.73	0.0032	-0.0018	0.0054	-0.0014	0.0704	0.333	26.4290	401.400	0.677
48	Wholesale and Retail Trade	-1815.32	0.0039	0.0059	0.0049	-0.0012	0.1773	0.918	10.0040	1151.400	0.098
49	Finance and Insurance	-248.31	0.0012	0.0040	0.0068	0.0080	0.1687	0.925	13.5870	310.700	0.365
50	Real Estate	89.03	-0.0032	0.0008	0.0001	-0.0066	0.1707	0.870	26.1110	612.900	0.641
51	Hotels and repairs Minus Aut	570.71	-0.0077	0.0093	-0.0020	-0.0039	0.0980	0.756	12.5520	356.800	0.738
52	Business Services	379.83	-0.0097	0.0015	-0.0051	-0.0229	0.1798	0.888	20.4240	428.700	0.559
53	Auto repair	446.60	0.0075	0.0186	0.0121	0.0111	0.1293	0.721	20.2070	471.900	0.492
54	Movies and Amusements	101.74	0.0061	0.0133	0.0090	0.0049	0.1030	0.931	7.6260	99.500	0.638
55	Medical and Educational Serv	668.04	0.0010	0.0032	0.0047	-0.0022	0.1140	0.915	12.1070	525.500	0.744

Table 4.6

The Cobb-Douglas Neo-classical Model.   Estimated 53 to 85.

	Sector Title	INTCP	DIF	DIF[1]	DIF[2]	DIF[3]	K	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	2113.90	0.0072	0.0072	0.0053	0.0115	0.0510	0.359	13.5660	1734.400	0.702
2	Crude Petroleum, Natural Gas	604.26	0.0073	0.0091	0.0069	0.0043	0.0648	0.613	20.7180	507.100	0.746
3	Mining	-91.95	-0.0043	0.0139	0.0149	0.0119	0.0913	0.347	19.7070	516.500	0.708
4	Construction	1151.77	0.0156	0.0241	0.0330	0.0179	0.1158	0.815	22.6160	1944.600	0.778
5	Food, Tobacco	330.16	0.0011	0.0003	0.0010	0.0019	0.0823	0.885	9.9900	316.500	0.754
6	Textiles	272.31	0.0017	0.0031	0.0021	0.0006	0.0479	0.413	16.2750	164.800	0.800
7	Knitting, Hosiery	-0.21	0.0049	0.0042	0.0004	0.0022	0.0898	0.485	51.7280	58.658	0.755
8	Apparel and Household Textile	185.37	0.0003	0.0011	-0.0005	0.0014	0.0479	0.206	37.3630	167.000	0.874
9	Paper	104.81	-0.0041	0.0090	0.0041	0.0090	0.0901	0.934	8.3600	206.700	0.221
10	Printing	12.40	0.0000	0.0031	0.0030	0.0010	0.1045	0.958	8.2140	117.200	0.447
11	Agricultural Fertilizers	61.21	0.0057	0.0185	0.0197	0.0278	0.0952	0.620	54.8530	158.600	0.561
12	Other Chemicals	688.81	-0.0004	0.0014	0.0020	0.0069	0.0741	0.838	12.0260	444.900	0.672
13	Petroleum Refining and Fuel	-513.09	-0.0002	0.0007	0.0026	0.0022	0.1586	0.777	31.3310	308.000	0.691
14	Rubber and Plastics	328.19	0.0022	0.0071	0.0051	0.0022	0.0628	0.688	17.5750	213.100	0.717
15	Footwear and Leather	137.67	0.0003	0.0010	0.0002	0.0006	-0.0114	0.021	24.0600	32.758	0.799
16	Lumber	149.82	0.0060	0.0066	0.0051	0.0104	0.0839	0.757	19.4690	175.000	0.621
17	Furniture	29.61	-0.0011	0.0038	0.0010	-0.0005	0.0790	0.661	17.2540	48.816	0.655
18	Stone, Clay and Glass	356.74	0.0009	0.0111	0.0076	0.0079	0.0728	0.659	16.0090	235.600	0.721
19	Iron and Steel	2557.86	-0.0014	0.0030	0.0046	0.0035	0.0020	0.204	15.7590	447.900	0.340
20	Non Ferrous Metals	186.72	-0.0000	0.0024	0.0050	0.0041	0.0775	0.702	16.6540	170.500	0.432
21	Metal Products	599.36	-0.0005	0.0021	0.0025	0.0021	0.0579	0.519	14.3170	316.500	0.629
22	Engines and Turbines	30.51	0.0000	0.0035	0.0038	0.0028	0.1120	0.809	27.9190	51.304	0.543
23	Agricultural Machinery	12.05	0.0026	0.0009	0.0048	0.0075	0.0939	0.673	20.1760	39.766	0.317
25	Metalworking Machinery	464.66	-0.0012	0.0056	0.0015	0.0050	-0.0104	0.293	20.3430	95.392	0.475
27	Special Industry Machinery	414.51	-0.0033	0.0015	0.0023	-0.0022	-0.0512	0.174	13.8340	38.161	0.568
28	Miscellaneous Non-Electrical	63.32	0.0004	0.0053	0.0025	0.0072	0.0966	0.903	10.3490	124.900	0.313
29	Computers	-124.41	0.0059	0.0221	0.0052	0.0218	0.1940	0.966	34.4550	124.100	0.670
30	Service Industry Machinery	17.76	0.0008	0.0044	0.0006	0.0023	0.0828	0.501	27.7100	55.432	0.752
31	Communications Machinery	-252.84	0.0036	0.0139	0.0013	0.0102	0.1419	0.922	20.5820	274.000	0.639
32	Heavy Electrical Machinery	1.94	-0.0016	0.0050	-0.0018	0.0049	0.0977	0.768	15.5510	78.791	0.592
33	Household Appliances	59.74	0.0003	0.0034	0.0001	0.0015	0.0482	0.143	27.7180	51.293	0.762
34	Electrical Lighting and wiri	58.32	-0.0023	0.0055	0.0024	0.0011	0.0886	0.751	21.2300	75.919	0.627
35	Radio, T.V. Phonographs	6.21	-0.0004	0.0054	0.0006	0.0019	0.1032	0.787	29.1710	24.275	0.560
36	Motor Vehicles	542.49	-0.0013	0.0003	0.0003	0.0006	0.0728	0.461	28.0190	745.100	0.401
37	Aerospace	-22.11	0.0018	0.0035	0.0023	0.0043	0.1083	0.505	32.4730	222.900	0.743
38	Ships and Boats	5.53	0.0103	0.0090	0.0004	0.0175	0.1261	0.661	93.5980	63.838	0.547
39	Other Transportation Equipme	4.65	0.0030	0.0021	0.0016	0.0021	0.1422	0.857	54.4700	27.251	0.770
40	Instruments	58.02	-0.0071	0.0063	-0.0027	-0.0000	0.1083	0.854	14.8870	105.400	0.592
41	Miscellaneous Manufacturing	169.30	0.0008	0.0019	-0.0023	0.0011	0.0470	0.361	16.2650	68.034	0.579
42	Railroads	747.88	0.0079	0.0140	0.0188	0.0237	0.0395	0.289	31.4260	1248.100	0.704
43	Air Transport	1346.06	-0.0142	-0.0179	0.0148	-0.0007	0.0821	0.501	31.5160	1440.600	0.709
44	Trucking and Other Transport	61.25	0.0104	0.0270	0.0075	0.0182	0.1303	0.925	16.5990	760.400	0.504
45	Communications Services	-111.42	0.0051	0.0031	0.0260	-0.0095	0.1128	0.959	9.6780	1034.000	0.717
46	Electric Utilities	281.71	0.0034	0.0086	0.0244	0.0021	0.0839	0.736	16.4840	1135.200	0.235
47	Gas, Water and Sanitation	-314.35	0.0078	-0.0057	0.0039	0.0078	0.1124	0.686	30.9610	668.900	0.676
48	Wholesale and Retail Trade	-3842.02	0.0096	0.0131	0.0042	-0.0070	0.2070	0.968	10.3890	1627.500	0.244
49	Finance and Insurance	-731.44	0.0028	0.0022	0.0149	-0.0019	0.2033	0.961	15.8620	549.600	0.464
50	Real Estate	527.94	-0.0053	0.0024	0.0002	-0.0076	0.1381	0.926	32.3420	810.900	0.482
51	Hotels and repairs Minus Aut	609.53	0.0053	0.0127	0.0081	0.0016	0.0862	0.783	12.5580	363.100	0.802
52	Business Services	-111.63	-0.0026	0.0077	0.0007	-0.0175	0.1947	0.971	19.1080	494.400	0.676
53	Auto repair	45.94	0.0206	0.0356	0.0149	-0.0003	0.1710	0.862	19.1470	585.400	0.556
54	Movies and Amusements	181.04	0.0035	0.0132	0.0141	0.0101	0.0908	0.948	7.3370	107.200	0.658
55	Medical and Educational Serv	376.91	0.0025	0.0012	-0.0006	-0.0115	0.1310	0.946	12.3790	711.100	0.666

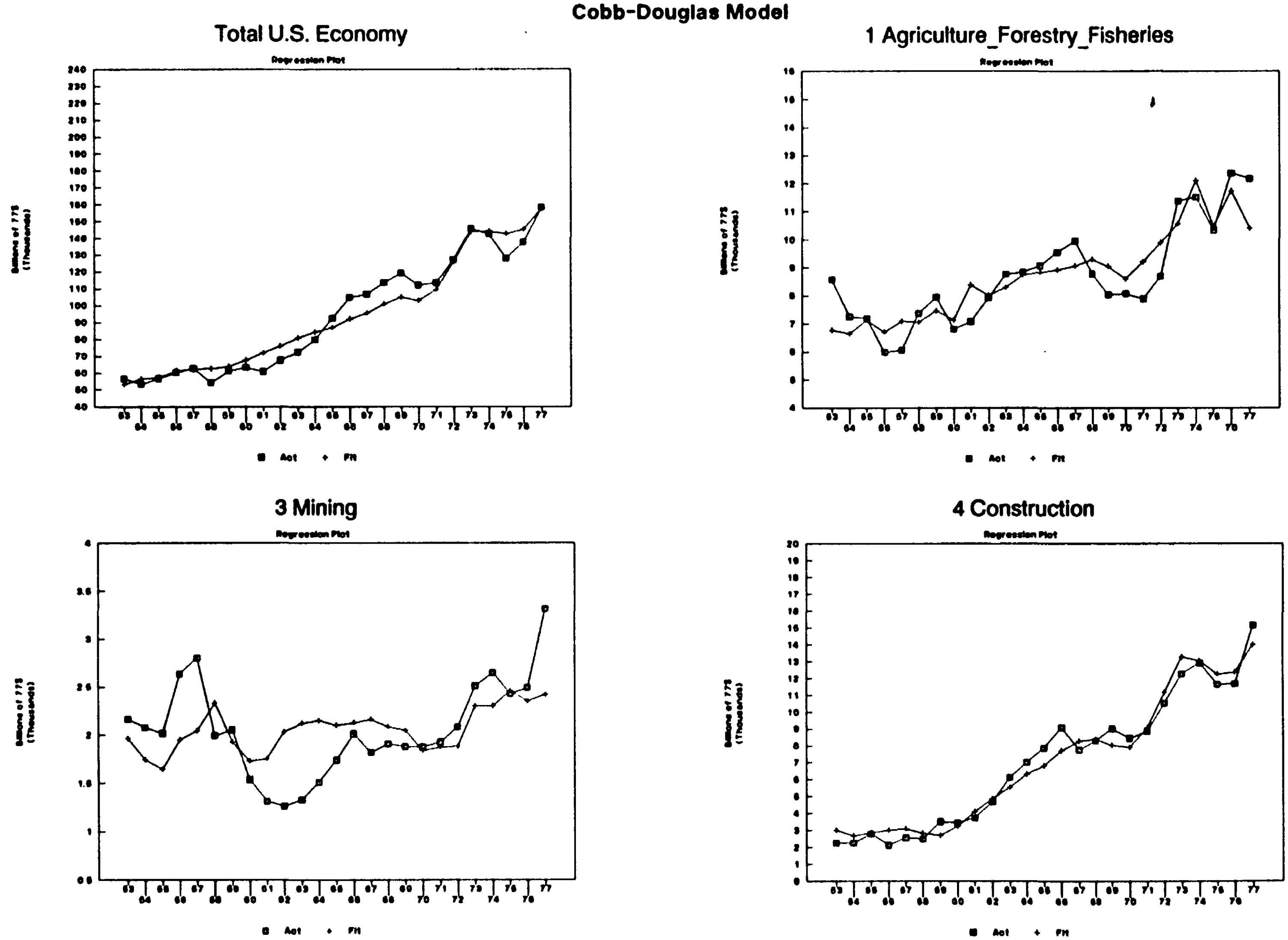

Figure 4.5.a - 1953 to 1977 Estimation

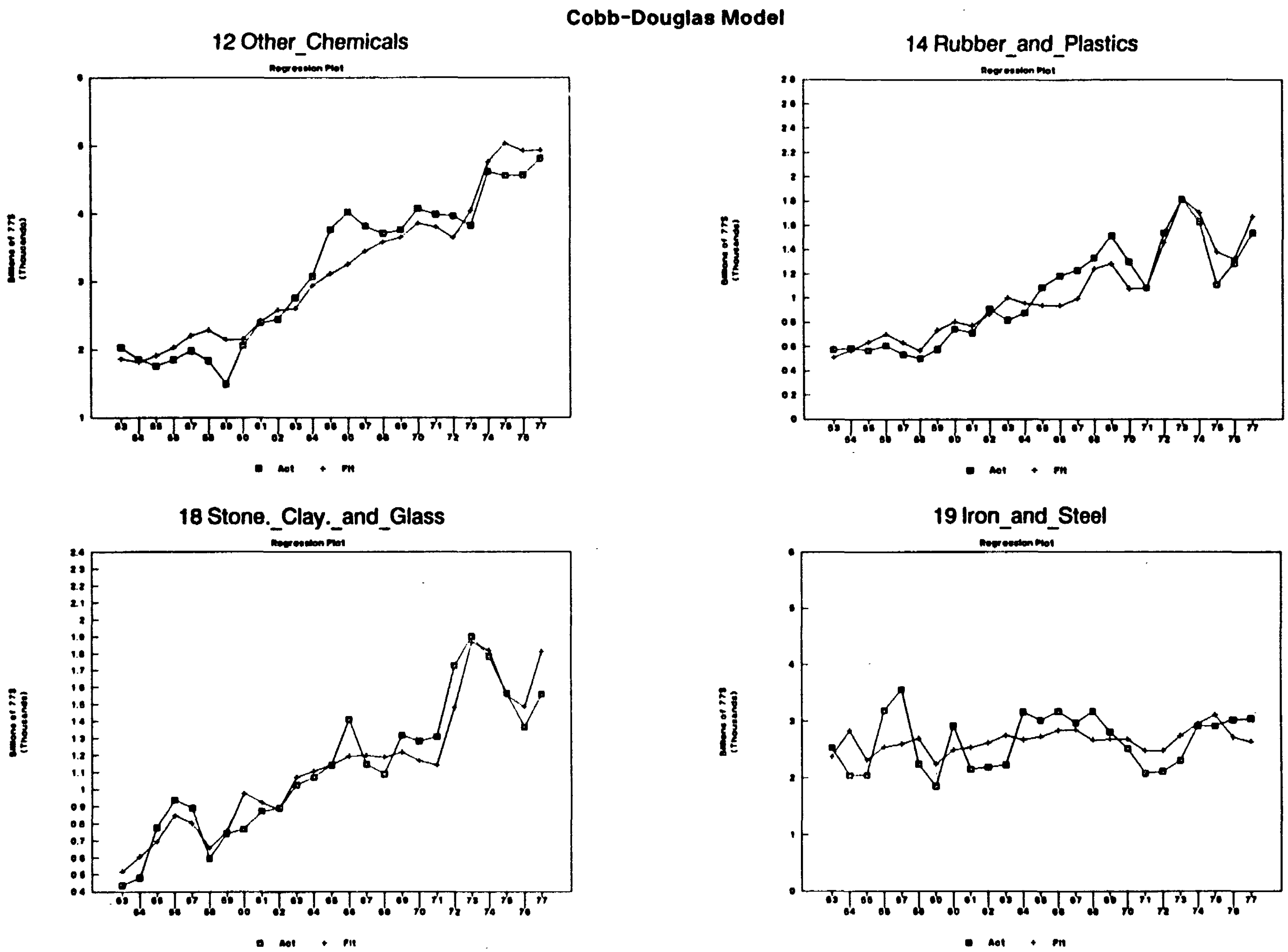

Figure 4.5.b - 1953 to 1977 Estimation

Cobb-Douglas Model

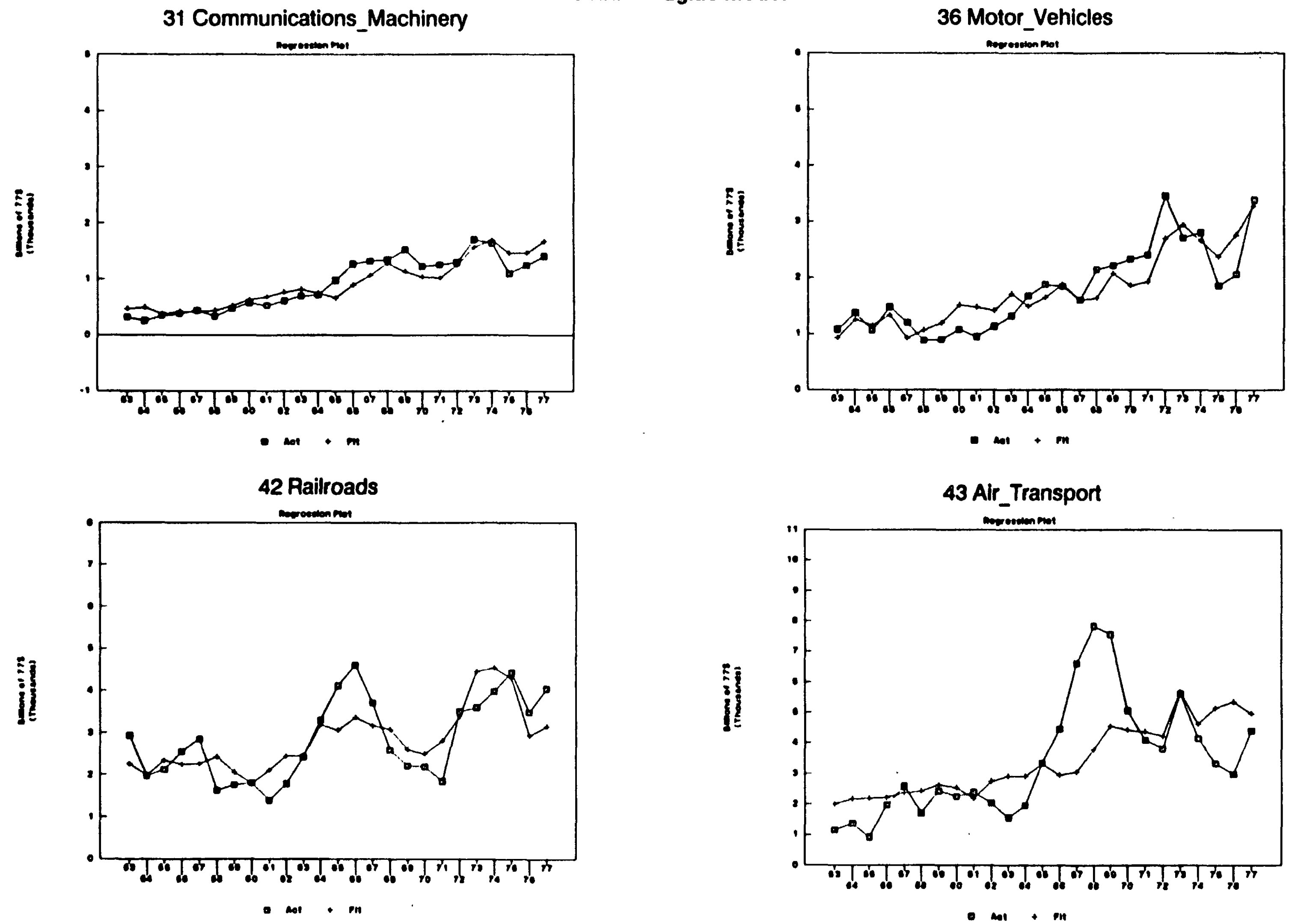

Figure 4.5.c - 1953 to 1977 Estimation

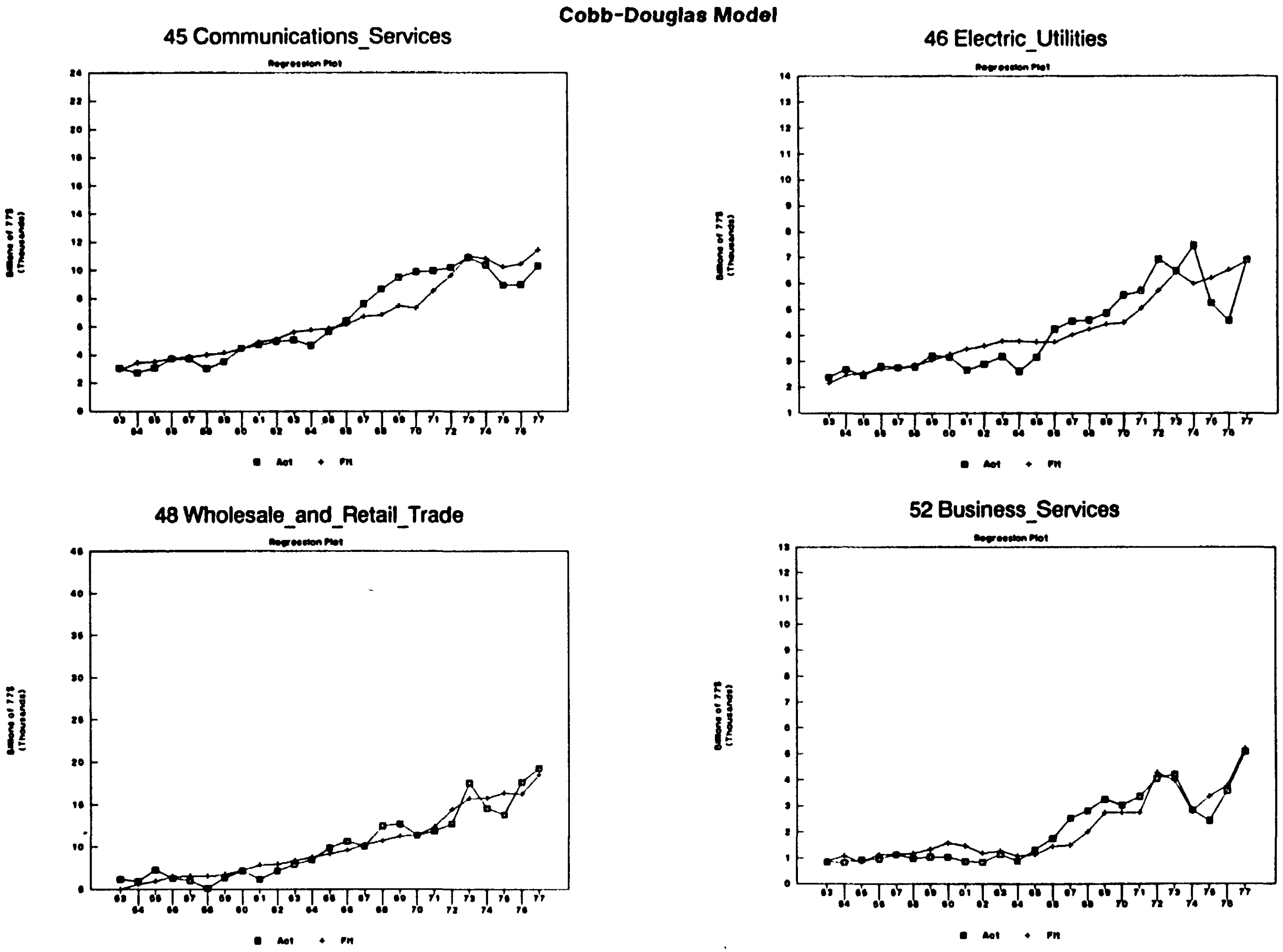

Figure 4.5.d - 1953 to 1977 Estimation

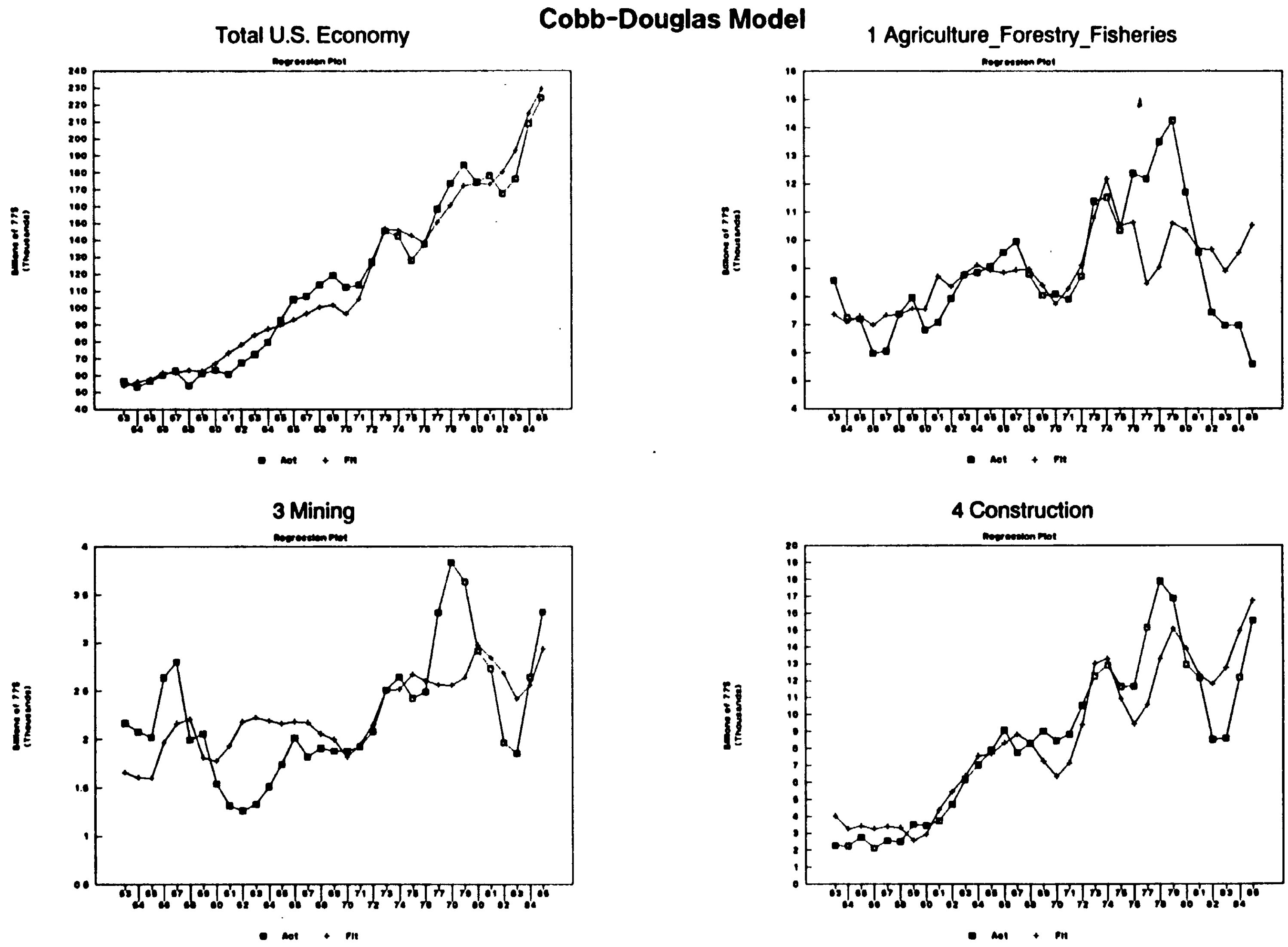

Figure 4.6.a - 1953 to 1985 Estimation

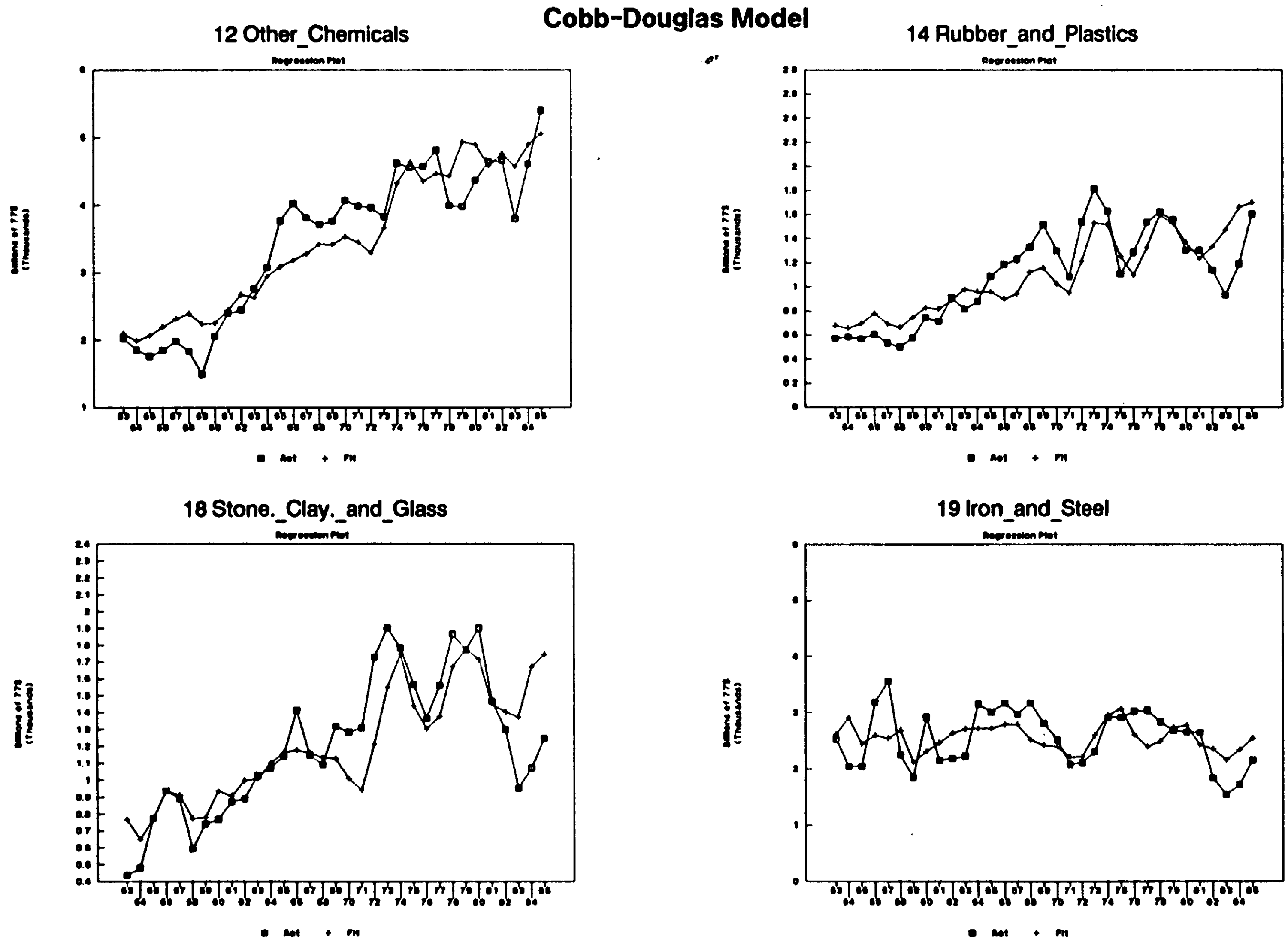

Figure 4.6.b - 1953 to 1985 Estimation

Cobb-Douglas Model

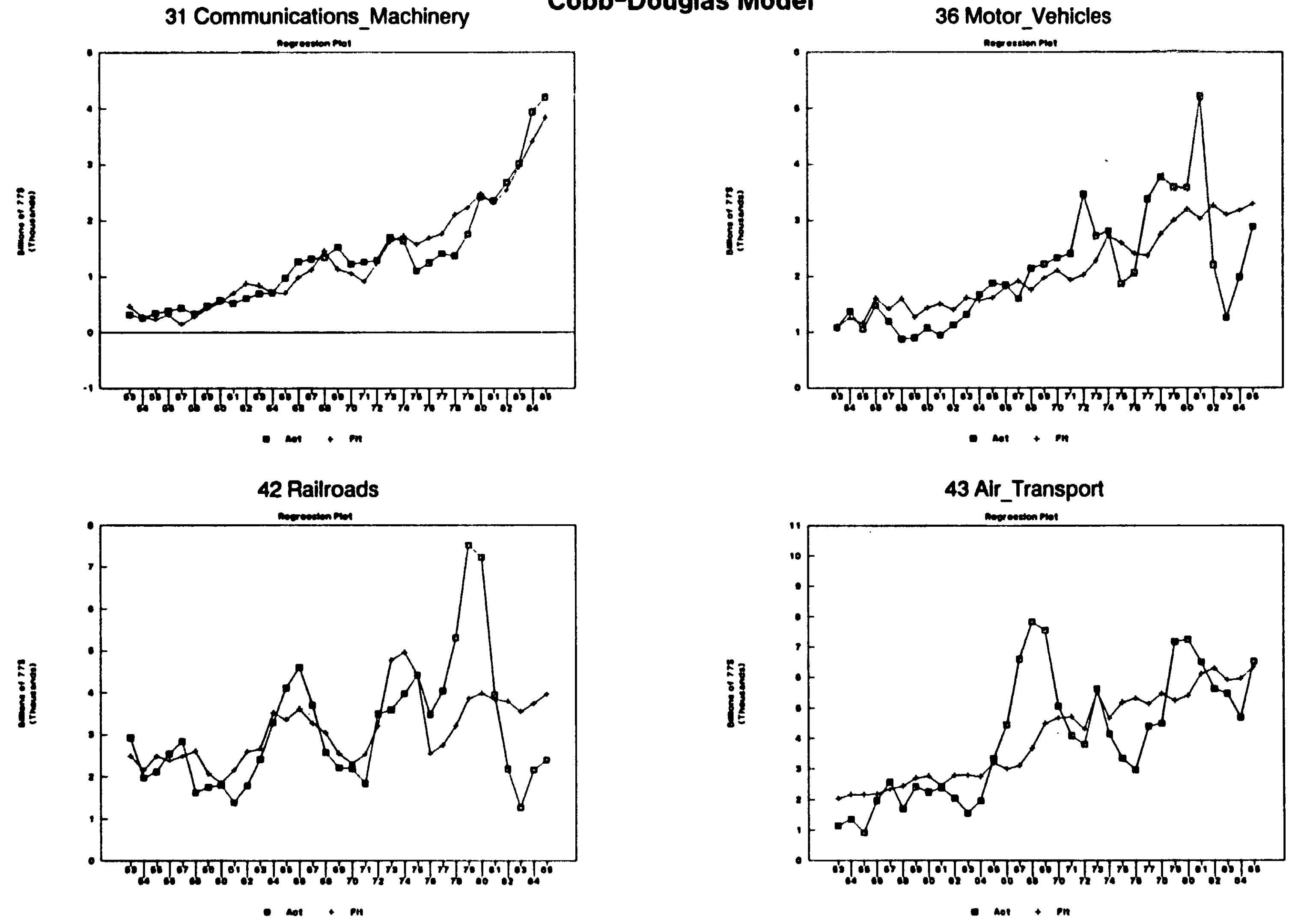

Figure 4.6.c - 1953 to 1985 Estimation

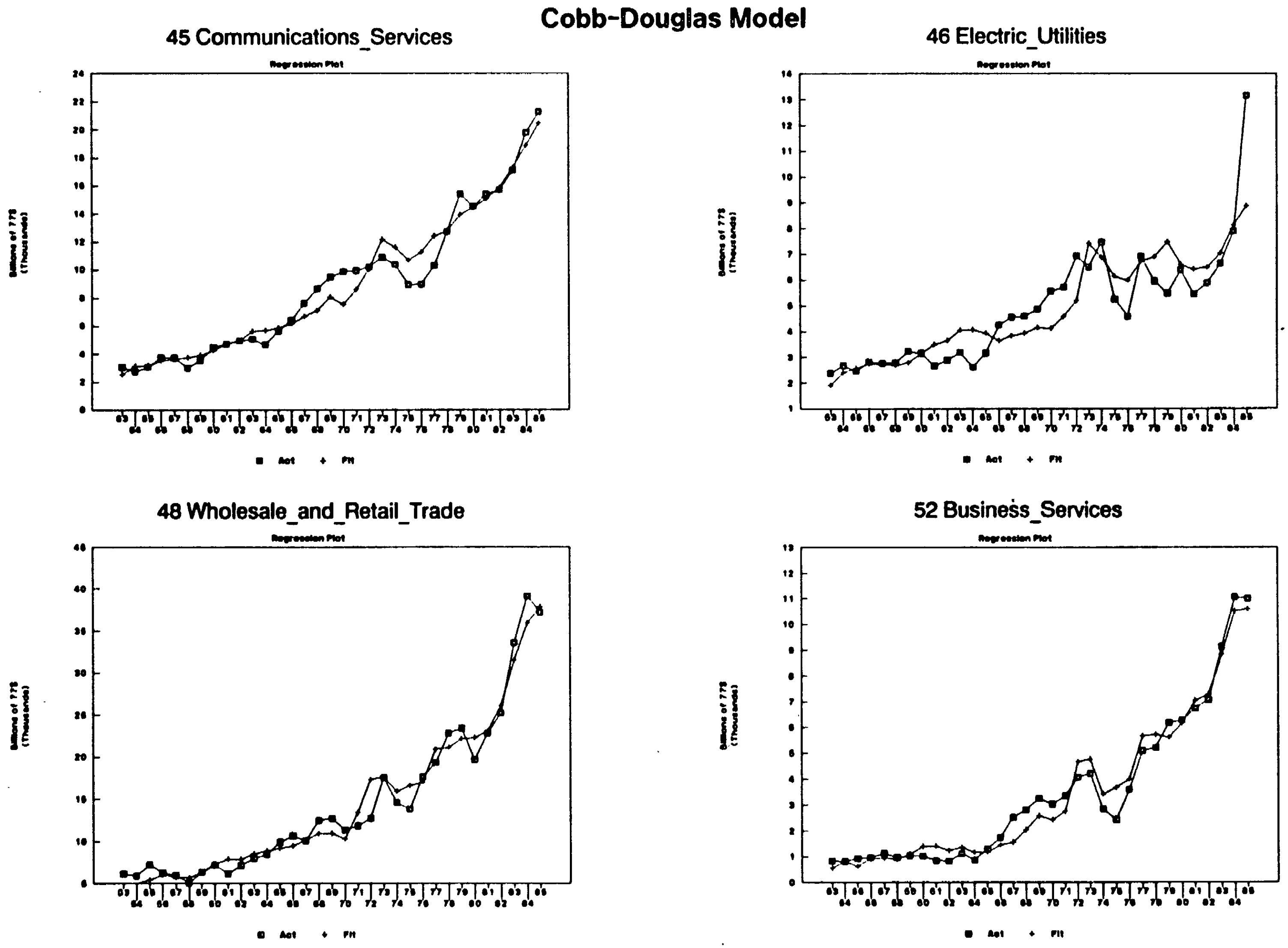

Figure 4.6.d - 1953 to 1985 Estimation

Table 4.7
Comparison of Estimated Depreciation Rates with Calculated Depreciation Rates

	Sector Title	Calculated	77 Est	85 Est
1	Agriculture, Forestry, Fisheries	0.0565	0.0903	0.0510
2	Crude Petroleum, Natural Gas	0.0707	0.0125	0.0648
3	Mining	0.0770	0.0463	0.0913
4	Construction	0.0904	0.1574	0.1158
5	Food, Tobacco	0.0643	0.1123	0.0823
6	Textiles	0.0562	0.0868	0.0479
7	Knitting, Hosiery	0.0562	0.1466	0.0898
8	Apparel and Household Textiles	0.0653	0.0982	0.0479
9	Paper	0.0619	0.0913	0.0901
10	Printing	0.0666	0.1042	0.1045
11	Agricultural Fertilizers	0.0827	0.2168	0.0952
12	Other Chemicals	0.0638	0.0964	0.0741
13	Petroleum Refining and Fuel Oil	0.0787	0.0686	0.1586
14	Rubber and Plastics	0.0619	0.0945	0.0628
15	Footwear and Leather	0.0595	0.0028	-0.0114
16	Lumber	0.0741	0.1291	0.0839
17	Furniture	0.0707	0.1230	0.0790
18	Stone, Clay and Glass	0.0757	0.1037	0.0728
19	Iron and Steel	0.0614	0.0169	0.0020
20	Non Ferrous Metals	0.0683	0.1074	0.0775
21	Metal Products	0.0679	0.0916	0.0579
22	Engines and Turbines	0.0820	0.1299	0.1120
23	Agricultural Machinery	0.0789	0.1354	0.0939
25	Metalworking Machinery	0.0696	-0.0153	-0.0104
27	Special Industry Machinery	0.0647	-0.0291	-0.0512
28	Miscellaneous Non-Electrical Machinery	0.0702	0.1110	0.0966
29	Computers	0.0908	0.1185	0.1940
30	Service Industry Machinery	0.0683	0.1405	0.0828
31	Communications Machinery	0.0662	0.1122	0.1419
32	Heavy Electrical Machinery	0.0689	0.1000	0.0977
33	Household Appliances	0.0633	0.0881	0.0482
34	Electrical Lighting and wiring Equip	0.0756	0.1338	0.0886
35	Radio, T.V. Phonographs	0.0675	0.1351	0.1032
36	Motor Vehicles	0.0645	0.1049	0.0728
37	Aerospace	0.0704	0.0673	0.1083
38	Ships and Boats	0.0794	0.2354	0.1261
39	Other Transportation Equipment	0.0779	0.2160	0.1422
40	Instruments	0.0765	0.1202	0.1083
41	Miscellaneous Manufacturing	0.0731	0.0832	0.0470
42	Railroads	0.0367	0.0641	0.0395
43	Air Transport	0.0819	0.0767	0.0821
44	Trucking and Other Transport	0.0845	0.1690	0.1303
45	Communications Services	0.0609	0.0985	0.1128
46	Electric Utilities	0.0582	0.0913	0.0839

47	Gas, Water and Sanitation	0.0568	0.0704	0.1124
48	Wholesale and Retail Trade	0.1218	0.1773	0.2070
49	Finance and Insurance	0.1100	0.1687	0.2033
50	Real Estate	0.0714	0.1707	0.1381
51	Hotels and repairs Minus Auto	0.0896	0.0980	0.0862
52	Business Services	0.0969	0.1798	0.1947
53	Auto repair	0.1335	0.1293	0.1710
54	Movies and Amusements	0.0796	0.1030	0.0908
55	Medical and Educational Services	0.0823	0.1140	0.1310

The regression plots for the aggregate of all industries and 15 selected industries are displayed in Figures 4.5.a to 4.6.d. In general, the Cobb-Douglas model tracks the actual data fairly well, and does a good job following turning points. However, it is enlightening to compare this model with the accelerator model in a sector such as Air Transport(43). Where the accelerator model catches the boom in jet aircraft investment in the late 60s, the Cobb-Douglas model almost completely misses it. Like the accelerator model, this model suffers from poor tracking ability in the Mining (2) and Iron and Steel (19) sectors.

Jorgenson generally achieved better fits than this in his work. However, much of his good fits can be ascribed to the inclusion of the lagged net investment term, which does not really contribute to a structural understanding of investment behavior. Without this term, the model slightly underperforms the simple accelerator model. How it compares in simulation performance will be analyzed in the next chapter.

4. CES Model I

This model is derived by assuming a CES production function with elasticity of substitution σ. The estimated model expresses net investment as a function of a constant term plus a four year distributed lag on a composite variable involving the capital stock, the proportional change in output, the proportional change in the relative cost of capital, and σ. It is because of this composite variable that the model is considered to be putty-putty, since the effects of output and capital cost are constrained to follow the same lag pattern. The estimated equation is reproduced below for reference:

$$(4.1) \qquad N_t = a_0 + \sum_{i=0}^{3} w_i X_{t-i}$$

where

$$X_t = \left[\underline{\Delta Q}_t - \sigma \underline{\Delta c} \right] K_{t-1}$$

In this model c is the *relative* user cost of capital, i.e., the capital user cost divided by output price. The estimate of σ in this model is expected to be positive, both because the relative user cost of capital is expected to have a negative impact on investment, and the fact that a negative σ is undefined within the context of a CES function. However, in the first attempt at estimating this equation, a good number of the estimated values for σ were negative. Therefore a soft constraint was applied to try to force σ to be positive.[62]

Tables 4.8 and 4.9 contain the regression results for both sets of estimations. The column labeled *SIGMA* in each table shows the industry estimates of σ, and the columns labeled W0 thru W3 are the distributed lag weights w_i on X_{t-i}. The sum of the weights is displayed in the column labeled SUMW, followed by the four regression statistics.

These results show that the constraint to encourage σ to be positive was only partially successful. More than half of the industries in the 53-77 estimation, and almost a third of the industries in the 53-85 estimation yield negative values for σ, even with a fairly strong weight on the constraint applied. These findings are notably different from those of Reimbold (1974), who calculated values for σ that were generally between .2 and 1.0. However, Reimbold used a quadratic programming technique, and iterated between a set of values for σ that were greater than or equal to zero until he found that value which gave the highest value for the objective function.

The distributed lag weights w_i were softly constrained to lie along a second degree Almon polynomial and to sum to unity. The constraint that the lag weights sum to unity was imposed because the

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[62] This is the first model that had to be estimated with a nonlinear estimation technique. The nonlinear optimisation routine used was the Nelder and Mead 'simplex' method, as implemented by the **G** regression package of INFORUM. The soft constraints were applied as penalty functions auxiliary to the mimimization of the sum of squared errors.

expression designated by X represents the long-run desired increase in the capital stock caused by given levels of output and relative user cost. If the weights do not sum to unity, this means that either too much or too little investment is being undertaken relative to the desired long-run level. A glance at Tables 4.8 and 4.9 will show that while the output weights sum to between 0.5 and 2.0 in most industries, 12 industries in the 53-77 estimation and 17 industries in the 53-85 estimation have a set of output weights that sum to a value outside of this range.

In general, the fits achieved by this model were not very impressive: 19 equations in the 53-77 estimation show values of R^2 of less than .6, and 10 of these industries show negative values of R^2[63]. In the 53-85 estimation 30 industries show values of R^2 of less than .6, but only 4 industries have negative values for R^2. The plots in Figures 4.7.a to 4.8.d also show that this model performs poorly in overall fitting ability. The fits for the Mining (3) sector and the Iron and Steel (19) sector are worse than with the Cobb-Douglas model, and many of the fitted series have spikes and turning points of their own, independent of the actual data. However, it is striking how in some sectors, such as the Stone, Clay and Glass (18), and Railroads (42), this model fits turning points better, even when

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[63] In a number of the models that follow, negative values for R^2 are possible because the equations are nonlinear, and subject to constraints. A negative R^2 means that a better fit would have been obtained by naively using the mean of the data.

Table 4.8

The CES Model - Version I. Estimated 53 to 77.

	Sector Title	SIGMA	W0	W1	W2	W3	SUMW	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.1292	0.1022	0.1034	0.1107	0.0996	0.4160	-0.135	16.3950	1849.000	0.659
2	Crude Petroleum, Natural Gas	0.2091	0.3074	0.0195	0.2270	0.3867	0.9406	-4.469	27.6100	517.500	0.820
3	Mining	1.1189	-0.0224	0.0128	0.0161	0.0612	0.0677	-0.260	20.4840	545.100	0.747
4	Construction	-0.2069	0.3418	0.6715	0.1433	0.9220	2.0785	0.799	26.9620	1720.200	0.645
5	Food, Tobacco	-0.0112	0.4315	0.3846	0.2856	0.4747	1.5765	0.777	13.9970	415.600	0.702
6	Textiles	6.5229	-0.0130	-0.0059	-0.0044	-0.0177	-0.0410	-0.059	21.9080	249.700	0.783
7	Knitting, Hosiery	-0.0017	0.3840	0.2328	0.2186	0.2075	1.0429	0.741	66.0570	43.546	0.524
8	Apparel and Household Textile	-0.0165	0.4250	0.3388	0.3947	0.4840	1.6424	0.688	25.5710	116.500	0.581
9	Paper	0.0172	0.1724	0.2664	0.1978	0.4066	1.0432	0.744	12.3080	287.300	0.132
10	Printing	-0.0145	0.4438	0.2560	0.3263	0.5028	1.5289	0.797	14.4130	170.300	0.489
11	Agricultural Fertilizers	0.1553	0.3232	0.2383	0.6516	1.0480	2.2610	0.851	34.5800	105.700	0.462
12	Other Chemicals	0.0716	0.1413	0.1929	0.1397	0.3307	0.8045	0.864	11.7160	395.300	0.312
13	Petroleum Refining and Fuel	0.3278	0.2231	0.2027	0.2179	0.1306	0.7742	0.293	42.4170	334.300	0.804
14	Rubber and Plastics	0.0002	0.2035	0.1698	0.1463	0.2022	0.7218	0.870	11.6090	140.700	0.384
15	Footwear and Leather	6.1984	-0.0063	-0.0013	-0.0054	-0.0091	-0.0221	-0.672	24.7130	38.867	0.781
16	Lumber	-0.0082	0.4062	0.2480	0.3773	0.4776	1.5091	0.725	19.6620	182.800	0.153
17	Furniture	-0.0023	0.1968	0.1859	0.1656	0.1693	0.7176	0.632	14.8340	50.764	0.480
18	Stone, Clay and Glass	-0.0447	0.3721	0.3894	0.2945	0.4208	1.4768	0.749	15.9460	195.600	0.503
19	Iron and Steel	5.1897	-0.0228	0.0053	-0.0164	0.0128	-0.0211	-2.387	26.8020	872.600	0.848
20	Non Ferrous Metals	-0.0293	0.1228	0.2248	0.1968	0.3860	0.9304	0.380	21.7810	249.100	0.517
21	Metal Products	-0.0827	0.1359	0.2095	0.0949	0.2217	0.6619	0.632	12.5280	290.900	0.529
22	Engines and Turbines	-0.0009	0.2967	0.3738	0.3770	0.2807	1.3283	0.919	22.1430	28.982	0.264
23	Agricultural Machinery	0.0002	0.1117	0.0675	0.1296	0.1790	0.4879	0.651	22.1210	38.653	0.345
25	Metalworking Machinery	0.0077	0.0206	0.1079	0.0282	0.1070	0.2636	-0.286	23.3510	141.100	0.684
27	Special Industry Machinery	1.5736	-0.0290	0.0115	0.0168	-0.0278	-0.0285	-0.111	14.6060	44.444	0.611
28	Miscellaneous Non-Electrical	-0.0267	0.1939	0.2117	0.1478	0.2737	0.8272	0.707	18.5340	174.400	0.588
29	Computers	0.001	0.0921	0.1560	0.0916	0.1655	0.5052	0.633	24.5080	104.900	0.765
30	Service Industry Machinery	-0.0016	0.1331	0.2028	0.1825	0.1894	0.7078	0.563	28.9580	54.917	0.732
31	Communications Machinery	-0.0448	0.2283	0.1613	0.2247	0.1471	0.7614	0.648	31.0720	273.700	0.794
32	Heavy Electrical Machinery	-0.0072	0.1732	0.2174	0.1401	0.2545	0.7852	0.578	18.7110	84.104	0.626
33	Household Appliances	0.0021	0.1202	0.0994	0.1252	0.0839	0.4287	0.392	27.5310	48.256	0.689
34	Electrical Lighting and wiri	-0.0052	0.2482	0.3163	0.3151	0.3237	1.2033	0.804	19.7910	66.094	0.660
35	Radio, T.V. Phonographs	-0.0005	0.1682	0.2517	0.2555	0.1625	0.8380	0.665	40.1170	28.081	0.475
36	Motor Vehicles	-0.1813	0.1361	0.2320	0.1775	0.1295	0.6751	0.643	23.3770	439.200	0.404
37	Aerospace	-0.0120	0.1622	0.1180	0.0527	0.2032	0.5361	-0.161	38.4170	268.500	0.823
38	Ships and Boats	-0.0011	0.8481	0.5512	0.9890	0.9908	3.3792	0.798	80.0200	50.809	0.154
39	Other Transportation Equipme	0.0003	0.3506	0.0907	0.3504	0.4264	1.2181	0.407	67.7980	42.693	0.753
40	Instruments	-0.0059	0.2087	0.1970	0.2184	0.1312	0.7552	0.855	15.7630	79.163	0.742
41	Miscellaneous Manufacturing	-0.0035	0.2581	0.1384	0.2064	0.1693	0.7723	0.473	16.1100	68.779	0.360
42	Railroads	-0.0334	0.1374	0.1983	0.1357	0.2049	0.6763	0.234	24.5530	834.000	0.427
43	Air Transport	-0.0432	0.2433	0.2865	0.2054	-0.1112	0.6240	0.741	26.6980	964.400	0.625
44	Trucking and Other Transport	-0.0077	0.6262	0.6090	0.8639	0.5558	2.6549	0.944	17.2280	491.200	0.551
45	Communications Services	0.1004	-0.0066	0.2208	0.5020	0.1277	0.8438	0.795	13.7740	1290.300	0.784
46	Electric Utilities	0.0090	-0.0075	0.4025	0.1745	0.1956	0.7651	0.854	12.2880	602.900	0.406
47	Gas, Water and Sanitation	0.5653	0.2287	0.0527	0.1817	0.1208	0.5839	-0.491	34.7360	600.300	0.754
48	Wholesale and Retail Trade	-0.0841	0.4698	0.4391	0.0579	0.1664	1.1332	0.941	8.4790	980.500	0.447
49	Finance and Insurance	-0.0080	0.6094	0.3591	0.5031	0.1196	1.5912	0.924	13.9600	312.700	0.382
50	Real Estate	-0.1958	0.4415	0.9461	0.9532	0.9778	3.3186	0.723	55.9060	896.400	0.868
51	Hotels and repairs Minus Aut	-0.0304	0.2922	0.5193	0.5073	0.5394	1.8582	0.525	21.6070	498.000	0.817
52	Business Services	-0.0419	0.8068	0.4039	-0.0390	0.5769	1.7486	0.841	24.4460	510.900	0.713
53	Auto repair	-0.0478	0.3275	0.3685	0.1920	0.1348	1.0229	0.719	23.7200	473.600	0.719
54	Movies and Amusements	0.5379	0.2294	0.2723	0.1936	0.1397	0.8350	0.725	20.3850	198.800	0.823
55	Medical and Educational Serv	-0.0334	0.5145	0.5420	0.0340	-0.0243	1.0662	0.899	13.8550	573.500	0.731

Table 4.9

The CES Model - Version I. Estimated 53 to 85.

	Sector Title	SIGMA	W0	W1	W2	W3	SUMW	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.1638	0.1005	0.1191	0.1651	0.1213	0.5059	0.218	17.0530	1915.900	0.663
2	Crude Petroleum, Natural Gas	0.3080	0.1628	0.3865	0.2152	0.3450	1.1095	0.125	32.4290	762.400	0.799
3	Mining	-0.0210	0.1185	0.1329	0.0922	0.0690	0.4126	0.098	22.5510	607.000	0.830
4	Construction	-0.3861	0.4097	0.5107	0.4203	0.3372	1.6780	0.859	20.0600	1697.100	0.792
5	Food, Tobacco	0.0378	0.4354	0.3590	0.3311	0.3710	1.4965	0.794	13.0400	423.900	0.601
6	Textiles	17.0894	-0.0023	-0.0018	-0.001	-0.0023	-0.0074	-0.293	20.7940	244.500	0.846
7	Knitting, Hosiery	-0.0034	0.2880	0.2307	0.2441	0.2149	0.9778	0.624	54.5790	50.142	0.604
8	Apparel and Household Textile	0.1191	0.3693	0.1851	0.1961	0.3101	1.0605	0.099	28.4910	177.900	0.704
9	Paper	-0.0217	0.1839	0.2958	0.3041	0.2422	1.0259	0.784	11.4110	372.200	0.199
10	Printing	-0.0008	0.4019	0.2543	0.2001	0.3759	1.2322	0.871	13.0790	205.500	0.528
11	Agricultural Fertilizers	0.2521	0.1331	0.4976	0.4611	0.7573	1.8491	0.715	36.2270	137.200	0.411
12	Other Chemicals	-0.0731	0.1311	0.1688	0.1488	0.1607	0.6094	0.578	14.6900	718.000	0.453
13	Petroleum Refining and Fuel	1.1240	-0.0903	0.0854	0.1291	0.1845	0.3087	0.345	37.6190	527.700	0.817
14	Rubber and Plastics	0.0366	0.1154	0.1357	0.0987	0.1081	0.4578	0.390	22.1020	298.000	0.744
15	Footwear and Leather	-0.0005	0.1145	0.1175	0.1321	0.1317	0.4959	0.032	23.8060	32.579	0.763
16	Lumber	-0.0230	0.2724	0.2349	0.3258	0.3819	1.2150	0.663	21.1120	205.900	0.420
17	Furniture	-0.0015	0.1628	0.1477	0.1264	0.1027	0.5396	0.602	14.7790	52.914	0.562
18	Stone, Clay and Glass	-0.0667	0.1887	0.2072	0.1824	0.2612	0.8395	0.435	22.0670	303.400	0.630
19	Iron and Steel	1.0378	-0.0173	0.0076	0.0292	0.0309	0.0504	-1.623	24.0390	813.100	0.842
20	Non Ferrous Metals	-0.0422	0.1102	0.1336	0.1628	0.1837	0.5902	0.159	24.1650	286.600	0.763
21	Metal Products	-0.0843	0.1298	0.1611	0.1222	0.1653	0.5784	0.502	13.2870	322.200	0.490
22	Engines and Turbines	-0.0007	0.0473	0.1250	0.0410	0.0886	0.3019	0.348	34.8540	94.829	0.872
23	Agricultural Machinery	-0.0002	0.0129	0.0613	0.1288	0.1301	0.3331	0.555	21.2240	46.388	0.649
25	Metalworking Machinery	0.0015	0.0440	0.0753	0.0542	0.0745	0.2480	-0.223	19.4510	125.500	0.779
27	Special Industry Machinery	0.0268	0.0233	0.0322	0.0550	-0.0126	0.0979	-0.003	15.9710	42.058	0.735
28	Miscellaneous Non-Electrical	-0.0272	0.0312	0.1755	-0.0200	0.2170	0.4037	0.305	28.8190	333.700	0.833
29	Computers	0.4571	0.1309	0.4074	0.1736	0.3206	1.0326	0.933	26.9790	173.100	0.660
30	Service Industry Machinery	-0.0003	0.0865	0.1164	0.1052	0.1123	0.4204	0.362	25.3980	62.725	0.683
31	Communications Machinery	0.1473	0.1468	0.3042	-0.0024	0.2909	0.7396	0.777	31.7890	463.200	0.722
32	Heavy Electrical Machinery	-0.0058	0.1079	0.1953	0.0449	0.1928	0.5409	0.365	21.6450	130.200	0.729
33	Household Appliances	0.0046	0.0886	0.0840	0.0531	0.0610	0.2867	0.140	27.2520	51.369	0.723
34	Electrical Lighting and wiri	-0.0081	0.1402	0.1674	0.1068	0.1675	0.5819	0.565	18.7030	100.300	0.682
35	Radio, T.V. Phonographs	-0.0008	0.1355	0.1589	0.1211	0.1290	0.5445	0.640	27.1190	31.586	0.655
36	Motor Vehicles	2194.6499	-0.0001	-0.0001	-0.0000	-0.0001	-0.0004	0.567	26.7110	668.400	0.303
37	Aerospace	-0.0042	0.2200	0.1309	0.0578	0.2446	0.6533	0.202	38.1870	283.100	0.747
38	Ships and Boats	0.0012	0.5753	0.4925	0.4660	0.5170	2.0508	0.563	43.9370	72.516	0.591
39	Other Transportation Equipme	7251.8701	-0.0001	-0.0000	-0.0000	-0.0001	-0.0001	0.508	37.8800	50.613	0.813
40	Instruments	-0.0047	0.1885	0.1955	0.0476	0.2344	0.6659	0.734	18.7790	142.200	0.655
41	Miscellaneous Manufacturing	-0.0039	0.2207	0.1104	0.0718	0.1603	0.5631	0.171	17.6430	77.476	0.408
42	Railroads	-0.0848	0.2101	0.2165	0.2253	0.1698	0.8217	0.526	26.9850	1018.300	0.564
43	Air Transport	-0.1248	0.0424	0.2458	0.0671	0.1510	0.5063	0.717	21.8600	1085.400	0.625
44	Trucking and Other Transport	-0.1839	0.5858	0.2893	0.3659	0.4966	1.7377	0.823	18.8710	1169.400	0.523
45	Communications Services	0.3334	0.2389	0.1949	0.2972	0.1982	0.9292	0.922	12.3490	1424.800	0.787
46	Electric Utilities	0.0464	0.1942	0.4346	0.3282	-0.1469	0.8100	0.684	18.4200	1241.700	0.400
47	Gas, Water and Sanitation	0.9068	0.2005	0.0716	0.2341	0.2737	0.7800	0.131	45.8720	1113.400	0.819
48	Wholesale and Retail Trade	-0.0228	0.9124	0.2541	0.1511	0.1927	1.5102	0.915	14.1130	2653.900	0.701
49	Finance and Insurance	0.2076	0.6039	0.0911	1.0147	0.1093	1.8189	0.947	17.7370	642.000	0.571
50	Real Estate	-0.4041	0.5976	0.6990	0.7642	0.9011	2.9619	0.808	36.6120	1301.600	0.582
51	Hotels and repairs Minus Aut	0.1053	0.4835	0.3744	0.2185	0.4387	1.5151	0.572	21.1320	510.600	0.811
52	Business Services	0.2087	0.7385	0.3818	0.0343	0.4034	1.5580	0.965	21.4210	543.200	0.680
53	Auto repair	-0.0602	0.4917	0.2588	0.1410	0.0789	0.9705	0.874	20.9300	557.500	0.527
54	Movies and Amusements	0.5181	0.1367	0.1710	0.1798	0.2461	0.7336	0.809	18.7360	205.700	0.845
55	Medical and Educational Serv	0.0683	0.5719	0.5845	-0.0199	0.0487	1.1851	0.922	13.5190	852.800	0.709

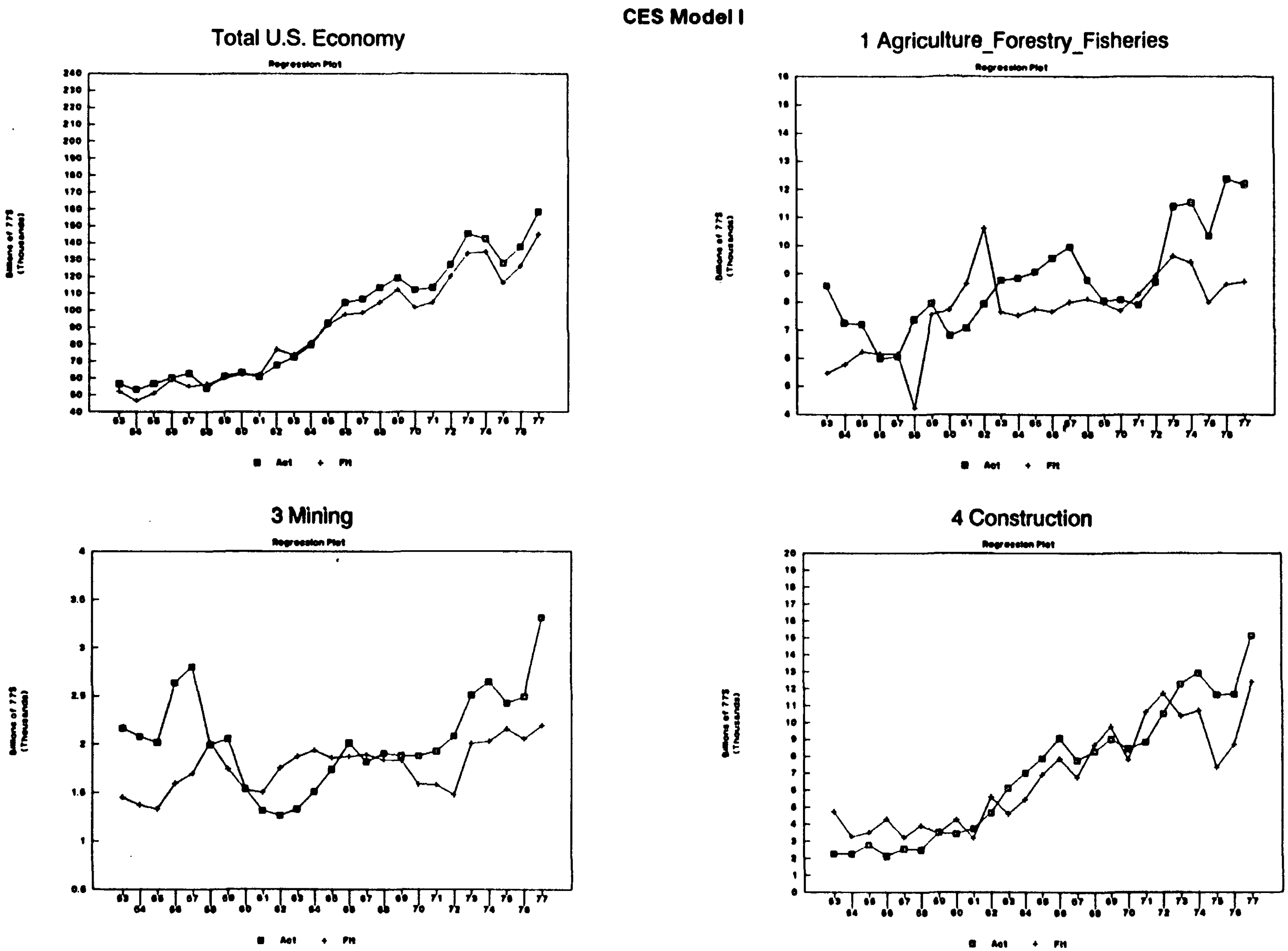


Figure 4.7.a - 1953 to 1977 Estimation

CES Model I

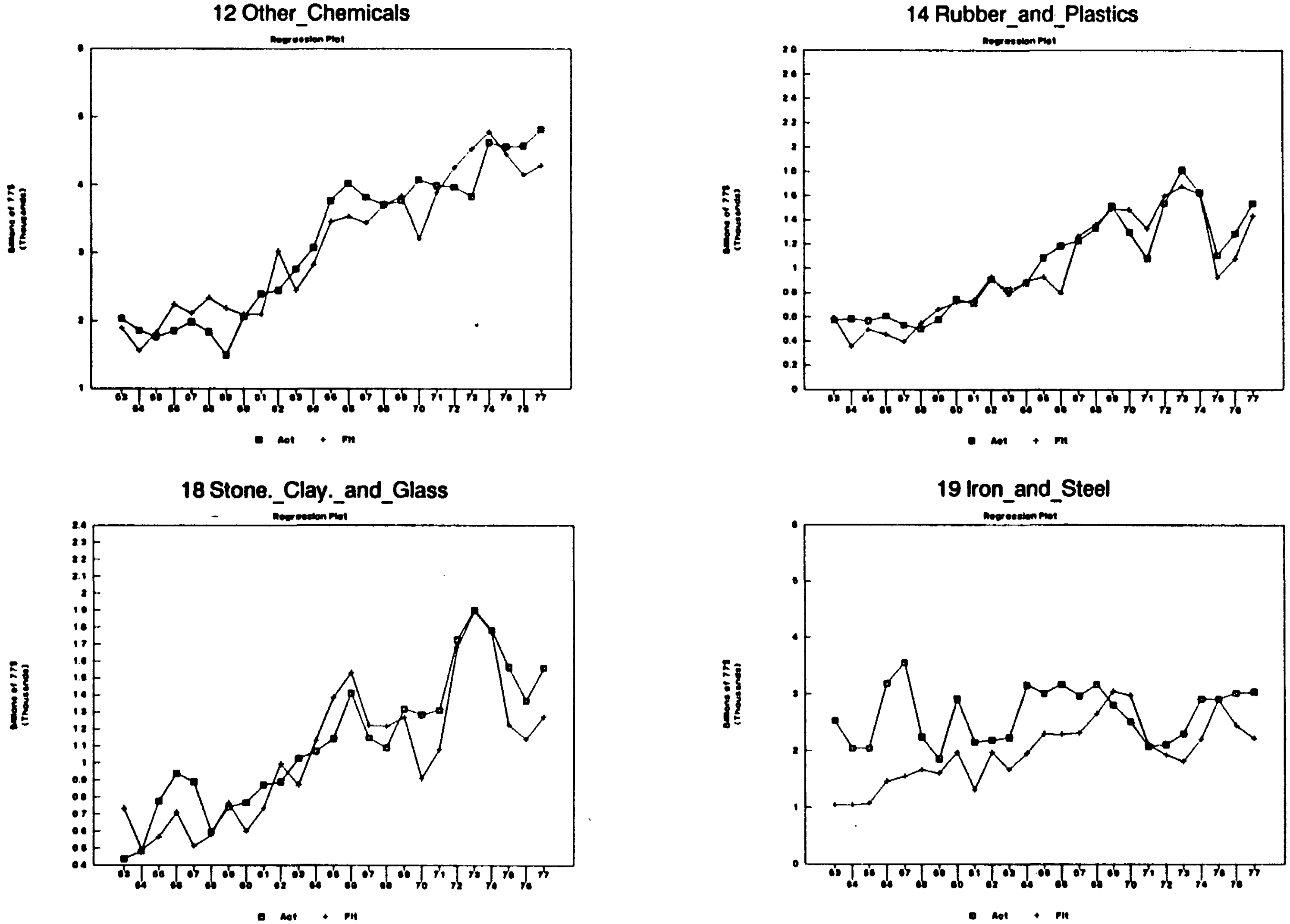
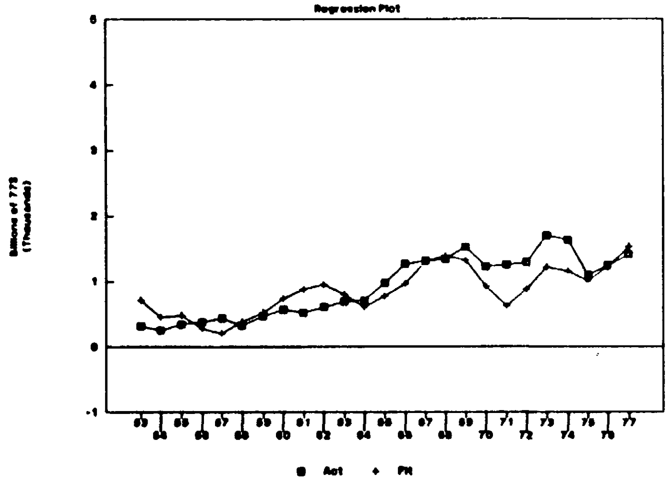


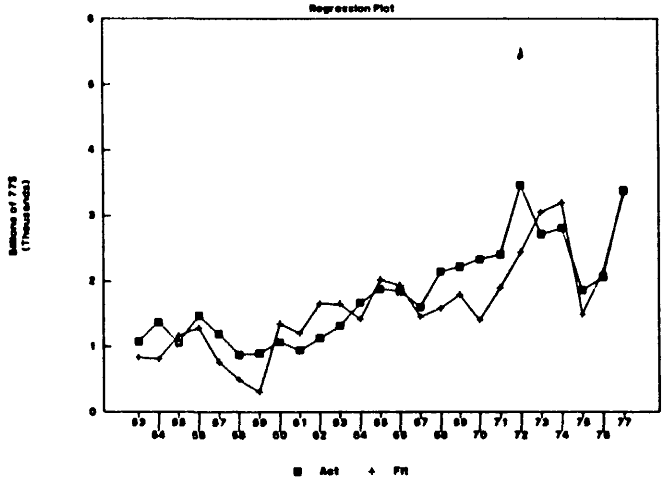
Figure 4.7.b - 1953 to 1977 Estimation

CES Model I

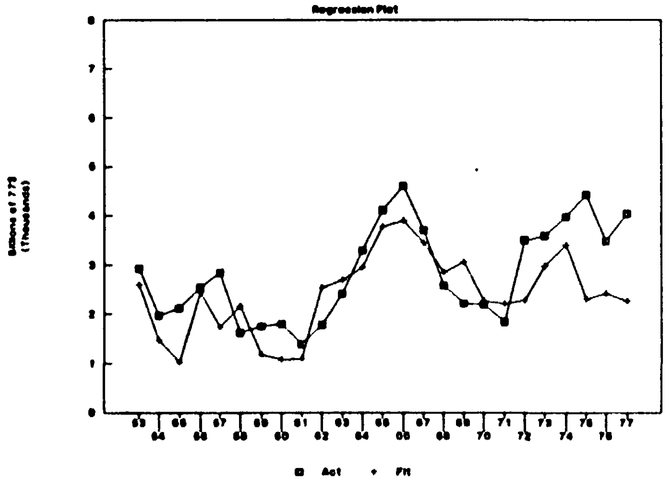
31 Communications_Machinery



36 Motor_Vehicles



42 Railroads



43 Air_Transport

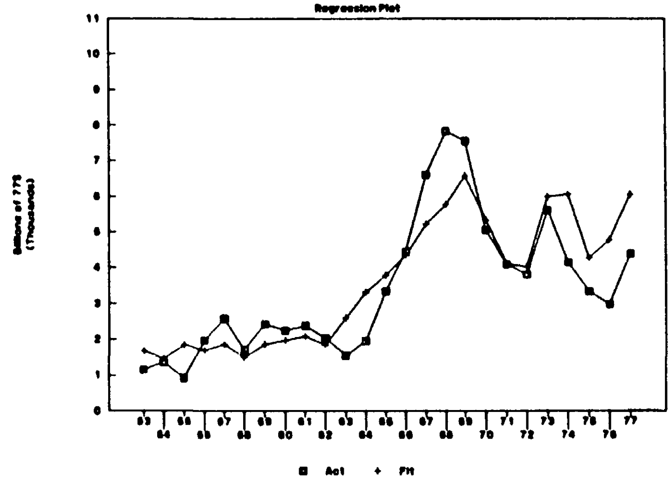


Figure 4.7.c - 1953 to 1977 Estimation

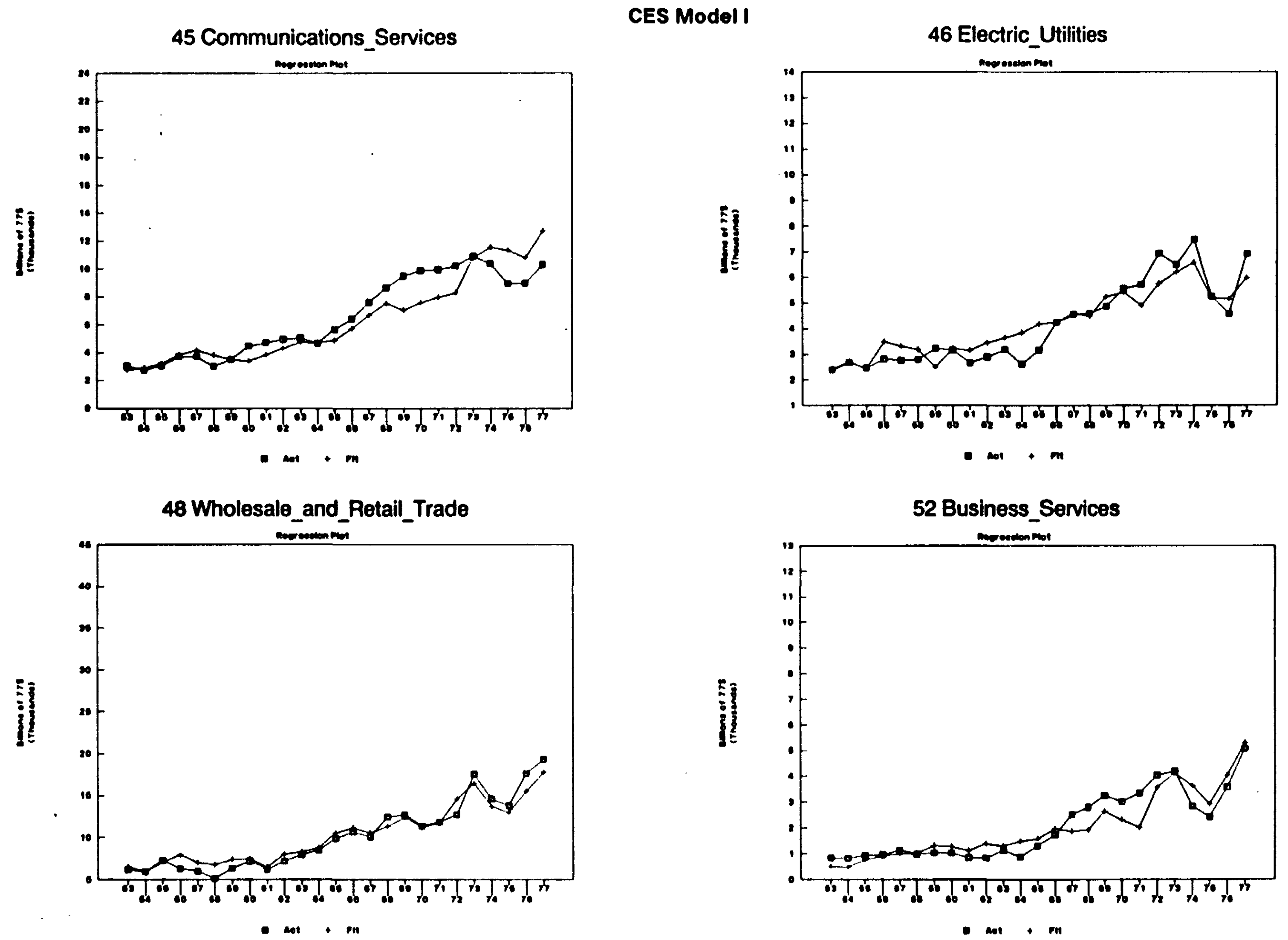


Figure 4.7.d - 1953 to 1977 Estimation

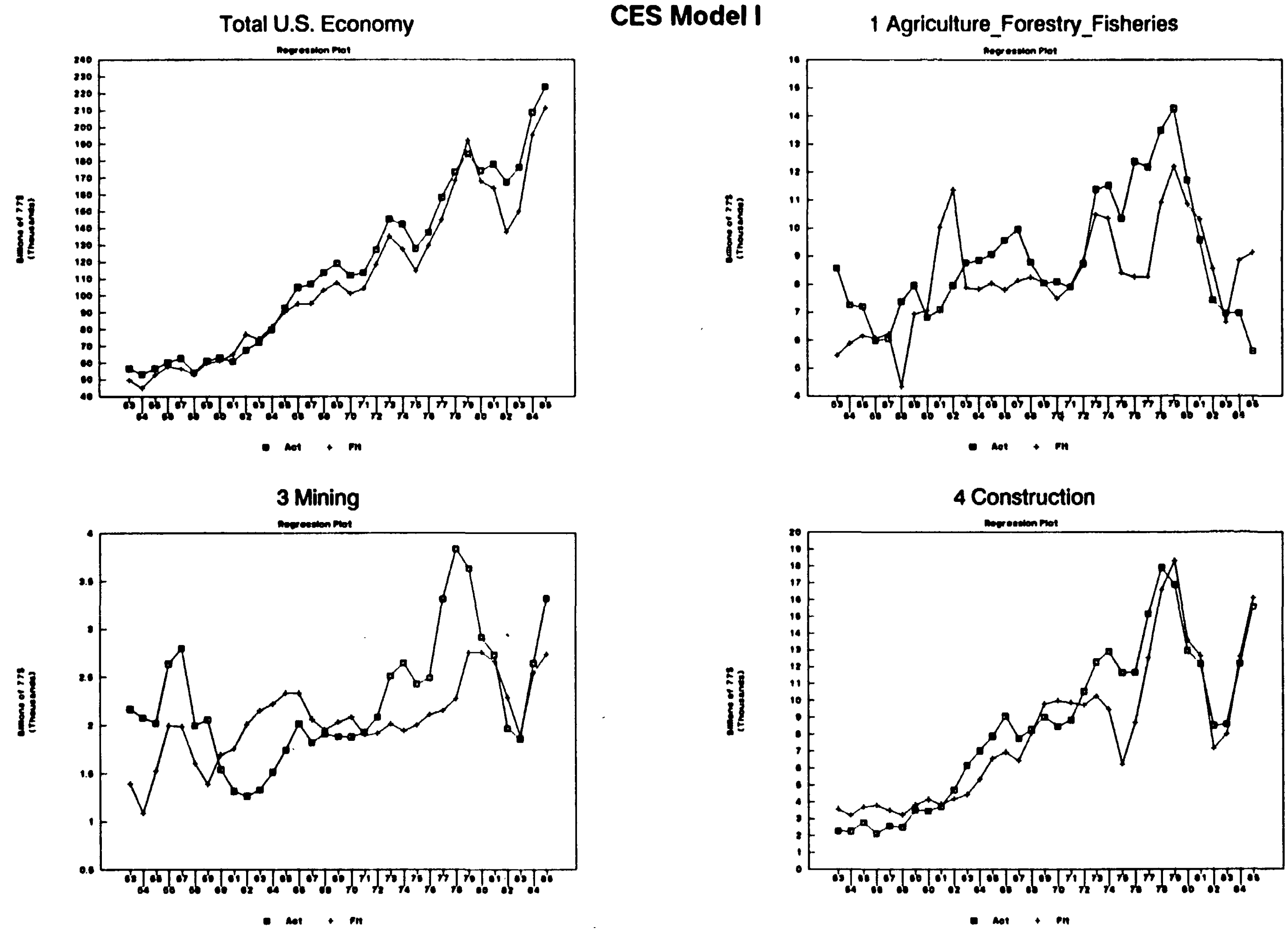


Figure 4.8.a - 1953 to 1985 Estimation

CES Model I

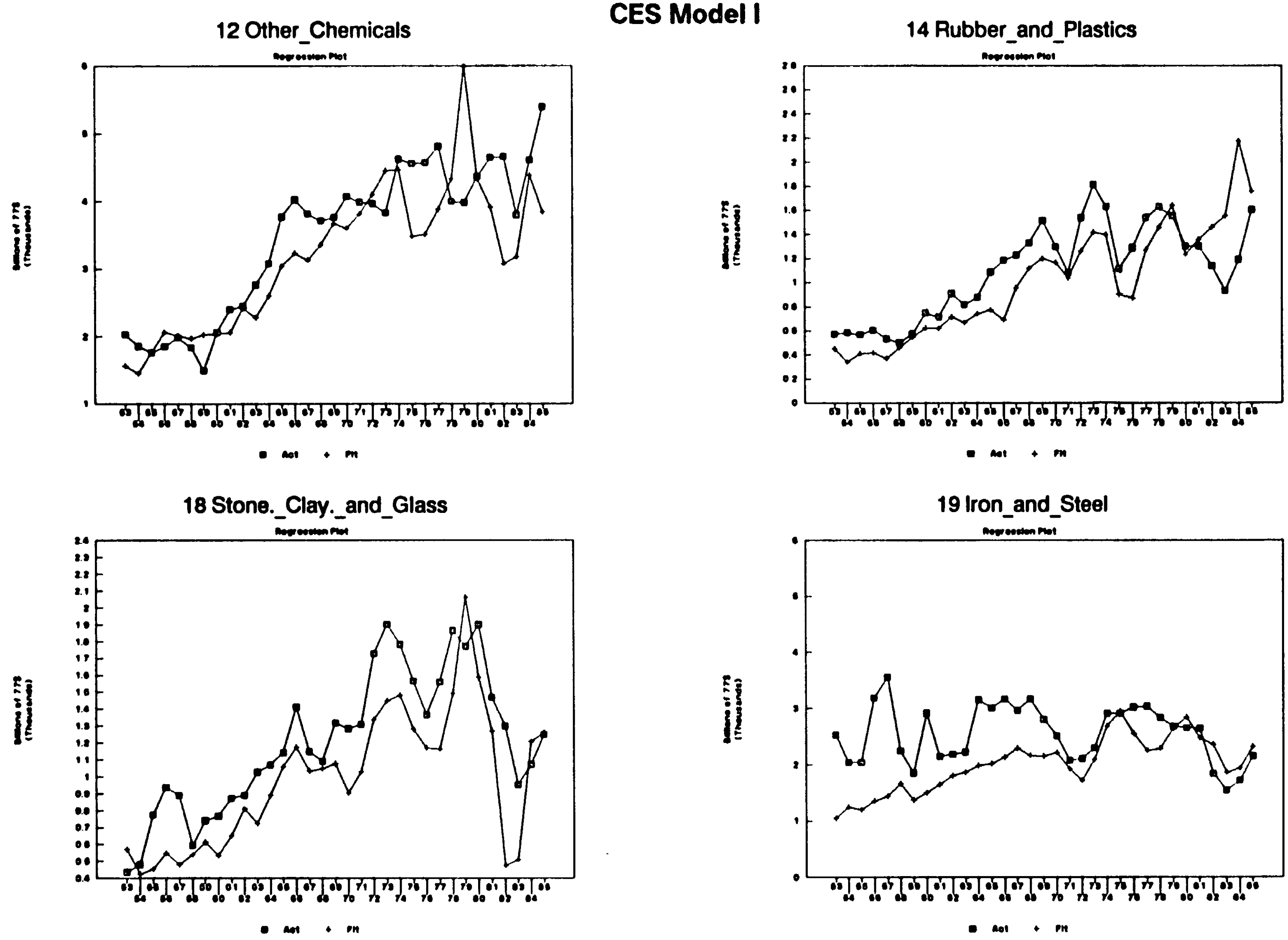


Figure 4.8.b - 1953 to 1985 Estimation

CES Model I

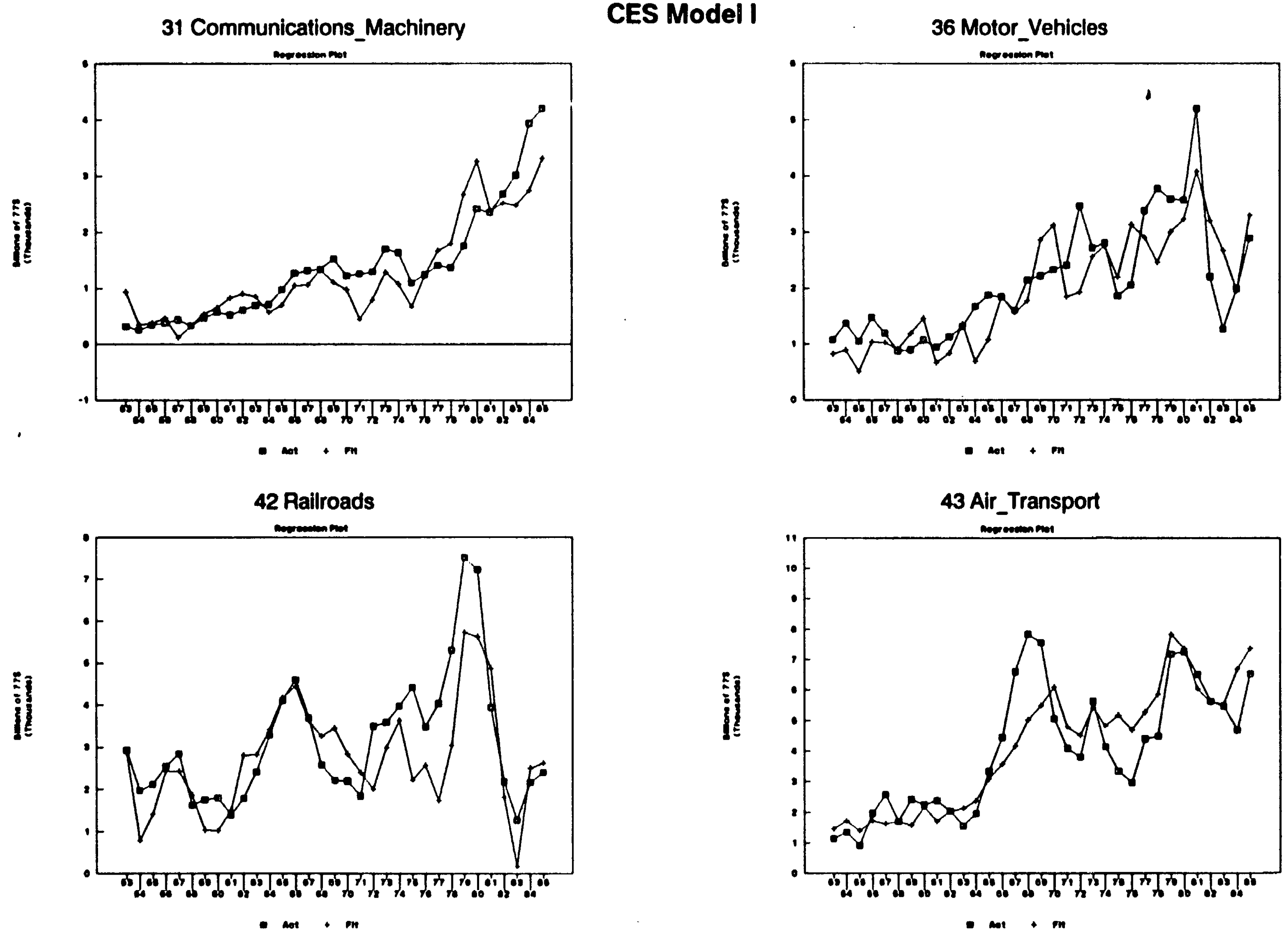


Figure 4.8.c - 1953 to 1985 Estimation

CES Model I

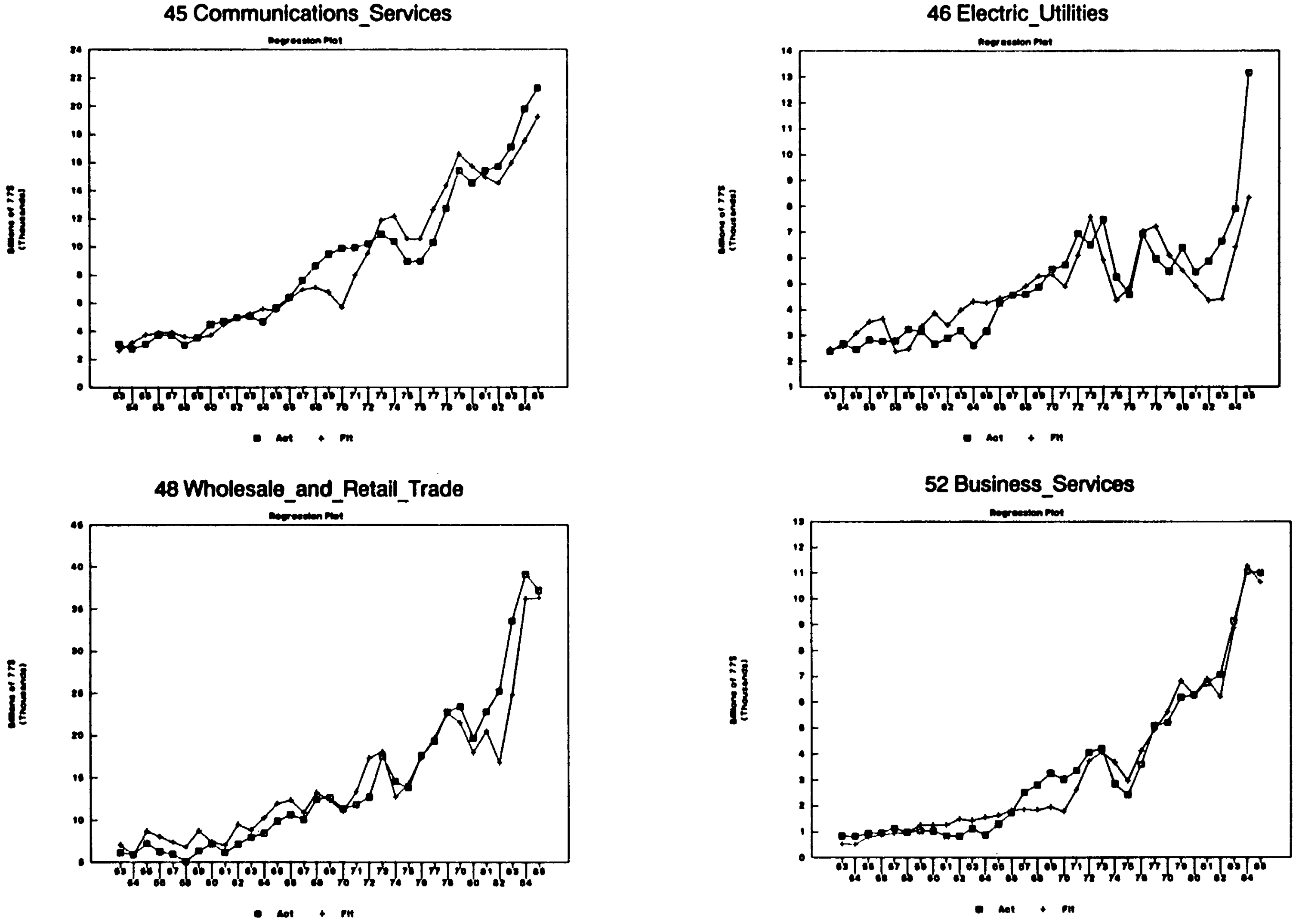


Figure 4.8.d - 1953 to 1985 Estimation

the regression has a lower R^2.

Some of the blame for the rather poor fits can be attributed to the soft constraints. Since the constraints were not even very successful at achieving reasonable results, this model should probably be abandoned as a sensible forecasting tool. However, this model will still be included for simulation testing in Chapter V.

5. CES Model II

This model is a cousin of the previous model, since it too is derived assuming a CES production function. However, investment responds to output and price changes with a different lag structure. The model expresses net investment as a function of the lagged capital stock, the lagged capital stock times a distributed lag on proportionate changes in output, and lagged capital stock times a distributed lag on proportionate changes in the relative user cost of capital. The estimated equation is reproduced below:

$$(5.1) \qquad N_t = a\, K_{t-1} + K_{t-1} \sum_{i=0}^{3} w_i \, \underline{\Delta Q}_{t-i} - K_{t-1} \sum_{i=0}^{3} \sigma_i \, \underline{\Delta c}_{t-i}$$

where all symbols are as in the previous model. The lag weights w_i on output are expected to be positive. The lag weights σ_i on the relative user cost of capital are also expected to be positive. The sum of these lag weights can be interpreted as the long run elasticity of substitution σ. Since this is a net investment model, the coefficient on capital stock does not relate to replacement investment, but rather to the effect of existing capital stock on new investment. Its sign could logically be either positive or negative. The w_i's were constrained to lie along a second degree Almon polynomial.[64] A version of this model was also tried where the sum of the w_i's was softly constrained to unity, but this version yielded extremely poor fits.

Tables 4.10.a to 4.11.b show the parameter estimates and regression statistics for both sets of estimations. The column labeled *STOCK* contains the coefficient *a* of the lagged capital stock. The columns labeled *QDOT* thru *QDOT[3]*, show the estimates of the weights w_i, on the changes in output, and the column labeled *SUMQ* shows the sum of these weights. Similarly, the columns *RDOT* thru *RDOT[3]* show the corresponding weights σ_i on the real cost of capital, and *SUMR* shows the sum of these weights, which is the estimate of the long run σ.

The estimates of the lagged capital stock coefficient *a* in both estimation periods are positive, except for 5 industries in the 53-77 estimation, and for 2 industries in the 53-85 estimation. One reason this coefficient may be positive is that the term is picking up trend effects, since the capital stock also follows a smooth trend. Another possible reason could be "measurement error" in the replacement investment estimates used to create the net investment

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[64] This model was estimated as in footnote 2.

series. For example, if the estimate for replacement investment (depreciation) were too low, then both the estimate of capital stock and of net investment would be higher for that period, and conversely if the estimate of replacement investment is too high. This measurement error alone would yield a positive correlation between capital stock and net investment. At any rate, capital stock seems to have a positive effect on net investment in most industries, but the interpretation of this coefficient is ambiguous.

The sum of the output coefficients should be positive, since this quantity is the long-run proportional increase in net investment brought about by given proportional increase in output, or the demand for capacity. For the most part, this condition is satisfied, except for 6 industries in the 53 to 77 estimation, and 3 industries in the 53 to 85 estimation. The estimates for σ ($\sum\sigma_i$) are also expected to be positive. However, 27 industries in the 53-77 estimation and 15 industries in the 53-85 estimation have negative estimates of σ. Almon and Barbera (1980) obtained no negative values for σ. However, like Reimbold, they used a quadratic programming technique, and constrained the estimate of σ to be greater than or equal to zero. Out of a total of 87 industries, they obtained an estimate of zero for σ in 32 cases, which means that σ would have been negative without the constraint applied. Either a negative value of σ or of the sum of the output weights will result in perverse simulation properties.

Of all the parameters estimated in this model, the coefficient on the capital stock appears to be the most stable. Both the values of *SUMQ* and *SUMR* (σ) are quite different between the two estimation periods. Furthermore, the estimated values of σ are very different in the two CES versions.

The quality of the fits for this model appears to be slightly better than that of the first CES model. Fourteen industries in the 53-77 estimation and 12 industries in the 53-85 estimation period have R^2s less than 0.6. Only 5 industries in each estimation have negative values for R^2. Figures 4.9.a to 4.10.d show plots of regression fits for both estimation sets. The impression that this model fits better than the first CES model suggested by a simple counting of R^2s is strengthened by these regression plots. For most sectors, CES model II is better than CES model I at picking up turning points, and in general quality of fit. A notable exception, however, is Mining (3), where the model has almost no explanatory power.

Table 4.10.a

The CES model - Version II. Estimated 53 to 77.

	Sector Title	STOCK	QDOT	QDOT[1]	QDOT[2]	QDOT[3]	SUMQ
1	Agriculture, Forestry, Fisher	0.0191	0.0257	-0.0199	-0.0215	-0.0007	-0.0164
2	Crude Petroleum, Natural Gas	0.0196	0.1620	-0.0205	0.0835	0.1305	0.3555
3	Mining	0.0153	-0.0841	-0.0215	-0.0018	-0.0101	-0.1175
4	Construction	0.0494	0.2402	0.2331	0.1227	0.0926	0.6887
5	Food, Tobacco	0.0436	-0.0058	-0.0890	-0.0589	-0.0063	-0.1599
6	Textiles	0.0118	0.0915	0.1057	0.1494	0.1184	0.4649
7	Knitting, Hosiery	0.0355	0.1006	0.0899	0.1284	0.1010	0.4199
8	Apparel and Household Textile	0.0177	0.1374	0.1558	0.2807	0.2271	0.8010
9	Paper	0.0324	0.0661	0.0611	0.0503	0.0732	0.2508
10	Printing	0.0314	0.1177	0.0986	0.1259	0.0967	0.4389
11	Agricultural Fertilizers	0.0661	-0.0215	0.0131	0.3723	0.3571	0.7210
12	Other Chemicals	0.0096	0.1515	0.1288	0.0930	0.2416	0.6149
13	Petroleum Refining and Fuel	-0.0150	0.1415	0.1053	0.4920	0.4574	1.1961
14	Rubber and Plastics	0.0178	0.1390	0.0907	0.1084	0.1109	0.4490
15	Footwear and Leather	0.0168	0.0058	0.0159	0.2838	0.2727	0.5782
16	Lumber	0.0396	0.0421	0.0911	0.1686	0.1162	0.4180
17	Furniture	0.0235	0.0489	0.0791	0.0508	0.0092	0.1881
18	Stone, Clay and Glass	0.0266	0.1411	0.1793	0.1775	0.0953	0.5931
19	Iron and Steel	0.0223	-0.0104	0.0061	-0.0196	0.0036	-0.0202
20	Non Ferrous Metals	0.0355	0.0064	0.0400	0.0810	0.0779	0.2053
21	Metal Products	0.0159	0.0968	0.1037	0.0928	0.0507	0.3440
22	Engines and Turbines	0.0414	0.0764	0.1019	0.1437	0.0982	0.4202
23	Agricultural Machinery	0.0284	0.0260	0.0208	0.0890	0.0827	0.2185
25	Metalworking Machinery	0.0097	0.0314	0.0639	0.0730	0.0640	0.2322
27	Special Industry Machinery	0.0036	0.0099	0.0287	0.0123	-0.0080	0.0429
28	Miscellaneous Non-Electrical	0.0281	0.0907	0.0648	0.0838	0.0813	0.3206
29	Computers	0.0197	0.0777	0.0707	0.0886	0.0877	0.3247
30	Service Industry Machinery	0.0168	0.0790	0.1056	0.1411	0.1032	0.4289
31	Communications Machinery	0.0249	0.0616	0.1166	0.1142	0.0192	0.3116
32	Heavy Electrical Machinery	0.0183	0.1010	0.0904	0.0905	0.0787	0.3606
33	Household Appliances	-0.0142	0.1278	0.1135	0.1779	0.1482	0.5674
34	Electrical Lighting and wiri	0.0228	0.1261	0.1692	0.1885	0.1200	0.6038
35	Radio, T.V. Phonographs	0.0682	0.0211	0.0276	0.0383	0.0278	0.1147
36	Motor Vehicles	0.0019	0.0781	0.1595	0.1224	0.0880	0.4480
37	Aerospace	0.0298	0.2294	0.0929	0.0785	0.1420	0.5428
38	Ships and Boats	0.1798	0.0152	-0.0032	-0.0010	0.0095	0.0205
39	Other Transportation Equipme	0.1026	0.0104	0.0094	0.0201	0.0185	0.0583
40	Instruments	0.0246	0.0583	0.1203	0.1120	0.0400	0.3306
41	Miscellaneous Manufacturing	0.0264	0.0640	0.0380	0.0182	0.0121	0.1323
42	Railroads	0.0144	0.0784	0.1068	0.0707	0.1220	0.3779
43	Air Transport	-0.0373	0.3826	0.3853	0.0687	-0.0336	0.8030
44	Trucking and Other Transport	0.0139	0.3654	0.4681	0.6478	0.4145	1.8958
45	Communications Services	-0.0004	0.2167	0.2257	0.2257	0.1279	0.7960
46	Electric Utilities	-0.0177	0.0640	0.5235	0.2504	0.1552	0.9931
47	Gas, Water and Sanitation	0.0406	-0.0241	-0.1208	-0.0403	0.0536	-0.1315
48	Wholesale and Retail Trade	0.0149	0.4962	0.2348	-0.0914	0.0418	0.6813
49	Finance and Insurance	0.0124	0.2741	0.1878	0.3555	0.2937	1.1110
50	Real Estate	0.0677	-0.1103	0.1560	0.5472	0.3000	0.8929
51	Hotels and repairs Minus Aut	0.0267	-0.1065	0.3156	0.4354	0.1774	0.8219
52	Business Services	0.0110	0.6513	0.6305	0.2922	0.0439	1.6179
53	Auto repair	0.0131	0.3462	0.2354	0.0466	0.0316	0.6597
54	Movies and Amusements	0.0475	-0.0144	0.0230	-0.0180	-0.0345	-0.0439
55	Medical and Educational Serv	0.0114	0.4686	0.3662	-0.0036	-0.0203	0.8109

Table 4.10.b

The CES model - Version II. Estimated 53 to 77.

	Sector Title	RDOT	RDOT[1]	RDOT[2]	RDOT[3]	SUMR	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.0273	0.0194	0.0195	0.0233	0.0894	0.551	11.5780	1163.300	0.587
2	Crude Petroleum, Natural Gas	-0.0316	-0.0217	-0.0097	0.0611	-0.0020	-3.445	24.3950	466.600	0.865
3	Mining	-0.0356	0.0360	0.0394	0.0855	0.1254	-0.067	22.1970	501.700	0.675
4	Construction	0.0237	0.0014	0.0564	0.1103	0.1918	0.941	17.2340	930.900	0.634
5	Food, Tobacco	-0.0038	0.0068	-0.0033	-0.0124	-0.0128	0.973	5.5650	144.800	0.779
6	Textiles	-0.0019	-0.0381	0.0530	-0.0500	-0.0370	0.676	13.8250	138.100	0.523
7	Knitting, Hosiery	0.1371	0.0025	-0.0209	-0.0246	0.0941	0.622	68.5690	52.599	0.590
8	Apparel and Household Textile	-0.0100	-0.0287	-0.0625	-0.0685	-0.1697	0.683	21.8040	117.600	0.662
9	Paper	-0.0203	0.0473	0.0004	0.0727	0.1000	0.808	11.3320	248.600	0.606
10	Printing	0.0012	-0.0089	-0.0041	-0.0402	-0.0519	0.946	8.3190	87.632	0.626
11	Agricultural Fertilizers	0.2996	0.0112	0.2501	0.0300	0.5909	0.812	34.4640	118.700	0.401
12	Other Chemicals	0.0597	-0.0693	0.0388	0.0503	0.0795	0.843	12.7220	424.800	0.275
13	Petroleum Refining and Fuel	0.0552	0.1507	0.1044	0.0273	0.3376	0.143	40.7400	367.800	0.723
14	Rubber and Plastics	-0.0330	0.0329	0.0500	-0.0290	0.0209	0.898	9.5480	124.500	0.303
15	Footwear and Leather	0.0162	0.0868	-0.0010	-0.0041	0.0979	0.141	18.9190	27.853	0.353
16	Lumber	0.0193	-0.0023	-0.0308	0.0053	-0.0085	0.936	13.0080	88.464	0.113
17	Furniture	-0.0139	-0.0128	-0.0046	-0.0077	-0.0390	0.795	15.0020	37.841	0.527
18	Stone, Clay and Glass	-0.0056	-0.0018	0.0084	-0.0439	-0.0429	0.911	8.9470	116.400	0.343
19	Iron and Steel	-0.0719	0.0530	-0.0140	0.1258	0.0930	-1.022	20.9620	674.300	0.665
20	Non Ferrous Metals	-0.0573	-0.0290	0.0780	-0.0181	-0.0264	0.765	16.9870	153.500	0.416
21	Metal Products	-0.0292	-0.0484	0.0033	-0.0268	-0.1011	0.885	7.4590	162.900	0.382
22	Engines and Turbines	-0.0182	-0.0109	0.0763	-0.0041	0.0431	0.853	19.5650	39.005	0.584
23	Agricultural Machinery	0.0723	0.0002	0.0066	-0.0013	0.0777	0.811	17.4120	28.484	0.059
25	Metalworking Machinery	-0.0395	0.0456	0.0356	-0.0220	0.0197	-0.134	24.6500	132.500	0.683
27	Special Industry Machinery	-0.0233	0.0017	0.0010	-0.0067	-0.0273	-0.022	16.1220	42.638	0.688
28	Miscellaneous Non-Electrical	-0.0211	-0.0375	0.0319	-0.0050	-0.0318	0.935	7.6900	82.398	0.341
29	Computers	-0.0042	-0.0175	0.0143	-0.0025	-0.0099	0.685	21.7220	97.105	0.678
30	Service Industry Machinery	-0.0085	0.0165	-0.0133	-0.0438	-0.0492	0.640	28.5070	49.845	0.670
31	Communications Machinery	-0.1270	0.0296	-0.0671	-0.0774	-0.2419	0.765	21.1730	223.300	0.672
32	Heavy Electrical Machinery	-0.0342	-0.0466	-0.0155	-0.0134	-0.1097	0.717	13.7330	68.915	0.740
33	Household Appliances	-0.0317	-0.0152	-0.0135	-0.0485	-0.1088	0.291	26.1700	52.141	0.575
34	Electrical Lighting and wiri	-0.0395	-0.0102	-0.0010	-0.0148	-0.0656	0.871	18.1480	53.725	0.611
35	Radio, T.V. Phonographs	0.0231	0.0371	0.1901	-0.0033	0.2470	0.447	42.1720	36.060	0.558
36	Motor Vehicles	-0.0416	-0.1253	-0.0769	-0.1355	-0.3792	0.449	24.4870	545.700	0.700
37	Aerospace	0.0367	-0.0280	0.0013	0.0070	0.0169	0.328	35.7220	204.200	0.701
38	Ships and Boats	0.0483	0.6244	-0.0081	0.9972	1.6618	0.727	57.0120	59.014	-0.110
39	Other Transportation Equipme	0.0373	0.0087	0.0063	-0.0003	0.0520	0.871	69.4380	19.942	0.837
40	Instruments	-0.0547	0.0488	-0.0326	-0.0324	-0.0709	0.878	12.2270	72.564	0.667
41	Miscellaneous Manufacturing	-0.0212	0.0053	-0.0231	-0.0032	-0.0422	0.704	12.2760	51.548	0.261
42	Railroads	0.0251	0.0144	0.0211	0.0300	0.0906	0.480	24.1850	686.900	0.447
43	Air Transport	0.0021	-0.0635	-0.0962	-0.0859	-0.2434	0.792	26.3670	865.400	0.582
44	Trucking and Other Transport	0.0447	0.0148	0.0194	-0.0816	-0.0026	0.938	17.3100	516.300	0.562
45	Communications Services	0.0318	0.0834	0.0151	0.0576	0.1880	0.735	14.1130	1466.500	0.741
46	Electric Utilities	0.0676	0.0147	-0.0027	0.0166	0.0962	0.797	16.3730	712.100	0.492
47	Gas, Water and Sanitation	0.0250	0.0075	0.0636	-0.0059	0.0901	0.280	27.4820	417.100	0.693
48	Wholesale and Retail Trade	-0.0362	-0.0615	0.0605	0.0819	0.0447	0.934	9.0710	1039.400	0.449
49	Finance and Insurance	-0.0023	0.0319	0.0603	0.0505	0.1404	0.918	12.9900	325.100	0.340
50	Real Estate	-0.1755	0.0036	-0.0949	-0.2510	-0.5178	0.833	39.7920	695.400	0.723
51	Hotels and repairs Minus Aut	-0.0316	0.0450	-0.0665	-0.1090	-0.1620	0.677	17.6550	410.500	0.636
52	Business Services	-0.1159	-0.1008	-0.1923	-0.3089	-0.7179	0.780	26.9560	601.800	0.608
53	Auto repair	-0.0988	-0.0872	0.0291	0.1192	-0.0378	0.715	22.1210	476.900	0.685
54	Movies and Amusements	0.0344	0.0723	0.0454	0.0323	0.1844	0.897	7.8810	121.400	0.622
55	Medical and Educational Serv	-0.0004	0.0063	0.0326	0.0281	0.0666	0.903	13.2680	562.700	0.737

Table 4.11.a

The CES model - Version II. Estimated 53 to 85.

	Sector Title	STOCK	QDOT	QDOT[1]	QDOT[2]	QDOT[3]	SUMQ
1	Agriculture, Forestry, Fisher	0.0108	0.1010	0.0714	0.0914	0.1151	0.3790
2	Crude Petroleum, Natural Gas	0.0212	0.3991	0.3914	0.0812	-0.0382	0.8334
3	Mining	0.0153	0.0252	0.0260	0.0273	0.0115	0.0900
4	Construction	0.0257	0.3887	0.4204	0.2087	0.2526	1.2703
5	Food, Tobacco	0.0247	0.2181	0.1803	0.0714	0.0468	0.5166
6	Textiles	0.0151	0.0468	0.0528	0.0102	0.0066	0.1164
7	Knitting, Hosiery	0.0174	0.1033	0.0924	0.1603	0.1318	0.4878
8	Apparel and Household Textile	0.0022	0.2416	0.1685	0.2492	0.2314	0.8907
9	Paper	0.0275	0.0445	0.0748	0.0983	0.1042	0.3218
10	Printing	0.0362	0.0856	0.0270	0.0196	0.0409	0.1730
11	Agricultural Fertilizers	0.0309	0.0784	0.1648	0.3943	0.3329	0.9703
12	Other Chemicals	0.0185	0.0859	0.0724	0.0511	0.1028	0.3122
13	Petroleum Refining and Fuel	0.0417	-0.0443	-0.1144	-0.0486	0.0651	-0.1421
14	Rubber and Plastics	0.0120	0.1882	0.1196	0.0740	0.1056	0.4873
15	Footwear and Leather	0.0079	0.0347	0.0348	0.2112	0.1991	0.4799
16	Lumber	0.0186	0.1697	0.2252	0.2397	0.1743	0.8090
17	Furniture	0.0169	0.0640	0.0763	0.0316	0.0020	0.1739
18	Stone, Clay and Glass	0.0137	0.1181	0.2019	0.2208	0.1511	0.6919
19	Iron and Steel	0.0157	0.0473	0.0402	0.0439	0.0540	0.1854
20	Non Ferrous Metals	0.0249	0.0726	0.0408	0.0876	0.1030	0.3040
21	Metal Products	0.0046	0.1259	0.1258	0.1182	0.0941	0.4640
22	Engines and Turbines	0.0406	0.0305	0.0488	0.0823	0.0654	0.2270
23	Agricultural Machinery	0.0197	0.0298	0.0394	0.1229	0.1083	0.3004
25	Metalworking Machinery	0.0068	0.0390	0.0589	0.0714	0.0664	0.2357
27	Special Industry Machinery	-0.0005	0.0232	0.0422	0.0349	0.0086	0.1088
28	Miscellaneous Non-Electrical	0.0269	0.0770	0.0668	0.0660	0.0557	0.2655
29	Computers	0.0465	0.0227	0.1189	0.2210	0.1707	0.5334
30	Service Industry Machinery	0.0137	0.0430	0.0632	0.0842	0.0614	0.2518
31	Communications Machinery	0.0574	-0.0426	0.0624	0.0719	0.1231	0.2148
32	Heavy Electrical Machinery	0.0260	0.0509	0.0371	0.0251	0.0297	0.1429
33	Household Appliances	0.0015	0.0541	0.0463	0.0574	0.0459	0.2036
34	Electrical Lighting and wiri	0.0199	0.0586	0.0782	0.0595	0.0407	0.2370
35	Radio, T.V. Phonographs	0.0482	0.0305	0.0258	0.0392	0.0349	0.1303
36	Motor Vehicles	0.0095	-0.0721	0.0155	0.1015	0.0991	0.1440
37	Aerospace	0.0345	0.0628	0.0906	0.1294	0.1262	0.4091
38	Ships and Boats	0.0529	0.0674	0.0682	0.3142	0.2948	0.7446
39	Other Transportation Equipme	0.0807	0.0260	0.0234	0.0806	0.0740	0.2040
40	Instruments	0.0392	0.0157	-0.0174	0.0052	0.0315	0.0351
41	Miscellaneous Manufacturing	0.0108	0.1387	0.0731	0.0434	0.0518	0.3070
42	Railroads	0.0124	0.1862	0.1554	0.1887	0.1315	0.6618
43	Air Transport	-0.0319	0.1932	0.2309	0.1327	0.1853	0.7421
44	Trucking and Other Transport	0.0366	0.3387	0.1031	0.1289	0.3413	0.9120
45	Communications Services	0.0520	-0.0671	0.0321	0.0620	0.0262	0.0532
46	Electric Utilities	0.0256	0.1021	0.4142	0.0882	-0.2495	0.3551
47	Gas, Water and Sanitation	0.0453	-0.0845	-0.0079	0.1539	0.0221	0.0836
48	Wholesale and Retail Trade	0.0593	0.2740	-0.0273	-0.2185	-0.3105	-0.2823
49	Finance and Insurance	0.0269	-0.0423	-0.0880	0.5420	0.5580	0.9696
50	Real Estate	0.0532	0.0341	0.2239	0.3410	0.3595	0.9584
51	Hotels and repairs Minus Aut	0.0167	0.0207	0.1367	0.3789	0.3025	0.8388
52	Business Services	0.0201	0.2482	0.5074	0.3057	-0.0046	1.0567
53	Auto repair	0.0362	0.3161	0.0693	-0.0355	-0.0846	0.2652
54	Movies and Amusements	0.0456	-0.0252	-0.0322	-0.0273	-0.0052	-0.0899
55	Medical and Educational Serv	0.0363	0.0959	0.2169	0.0315	-0.0121	0.3321

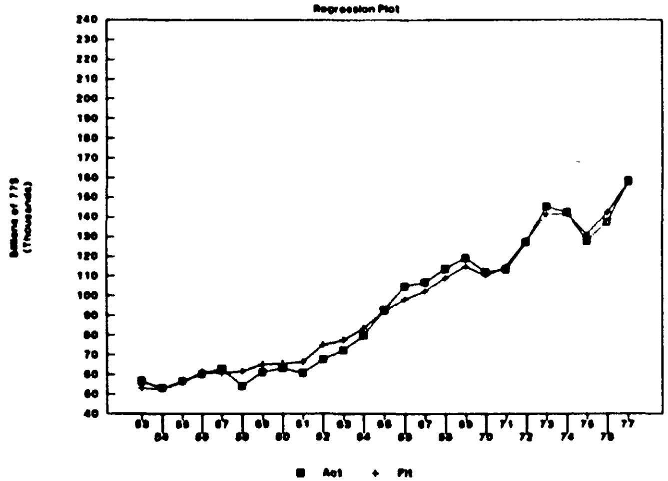
Table 4.11.b

The CES model - Version II.   Estimated 53 to 85.

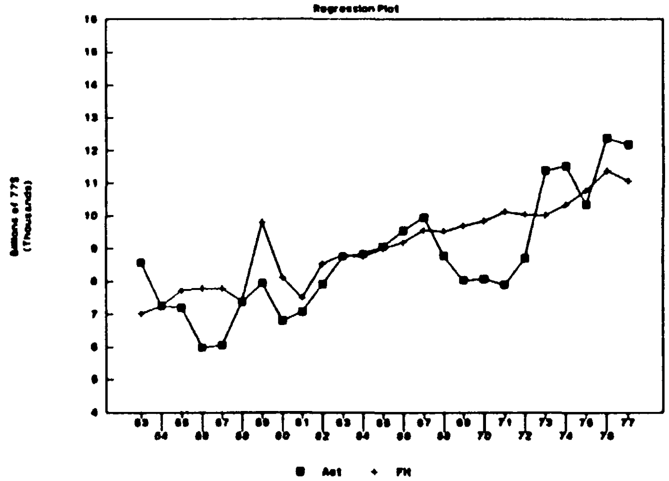
	Sector Title	RDOT	RDOT[1]	RDOT[2]	RDOT[3]	SUMR	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.0459	0.0210	0.0252	0.0596	0.1517	-0.311	24.2720	2479.800	0.636
2	Crude Petroleum, Natural Gas	0.0625	0.0936	0.1059	0.0560	0.3180	-0.036	31.6390	829.600	0.756
3	Mining	-0.0419	0.0473	0.0356	0.0795	0.1205	0.190	23.7380	575.400	0.788
4	Construction	-0.0045	-0.0825	-0.0709	0.2130	0.0551	0.861	17.1740	1684.600	0.571
5	Food, Tobacco	0.0417	-0.0021	0.0419	0.0659	0.1474	0.783	11.7480	435.700	0.849
6	Textiles	0.0266	0.0089	0.0338	0.0202	0.0895	0.163	18.2370	196.700	0.862
7	Knitting, Hosiery	0.0132	-0.0007	-0.0227	-0.0236	-0.0337	0.633	47.6010	49.548	0.545
8	Apparel and Household Textile	0.1060	-0.0390	-0.0018	0.0126	0.0777	0.102	31.3180	177.600	0.752
9	Paper	-0.0342	0.0415	0.0203	0.0590	0.0867	0.866	11.1490	293.200	0.389
10	Printing	-0.0201	0.0066	0.0359	0.0102	0.0327	0.948	8.4240	130.100	0.533
11	Agricultural Fertilizers	0.1892	0.1757	0.1975	0.2111	0.7735	0.429	45.0970	194.300	0.501
12	Other Chemicals	-0.0255	-0.0046	-0.0088	0.0611	0.0222	0.769	11.9690	531.000	0.401
13	Petroleum Refining and Fuel	-0.0243	0.0426	0.0702	0.0641	0.1526	0.711	38.4980	350.700	0.810
14	Rubber and Plastics	-0.0067	0.0434	0.0122	0.1653	0.2142	0.130	19.1380	355.900	0.673
15	Footwear and Leather	-0.0037	0.0231	0.0039	-0.0065	0.0168	0.021	27.1180	32.763	0.527
16	Lumber	0.0704	-0.0125	-0.0305	0.1317	0.1591	0.643	18.9030	212.000	0.608
17	Furniture	-0.0133	-0.0070	0.0114	0.0467	0.0378	0.673	15.2940	47.970	0.703
18	Stone, Clay and Glass	0.0110	-0.0328	-0.0657	-0.0889	-0.1764	0.661	15.7870	235.000	0.408
19	Iron and Steel	-0.0102	0.0022	0.0060	0.0890	0.0871	-0.688	20.0850	652.300	0.661
20	Non Ferrous Metals	-0.0190	0.0349	0.0442	0.0237	0.0838	0.641	16.2370	187.300	0.579
21	Metal Products	-0.0084	-0.0526	-0.0454	-0.0253	-0.1317	0.540	13.1830	309.600	0.557
22	Engines and Turbines	-0.0139	-0.0080	0.0130	-0.0192	-0.0281	0.807	20.0410	51.629	0.568
23	Agricultural Machinery	0.0176	-0.0087	-0.0088	0.0033	0.0033	0.809	16.1350	30.415	0.164
25	Metalworking Machinery	-0.0143	0.0170	0.0241	-0.0205	0.0063	-0.082	19.0790	118.000	0.692
27	Special Industry Machinery	-0.0325	-0.0117	-0.0199	-0.0012	-0.0653	-0.002	15.6190	42.035	0.746
28	Miscellaneous Non-Electrical	-0.0350	-0.0501	-0.0425	-0.0445	-0.1722	0.928	7.7800	107.300	0.468
29	Computers	0.0634	0.1653	0.1918	-0.0627	0.3578	0.933	25.7030	172.800	0.651
30	Service Industry Machinery	0.0046	-0.0051	-0.0134	-0.0254	-0.0393	0.492	25.7140	55.979	0.682
31	Communications Machinery	0.0233	0.1654	0.1438	-0.0654	0.2671	0.835	27.9740	398.600	0.604
32	Heavy Electrical Machinery	-0.0330	-0.0352	0.0020	-0.0203	-0.0865	0.739	16.4020	83.484	0.706
33	Household Appliances	-0.0097	0.0032	-0.0048	-0.0125	-0.0238	0.114	26.6150	52.149	0.759
34	Electrical Lighting and wiri	-0.0342	-0.0274	0.0082	-0.0115	-0.0649	0.712	17.3780	81.595	0.726
35	Radio, T.V. Phonographs	0.0194	0.0083	0.1527	0.0082	0.1886	0.553	31.8210	35.189	0.642
36	Motor Vehicles	-0.0609	-0.0269	-0.1024	-0.3050	-0.4952	0.066	34.6360	981.400	0.441
37	Aerospace	0.0544	0.0952	0.0876	0.0444	0.2816	0.504	33.9990	223.100	0.693
38	Ships and Boats	0.1884	0.0050	0.0313	0.4774	0.7020	0.604	40.7720	68.981	0.578
39	Other Transportation Equipme	0.2067	0.1171	0.2497	0.1309	0.7044	0.783	50.9320	33.616	0.823
40	Instruments	-0.0292	-0.0044	0.0945	-0.0232	0.0377	0.817	14.6620	117.900	0.629
41	Miscellaneous Manufacturing	-0.0222	-0.0189	-0.0175	0.0367	-0.0220	0.290	17.5890	71.685	0.628
42	Railroads	0.0228	-0.0085	0.0087	0.0232	0.0462	0.629	27.0000	901.800	0.522
43	Air Transport	0.0003	-0.0514	-0.0190	-0.0361	-0.1062	0.796	21.0310	919.900	0.445
44	Trucking and Other Transport	0.0337	0.1318	-0.0136	0.0924	0.2443	0.929	15.3330	741.300	0.296
45	Communications Services	0.0023	0.0191	0.0483	-0.0104	0.0594	0.941	11.0210	1239.800	0.661
46	Electric Utilities	0.0274	0.0225	-0.0199	0.0553	0.0852	0.802	16.7790	984.700	0.226
47	Gas, Water and Sanitation	0.0760	-0.0198	0.0347	0.0918	0.1828	0.655	32.7790	701.600	0.797
48	Wholesale and Retail Trade	-0.0255	0.0268	0.0330	-0.0059	0.0284	0.971	12.0520	1556.600	0.443
49	Finance and Insurance	0.0829	0.0508	0.2232	-0.0219	0.3350	0.908	16.7770	842.500	0.359
50	Real Estate	-0.0306	0.0200	-0.1092	-0.2195	-0.3394	0.890	30.6610	985.400	0.476
51	Hotels and repairs Minus Aut	0.1159	0.1221	0.0433	-0.0215	0.2597	0.574	19.1500	509.000	0.757
52	Business Services	0.1047	0.1482	-0.0005	-0.1996	0.0528	0.919	22.5220	825.900	0.449
53	Auto repair	-0.0914	0.0551	0.0219	0.0553	0.0409	0.894	18.2030	512.100	0.513
54	Movies and Amusements	0.0291	0.0676	0.0687	0.0789	0.2444	0.826	11.0200	196.400	0.796
55	Medical and Educational Serv	0.0428	-0.0031	0.0098	-0.0767	-0.0272	0.927	13.3580	824.200	0.706

CES Model II

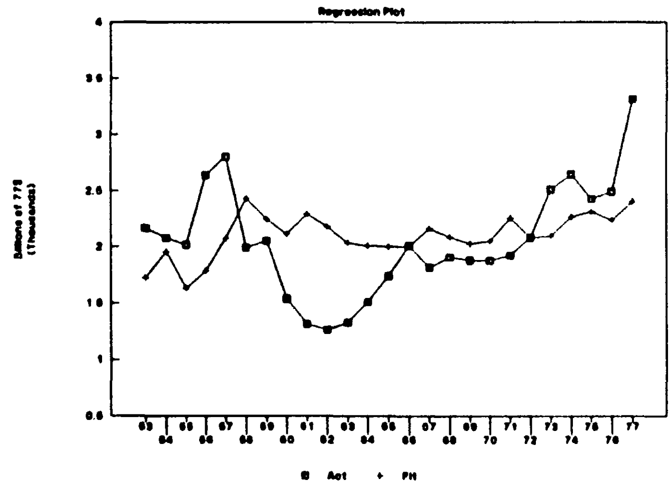
Total U.S. Economy



1 Agriculture_Forestry_Fisheries



3 Mining



4 Construction

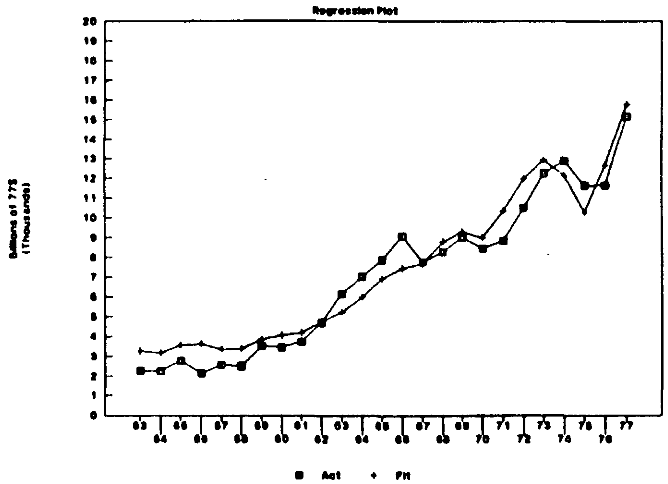


Figure 4.9.a - 1953 to 1977 Estimation

CES Model II

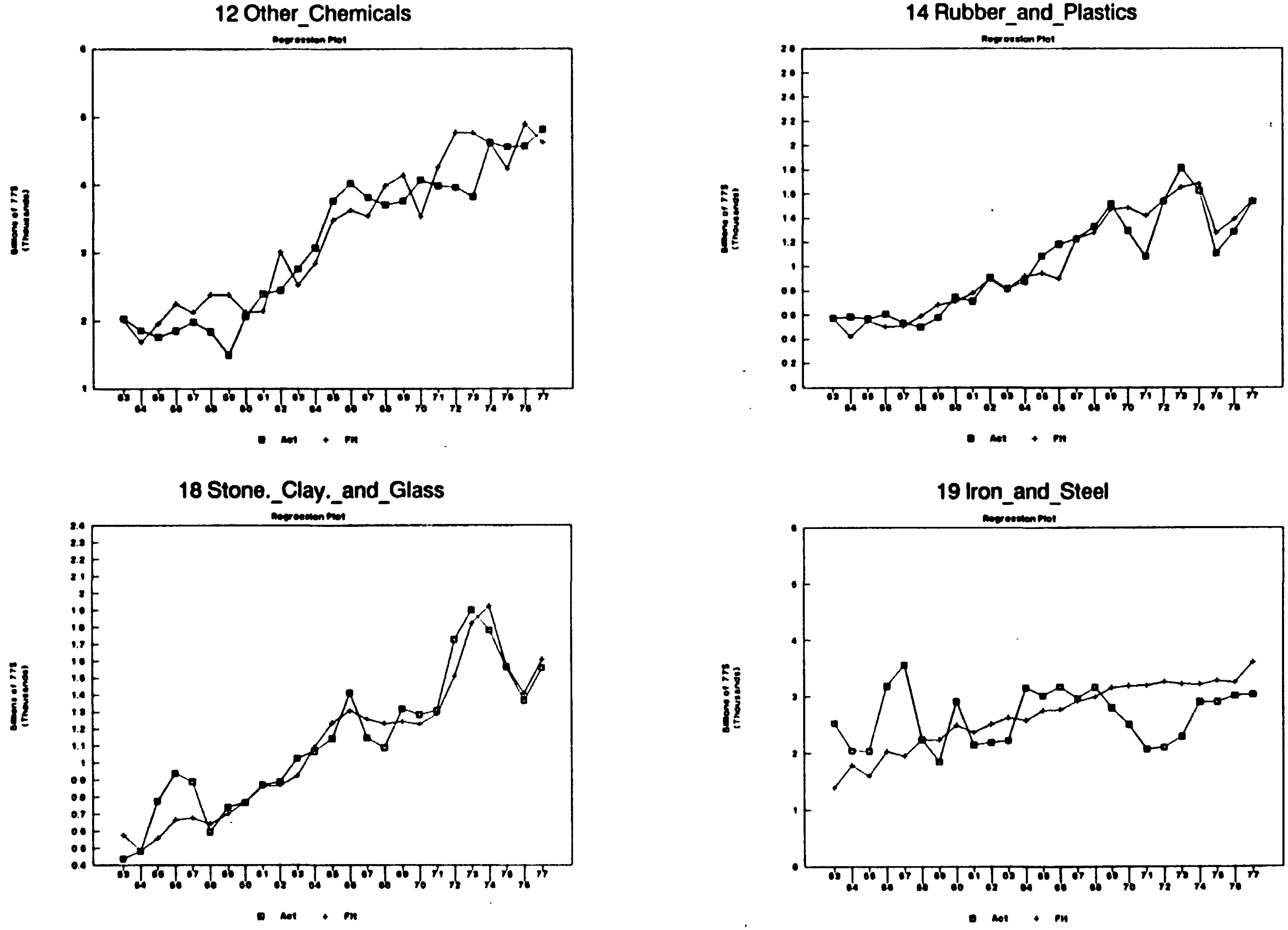
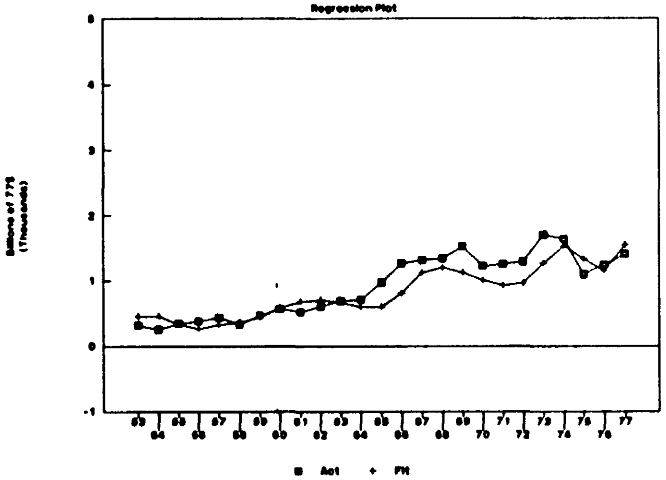


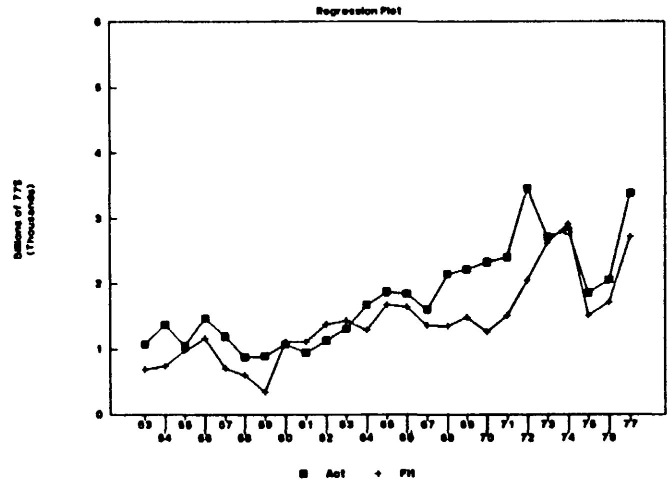
Figure 4.9.b - 1953 to 1977 Estimation

CES Model II

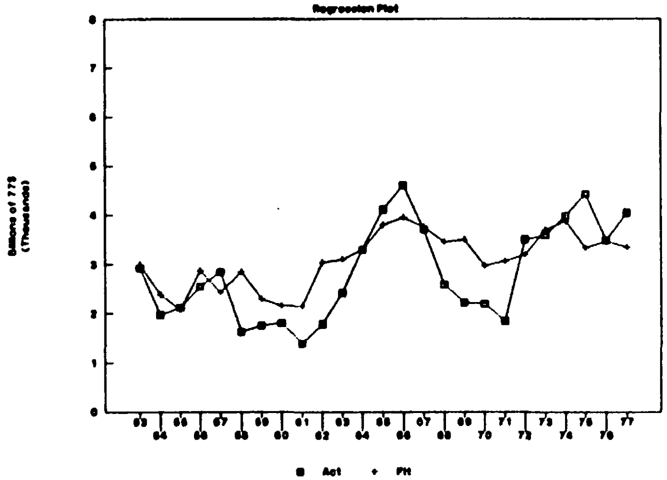
31 Communications_Machinery



36 Motor_Vehicles



42 Railroads



43 Air_Transport

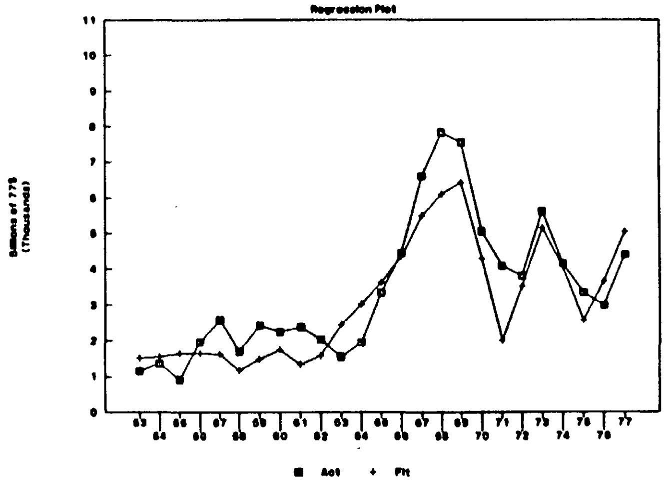
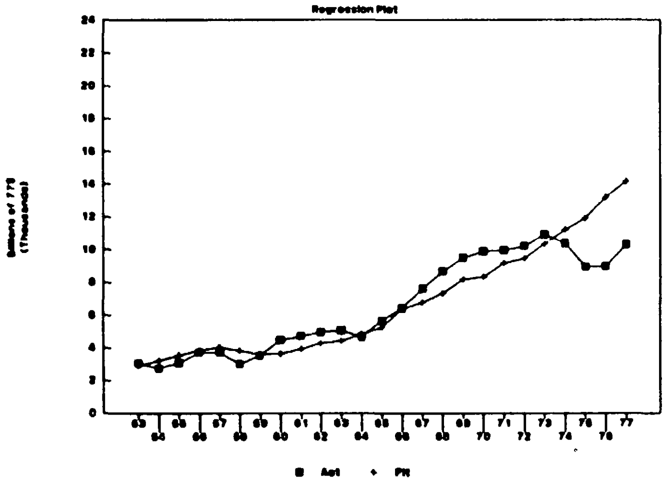


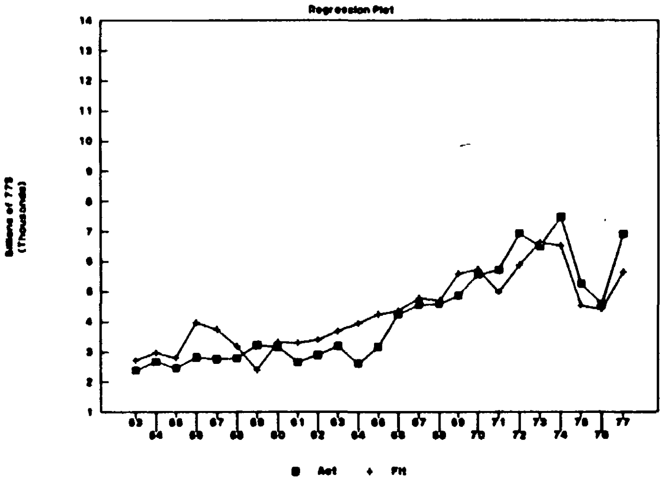
Figure 4.9.c - 1953 to 1977 Estimation

CES Model II

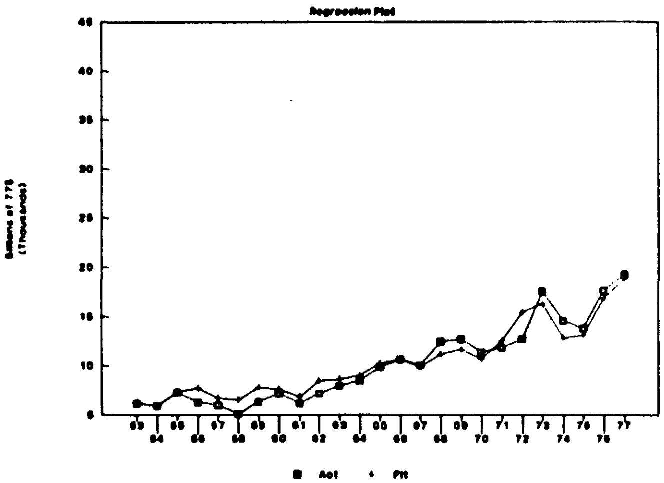
45 Communications_Services



46 Electric_Utilities



48 Wholesale_and_Retail_Trade



52 Business_Services

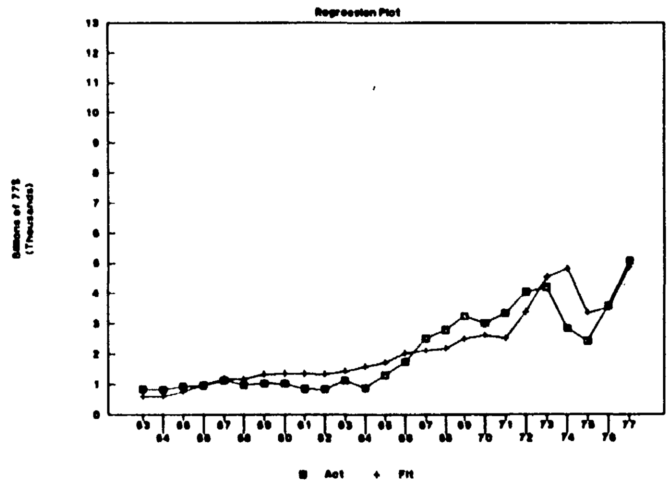


Figure 4.9.d - 1953 to 1977 Estimation

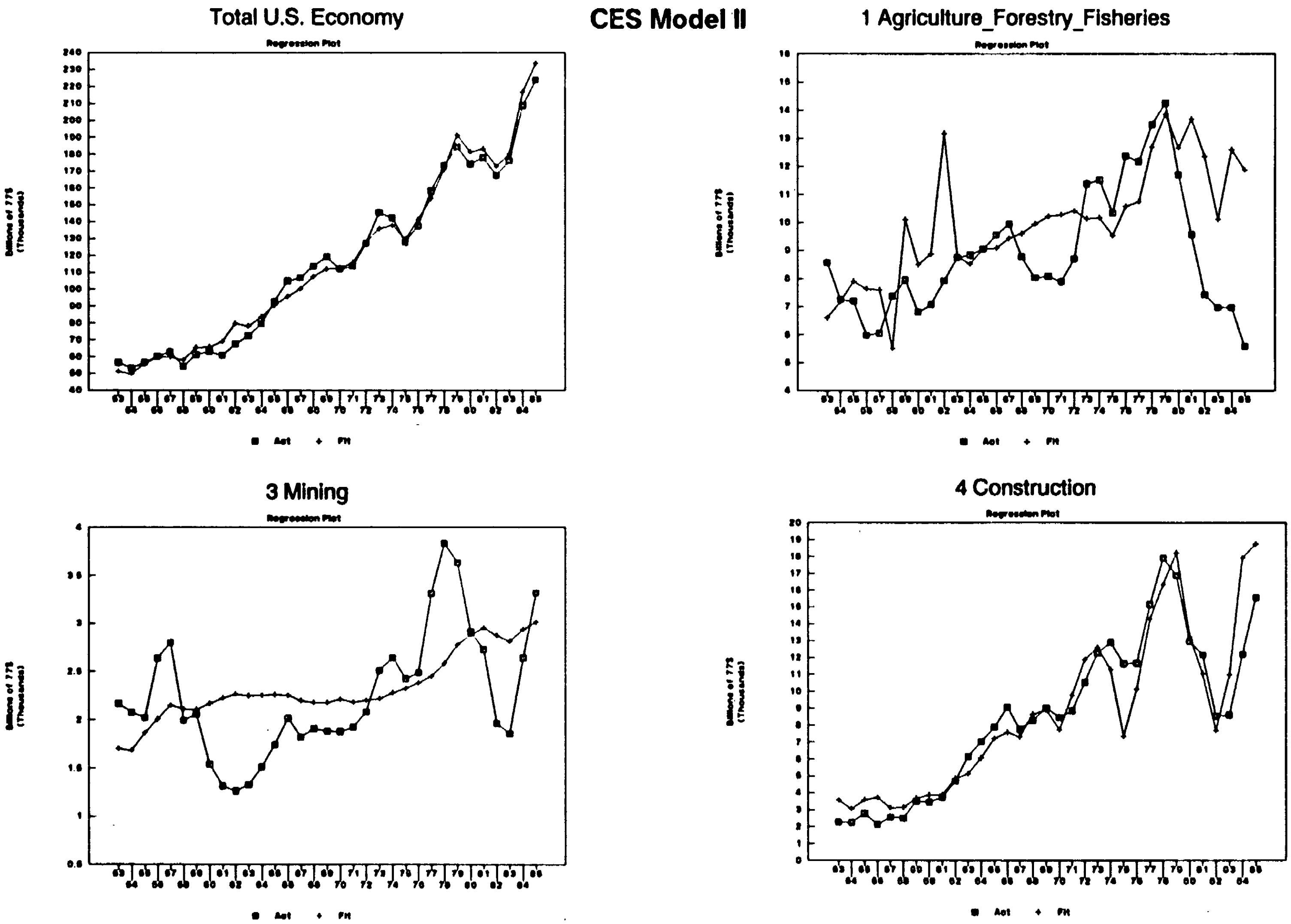


Figure 4.10.a - 1953 to 1985 Estimation

CES Model II

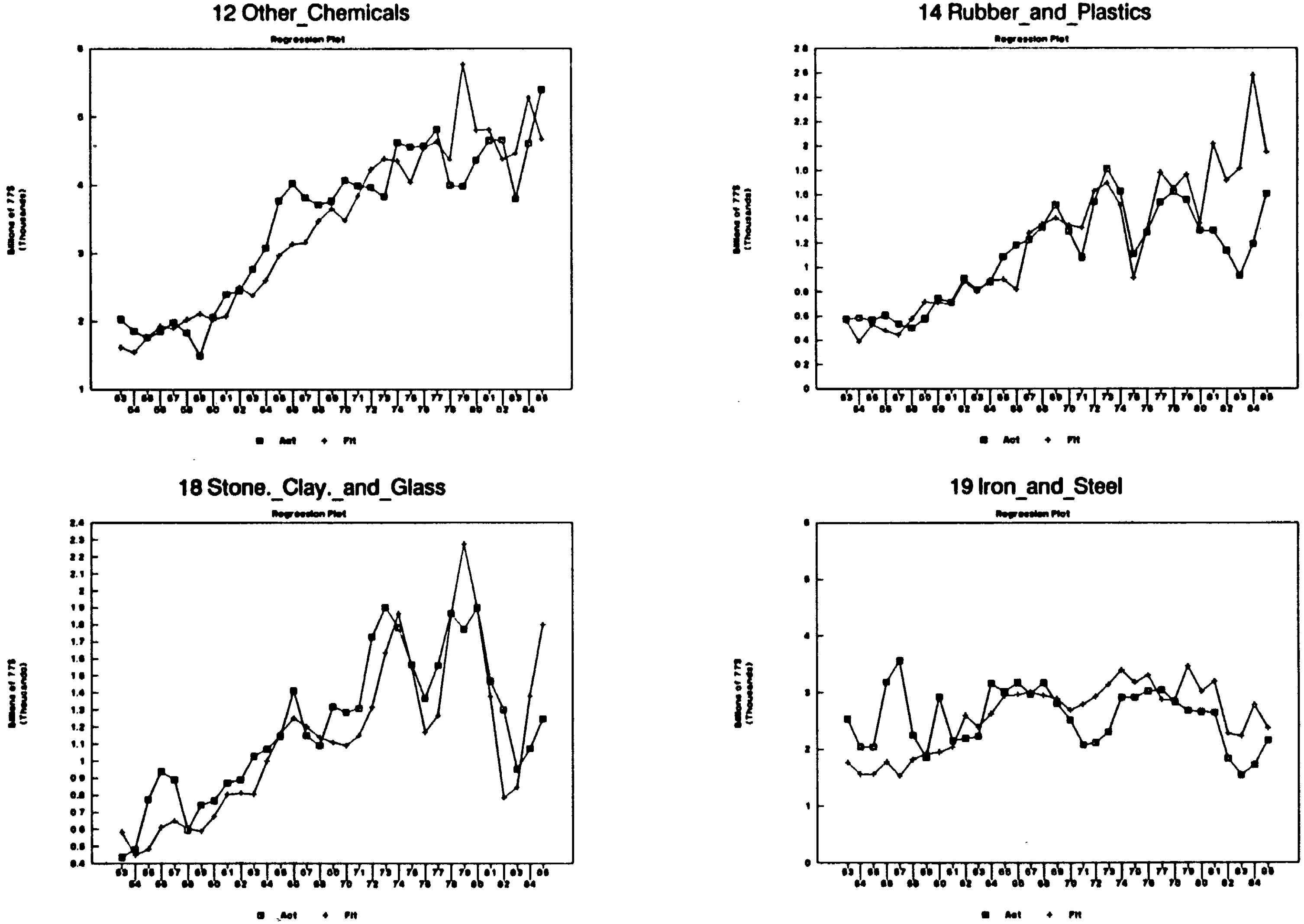


Figure 4.10.b - 1953 to 1985 Estimation

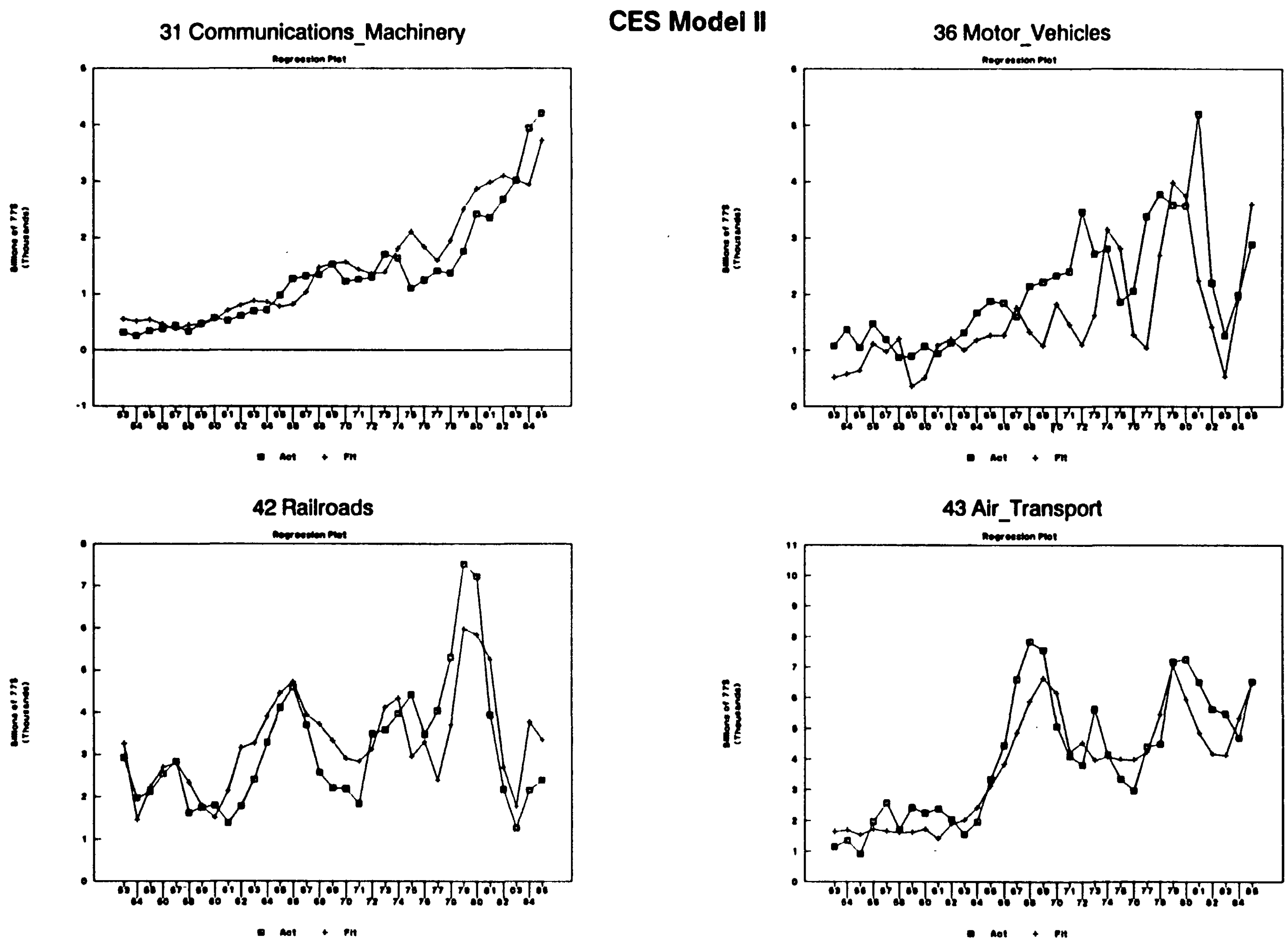


Figure 4.10.c - 1953 to 1985 Estimation

CES Model II

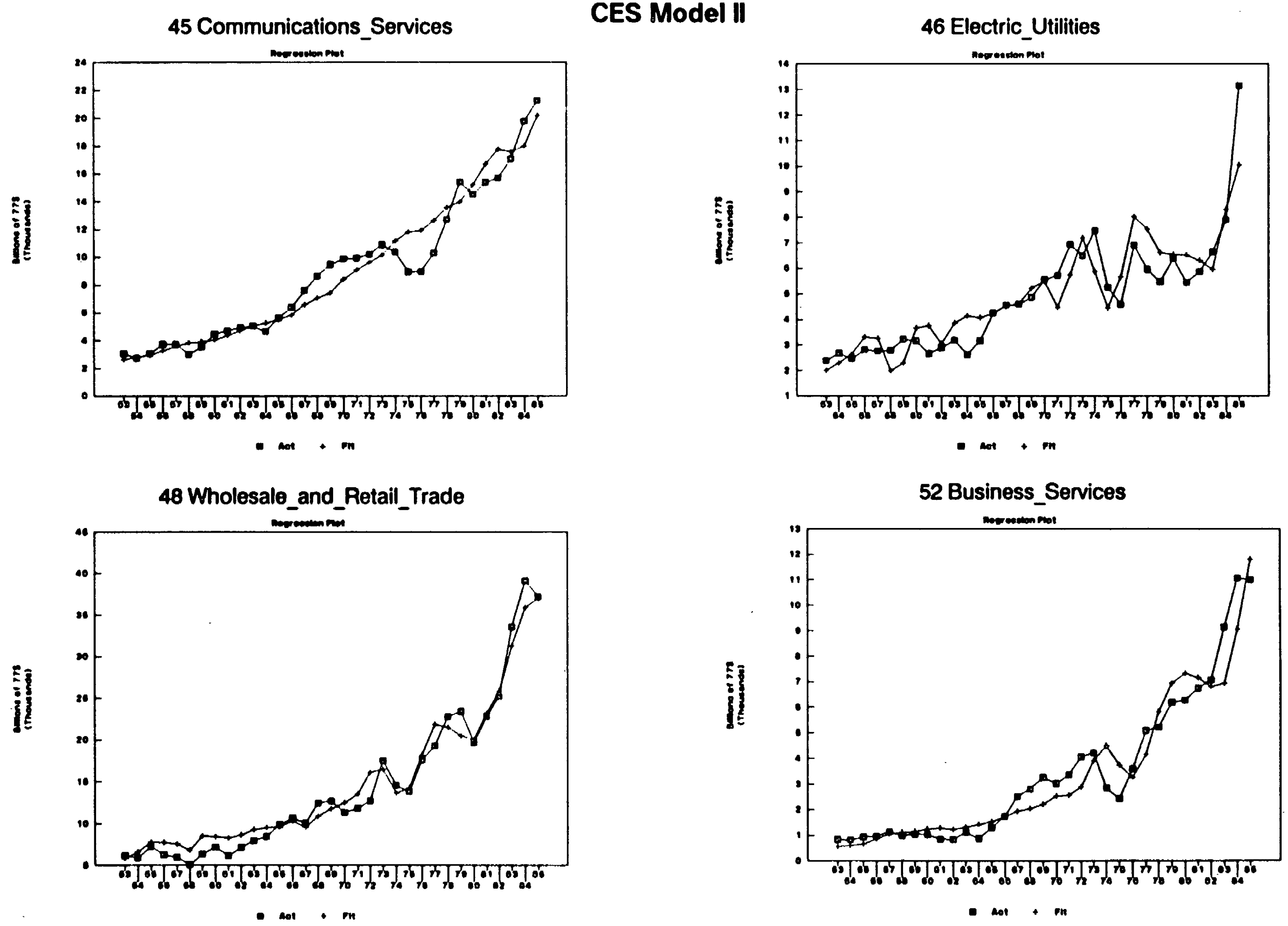


Figure 4.10.d - 1953 to 1985 Estimation

6. The Generalized Leontief Putty-Putty Model

This model is fully described in Chapter III, section 6, so equations will be reproduced here merely for convenience. The model was estimated as a joint system of factor demands for net investment, labor and energy. The system was subject to cross-equation constraints and to both equality and inequality constraints. These constraints will be discussed below. The final set of equations that were estimated is reproduced here as (6.1), (6.2) and (6.3).

$$(6.1) \qquad N_t = e^{-a_{K1}t_1 + a_{K2}t_2} \left[\left\{ \sum_m b_{Km} (P_m/P_K)_t^{1/2} \sum_{i=0}^{3} w_i^K \, \Delta Q_{t-i} \right\} + Q_t \sum_{i=0}^{3} v_i^K \left\{ b_{KL} \Delta (P_L/P_K)_{t-i}^{1/2} + b_{KE} \Delta (P_E/P_K)_{t-i}^{1/2} \right\} \right]$$

$$(6.2) \qquad L_t = e^{-a_{L1}t_1 + a_{L2}t_2} \left\{ \sum_m b_{Lm} (P_m/P_L)_t^{1/2} \right\} \sum_{i=0}^{3} w_i^L \, Q_{t-i}$$

$$(6.3) \qquad E_t = e^{-a_E t} \left\{ \sum_m b_{Em} (P_m/P_E)_t^{1/2} \right\} \sum_{i=0}^{3} w_i^E \, Q_{t-i}$$

where $m = E, K, L$

The constraints that were applied during the estimation of this system are as follows:[65]

---

[65] This system was estimated with a quadratic programming algorithm developed at INFORUM. The algorithm estimates a system of equations as one quadratic objective function subject to linear inequality constraints. In order to impose an equality constraint, two inequality constraints are applied; one from each side.

(6.4) $\sum w_i^K = 1; \quad \sum v_i^K = 1; \quad \sum w_i^L = 1; \quad \sum w_i^E = 1$

(6.5) $w_1^j \geq w_2^j \geq w_3^j; \quad w_i^j \geq 0, \quad i = 0..3, \quad j = K,L,E;$

(6.6) $b_{KL} + b_{KE} \geq 0; \quad b_{KL} + b_{EL} \geq 0; \quad b_{KE} + b_{LE} \geq 0$

(6.7) $-.005 \leq -a_{K1} + a_{K2} \leq .005; \quad a_E \leq .03; \quad -a_{L2} + a_{L1} \leq .07$

The constraints (6.4) were applied to ensure that a one-to-one relationship exists between an increase in desired capital stock and the eventual increase in investment that this brings about. The constraints (6.5) were applied to force the lag pattern in the *w*'s to decay smoothly, and to be nonnegative. The constraints on the *b*'s, (6.6), was applied to force own price elasticities to be nonpositive.

The constraints (6.7) require a word of explanation. The reason for a second time trend in the investment and labor equations is that for many industries there is an abrupt change in the rate of growth of the capital-output and labor-output ratios, starting about 1970. This was the period of the much-debated slowdown in the rate of productivity growth. The use of two time trends in these equations serves both to improve the fit of the equation, and to provide a forecast more consistent with recent experience. The trends are constrained for two reasons. With unconstrained trend terms, the estimates for many industries do not converge, and the trend coefficients become unacceptably large as the number iterations increases. The trend terms were also constrained for somewhat *ad hoc* reasons. In some industries, the estimated trend term was so large that the equation gave unreasonable forecasts once it was inserted into the model. In these cases, most of the movement was exponential trend, with only a small role left for output or relative prices. Although the imposition of this sort of constraint may seem unacceptable at first, it was necessary in order to achieve an equation that can give reasonable results in a model.

After estimating and testing various versions of the investment equation from this system, an egregious problem with its forecasting properties was observed: investment did not tend to grow at a rate commensurate with output, even though it may have done so in the historical data. Examining the estimated net investment equation and the theory behind it in closer detail revealed the problem. From Chapter II, equation (4.28), one can see that the optimal capital-output ratio is equal to:

$$(6.8) \qquad (K/Q)^{*} = e^{-a_{K1}t_{1}+a_{K2}t_{2}}f(P)$$

where $f(P) = \sum_{m} b_{Km}(P_m/P_K)^{1/2}; \qquad m = E,K,L$

However, the estimation of the system (6.1)-(6.3) did not yield estimates of $(K/Q)^{*}$ that were even close to the actual level of (K/Q). The corresponding formulas for $(L/Q)^{*}$ and $(E/Q)^{*}$ also did not yield estimates close to the actual values. For this reason, the "desired" capital-output ratio that the investment equation was tending towardswas not in line with historical experience or common sense. To solve this problem, I estimated the system in two stages. In the first stage, the following system (6.9)-(6.11) was estimated:

$$(6.9) \qquad K/Q = e^{-a_{K1}t_1+a_{K2}t_2} \left\{\sum_m b_{Km}(P_m/P_K)^{1/2}\right\}$$

$$(6.10) \qquad L/Q = e^{-a_{L1}t_1+a_{L2}t_2} \left\{\sum_m b_{Lm}(P_m/P_L)^{1/2}\right\}$$

$$(6.11) \qquad E/Q = e^{-a_E t_1} \left\{\sum_m b_{Em}(P_m/P_E)^{1/2}\right\}$$

where $m = E,K,L$

The estimates from this first stage determined the trends and the price elasticities, based on the histories of the capital-output, labor-output and energy-output ratios. In the second stage of the estimation, these parameters were inserted into the system (6.1)-(6.3) as constants, and the distributed lag parameters were estimated. This technique yielded much more satisfactory simulation results. Of course, the estimates of price elasticities and time trends obtained were different from the one-stage estimation. The two-stage technique probably yields long-run elasticity estimates, since the capital-output ratio is changing slowly over time.

An intercept term was added to the net investment equation in order to improve the fitting ability of this equation, which often had negative values for R^2 for many industries. This intercept term also improved the forecasting performance of the investment equation.

Tables 4.12.a to 4.13.b show the estimated parameters for the Generalized Leontief putty-putty model for both the 53-77 estimation period and for the 53-85 estimation period. Note that only the parameters relevant to the investment equations have been included in these tables. The column labeled *INTCP* expresses the intercept term of the investment equation, divided by 1000. The three Generalized Leontief b_{ij} parameters are displayed next, followed by the two time trends, a_{K1} and a_{K2}. The distributed lag weights w_{K0} to w_{K3} and v_{K0} to v_{K3} are next, followed by the regression statistics R^2, *AAPE*, *SEE* and *RHO*.

The R^2s for many industries are low, and sometimes negative, due to the fact that this is a non-linear model with many equality and inequality constraints. In fact, in the 53 to 77 estimation, 28 industry regressions have $R^2 < .6$, and 9 of these are negative. Similarly, in the 53 to 85 estimation, 28 industry regressions have $R^2 < .6$, and 12 are negative. The estimation plots included as Figures 4.11.a to 4.12.d bear out the impression that is gained from looking at R^2s. In sectors such as Agriculture (1), Mining (3), Iron and Steel (19), and Communications Machinery (31), the fitted values seem to have more extreme movements than the actual values, a sign of negative R^2s. This is due primarily to the exact equality contraints on the change in output and change in price distributed lag weights.[66]

The constraints on the sums of the *w*'s and the *v*'s of course hold exactly. The pattern of the *w*'s is smooth for the most part, with most industries showing a humped lag distribution. However, the pattern of lag on the *v*'s is much more irregular, with many

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[66]Relaxing these constraints somewhat gave better fits, but a less-reasonable forecasting model, in which capital-output ratios tended to "drift" rapidly.

coefficients taking zero values. The constraints on the time trends were binding for every industry and for both estimation periods. In other words, the equations did not explain the observed movement in capital-output ratios by relative price movements alone for most industries. In all but 14 industries in the 53 to 77 estimation, a_{K1} is positive, and a_{K2} is zero in 36 industries, negative in 3 industries, and positive in the rest. In the 53 to 85 estimation, the trend parameters follow a similar pattern, with a_{K1} positve in all but 13 industries, and a_{K2} zero in 40 industries, negative in 3 industries, and positive in the rest. This means that in most industries, capital-output ratios have been falling, on average, through the entire estimation period. In roughly a quarter of the industries (those with positive a_{K2}), that trend has reversed somewhat since around 1970. Note that the intercept term displayed is the actual intercept term divided by 1000.[67] The values of the *b* parameters are important for determining price elasticities, and these will be examined next.

The own- and cross-price elasticities are expressed in terms of the *b* parameters, factor shares and relative factor prices. For the capital demand equation, the relevant price elasticity formulas are derived from (6.9) to yield the following:

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[67]This was done to keep the estimated parameters at roughly the same magnitude, which prevents the contours of the optimization function from becoming too enlongated. This enhances the speed of convergence to the solution.

$$(6.12) \quad E_{KL} = \frac{1}{2}\cdot\frac{Q}{K}\cdot f(t)\cdot b_{KL}(P_L/P_K)^{1/2}$$

$$(6.13) \quad E_{KE} = \frac{1}{2}\cdot\frac{Q}{K}\cdot f(t)\cdot b_{KE}(P_E/P_K)^{1/2}$$

$$(6.14) \quad E_{KK} = -\frac{1}{2}\cdot\frac{Q}{K}\cdot f(t)\cdot\left[b_{KL}(P_L/P_K)^{1/2} + b_{KE}(P_E/P_K)^{1/2}\right]$$

$$\text{or:} \quad E_{KK} = -(E_{KL} + E_{KE})$$

where $f(t) = e^{-a_{K1}t_1+a_{K2}t_2}$

In other words, the sum of the three price elasticities for capital must sum to zero. Since the own-price elasticity of capital is constrained to be non-positive, this requires capital to be a complement to one of the other factors, and a substitute to the other.

Tables 4.14 and 4.15 give estimates of the elasticities of capital with respect to the own price, the price of labor, and the energy price, for the 53-77 and the 53-85 estimation periods. Note that because of the two-stage estimation procedure used, these elasticities are applicable to both the putty-putty and the putty-clay models.[68]

The own price elasticity of capital is for the most part

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[68]These elasticity estimates are given for the most recent year of the estimation. Although this value is not necessarily representative of the entire period of the estimation, it yields an idea of what to expect of the equations' behavior in the first few years of a forecast. The elasticities are the same for both models, because the elasticity formulas consist of the *b* parameters along with fitted cost shares, which are all estimated in the first stage of estimation in which both models are identical.

negative in both sets of estimations, although 13 industries in the 53-77 estimation and 15 industries in the 53-85 estimation needed to be constrained to be zero. Seven of these industries needed to be constrained in both sets of estimations. (Among these are Iron and Steel (19), Motor Vehicles (36), Communications Services (45), and Business Services (52).)

The cross-price elasticities between factors have not been constrained to any particular sign in this model. As to whether capital and energy are substitutes or complements, the models yield mixed results: In the 53-77 estimation period, 23 industries show capital and energy as complements; in the 53-85 period, only 16 industries show complementarity. In any case, the elasticities are small. Only seven industries have energy-capital cross-price elasticities greater than 0.1 in absolute value in both periods.

Capital and labor also appear to be substitutes in most industries, with the capital-labor elasticity taking a negative sign in only 7 industries in the 53-77 estimation, and 17 industries in the 53-85 estimation. The capital-labor elasticities tend to be larger in absolute value than the capital-energy elasticities, and noticeably so in the 53-77 period. Recalling equations (6.12) to (6.14), however, it can be seen that the own- and cross-price elasticities for capital in any given industry must sum to zero, so that the higher capital-labor cross-price elasticities in the 53-77 period are directly related to the finding of high own-price elasticities for capital in this period.

Table 4.12.a

Generalized Leontief putty-putty investment equation. Estimated 53 to 77.

	Sector Title	INTCP	b[KK]	b[KL]	b[KE]	a[K1]	a[K2]	w[K0]	w[K1]	w[K2]	w[K3]
1	Agriculture, Forestry, Fisher	-0.0593	1.2047	0.0138	-0.0256	0.0050	0.0050	0.3159	0.2733	0.2733	0.1375
2	Crude Petroleum, Natural Gas	0.2883	0.2898	0.0184	-0.0531	0.0050	0.0000	0.5642	0.1844	0.1844	0.0670
3	Mining	0.1038	0.6924	0.0076	0.0691	0.0050	0.0050	0.1548	0.4032	0.3647	0.0773
4	Construction	1.9237	-0.2387	0.1102	0.0201	-0.0050	0.0000	0.4141	0.3976	0.1562	0.0321
5	Food, Tobacco	0.4243	0.0300	0.0173	0.0037	-0.0050	0.0000	0.2954	0.3832	0.2515	0.0699
6	Textiles	0.1058	0.3389	-0.0040	0.0160	0.0050	0.0000	0.1805	0.3422	0.3422	0.1352
7	Knitting, Hosiery	-0.010	0.0292	0.0203	0.0611	-0.0008	-0.0050	0.5589	0.1932	0.1932	0.0547
8	Apparel and Household Textile	0.0902	0.1040	-0.0003	0.0067	-0.0008	-0.0050	0.2804	0.3512	0.3512	0.0171
9	Paper	0.2725	0.3771	0.0132	0.0148	0.0050	0.0050	0.2153	0.2616	0.2616	0.2616
10	Printing	0.1849	0.1730	0.0007	0.0200	-0.0050	0.0000	0.3443	0.2517	0.2517	0.1523
11	Agricultural Fertilizers	0.0856	-0.1837	0.1439	-0.1731	-0.0050	0.0000	0.0000	0.3333	0.3333	0.3333
12	Other Chemicals	-0.1687	0.5524	-0.0000	0.0000	0.0050	0.0000	0.2294	0.2569	0.2569	0.2569
13	Petroleum Refining and Fuel	-0.0025	0.1281	0.0004	-0.0016	0.0050	0.0050	0.3277	0.2585	0.2069	0.2069
14	Rubber and Plastics	-0.0037	0.2927	0.0312	0.0130	0.0050	0.0000	0.2894	0.2794	0.2794	0.1519
15	Footwear and Leather	0.0164	0.1450	0.0029	-0.0064	-0.0038	0.0012	0.2384	0.3378	0.3378	0.0861
16	Lumber	0.1863	-0.2283	0.0972	-0.0136	0.0010	0.0050	0.3141	0.2438	0.2438	0.1983
17	Furniture	0.0111	0.1818	0.0005	0.0130	0.0050	0.0000	0.3322	0.2803	0.2803	0.1072
18	Stone, Clay and Glass	0.2773	-0.0016	0.0672	-0.0042	0.0050	0.0050	0.3851	0.3237	0.1876	0.1035
19	Iron and Steel	0.7054	0.3962	0.0012	-0.0041	0.0050	0.0000	0.2640	0.3059	0.2536	0.1765
20	Non Ferrous Metals	0.1796	0.1955	0.0141	-0.0138	0.0050	0.0000	0.1390	0.2870	0.2870	0.2870
21	Metal Products	0.1669	0.1576	0.0063	0.0322	0.0050	0.0000	0.2770	0.2940	0.2940	0.1350
22	Engines and Turbines	0.0317	-0.0450	0.0560	-0.0529	-0.0048	-0.0050	0.2977	0.3512	0.3512	0.0000
23	Agricultural Machinery	0.0132	0.1483	0.0066	0.0082	0.0050	0.0000	0.3117	0.3099	0.3099	0.0685
25	Metalworking Machinery	0.0410	0.2277	0.0198	0.0111	0.0050	0.0000	0.3064	0.3347	0.3347	0.0243
27	Special Industry Machinery	-0.0419	0.0190	0.0572	0.0297	0.0050	0.0000	0.3270	0.3126	0.3126	0.0478
28	Miscellaneous Non-Electrical	0.1549	0.2393	-0.0015	0.0044	0.0050	0.0050	0.3252	0.2467	0.2467	0.1814
29	Computers	-0.0374	0.4642	0.0033	0.0112	0.0050	0.0000	0.2642	0.3445	0.3445	0.0468
30	Service Industry Machinery	-0.0136	0.0554	0.0220	0.0602	0.0050	0.0000	0.3520	0.3174	0.3174	0.0133
31	Communications Machinery	-0.0297	0.4845	-0.0009	0.0098	0.0050	0.0000	0.3337	0.3203	0.3203	0.0257
32	Heavy Electrical Machinery	0.0439	0.2560	0.0038	-0.0104	0.0050	0.0000	0.3442	0.2595	0.2595	0.1368
33	Household Appliances	-0.0435	-0.0167	0.0644	0.0147	0.0050	0.0000	0.3947	0.2800	0.2800	0.0453
34	Electrical Lighting and wiri	0.0683	0.2622	-0.0030	0.0084	0.0050	0.0050	0.2688	0.3515	0.3139	0.0658
35	Radio, T.V. Phonographs	0.0080	0.2242	-0.0240	0.0619	0.0050	0.0000	0.2102	0.4723	0.2301	0.0874
36	Motor Vehicles	0.3631	0.2199	0.0041	-0.0139	0.0050	0.0000	0.3402	0.4071	0.2386	0.0141
37	Aerospace	0.0980	0.0961	0.0031	0.0077	0.0050	0.0050	0.3734	0.3065	0.3065	0.0137
38	Ships and Boats	0.0518	-0.0094	0.0104	0.0138	-0.0050	0.0000	0.3944	0.2908	0.2908	0.0240
39	Other Transportation Equipme	0.0326	-0.0247	0.0112	0.0122	0.0050	0.0050	0.4823	0.2102	0.2102	0.0974
40	Instruments	0.0330	0.1873	0.0208	-0.0032	0.0050	0.0000	0.2929	0.3139	0.3139	0.0793
41	Miscellaneous Manufacturing	0.0333	0.2241	-0.0013	0.0213	0.0050	0.0000	0.3595	0.3061	0.3061	0.0283
42	Railroads	0.8194	1.6136	0.0820	-0.0999	0.0050	0.0000	0.2598	0.3270	0.3270	0.0863
43	Air Transport	-1.0527	2.4789	0.0665	0.1245	0.0050	0.0000	0.3234	0.4120	0.2646	0.0000
44	Trucking and Other Transport	0.8257	-0.4172	0.1617	0.0000	-0.0050	0.0000	0.5352	0.2324	0.2324	0.0000
45	Communications Services	0.1182	2.0024	0.0004	-0.0013	0.0050	0.0000	0.0000	0.5000	0.5000	0.0000
46	Electric Utilities	-0.5252	1.3691	0.0008	0.0027	0.0050	0.0050	0.1537	0.4266	0.4165	0.0032
47	Gas, Water and Sanitation	0.0507	0.2493	0.0060	0.0218	0.0050	0.0000	0.1369	0.3744	0.3744	0.1144
48	Wholesale and Retail Trade	0.7284	0.2254	0.0135	-0.0275	-0.0050	0.0000	0.4205	0.2878	0.1459	0.1459
49	Finance and Insurance	0.3769	-0.0021	0.0434	-0.0108	-0.0050	0.0000	0.6698	0.1140	0.1140	0.1022
50	Real Estate	0.8803	0.1036	0.0042	-0.0030	-0.0050	0.0000	0.1923	0.5837	0.2112	0.0128
51	Hotels and repairs Minus Aut	0.5593	-0.0835	0.1745	-0.1079	0.0050	0.0050	0.0354	0.3215	0.3215	0.3215
52	Business Services	0.5763	0.1024	0.0106	-0.0290	-0.0050	0.0000	0.7521	0.0826	0.0826	0.0826
53	Auto repair	0.4639	0.0594	0.1076	-0.0138	0.0050	0.0000	0.3902	0.3932	0.2075	0.0091
54	Movies and Amusements	0.2366	-0.1624	0.2038	-0.0975	0.0050	0.0000	0.2127	0.3214	0.2790	0.1869
55	Medical and Educational Serv	0.7122	0.0076	0.0859	-0.0349	0.0050	0.0050	0.4533	0.5199	0.0134	0.0134

Table 4.12.b

Generalized Leontief putty-putty investment equation. Estimated 53 to 77.

	Sector Title	v[K0]	v[K1]	v[K2]	v[K3]	RSQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	1.0000	0.0000	0.0000	0.0000	-0.096	18.028	1816.700	0.670
2	Crude Petroleum, Natural Gas	0.4616	0.5384	0.0000	0.0000	-3.301	23.922	459.000	0.778
3	Mining	0.0000	0.0000	1.0000	0.0000	-1.037	30.372	693.000	0.867
4	Construction	0.0000	0.0000	0.0000	1.0000	0.772	34.636	1832.800	0.864
5	Food, Tobacco	0.4645	0.0000	0.0000	0.5355	0.763	16.608	428.600	0.852
6	Textiles	0.0000	1.0000	0.0000	0.0000	0.553	17.168	162.200	0.559
7	Knitting, Hosiery	0.4219	0.2411	0.2333	0.1037	0.788	46.447	39.418	0.483
8	Apparel and Household Textile	1.0000	0.0000	0.0000	0.0000	0.493	34.032	148.600	0.763
9	Paper	0.0000	0.0000	0.0483	0.9517	0.785	10.419	263.200	0.348
10	Printing	0.8896	0.0000	0.1104	0.0000	0.792	18.544	172.300	0.794
11	Agricultural Fertilizers	0.0000	0.0000	0.0000	1.0000	0.440	61.095	204.800	0.643
12	Other Chemicals	1.0000	0.0000	0.0000	0.0000	0.777	12.260	506.200	0.510
13	Petroleum Refining and Fuel	0.0000	0.0000	0.0000	1.0000	0.094	45.821	378.300	0.813
14	Rubber and Plastics	1.0000	0.0000	0.0000	0.0000	0.693	16.466	216.400	0.321
15	Footwear and Leather	0.0000	0.0000	0.0000	1.0000	0.207	17.952	26.768	0.571
16	Lumber	0.1591	0.0000	0.0000	0.8409	0.766	21.843	168.400	0.519
17	Furniture	0.0000	0.0000	0.0000	1.0000	0.576	17.414	54.472	0.461
18	Stone, Clay and Glass	0.0988	0.0000	0.0127	0.8885	0.836	12.985	158.000	0.780
19	Iron and Steel	0.0000	1.0000	0.0000	0.0000	-4.763	34.344	1138.300	0.770
20	Non Ferrous Metals	0.0000	0.0000	0.2905	0.7095	0.498	24.811	224.100	0.650
21	Metal Products	1.0000	0.0000	0.0000	0.0000	0.563	15.197	317.200	0.628
22	Engines and Turbines	0.0799	0.8565	0.0000	0.0635	0.818	35.186	43.269	0.726
23	Agricultural Machinery	1.0000	0.0000	0.0000	0.0000	0.105	30.487	61.932	0.475
25	Metalworking Machinery	0.0000	0.7932	0.2068	0.0000	-2.243	40.760	224.100	0.713
27	Special Industry Machinery	1.0000	0.0000	0.0000	0.0000	-10.445	53.854	142.700	0.752
28	Miscellaneous Non-Electrical	0.0000	0.0000	0.0000	1.0000	0.733	18.170	166.400	0.658
29	Computers	0.0000	1.0000	0.0000	0.0000	0.291	36.920	145.700	0.734
30	Service Industry Machinery	1.0000	0.0000	0.0000	0.0000	0.497	33.733	58.927	0.601
31	Communications Machinery	1.0000	0.0000	0.0000	0.0000	0.312	41.970	382.600	0.558
32	Heavy Electrical Machinery	0.0000	1.0000	0.0000	0.0000	0.432	23.054	97.589	0.638
33	Household Appliances	0.1857	0.0000	0.0000	0.8143	-0.263	31.036	69.570	0.533
34	Electrical Lighting and wiri	0.0000	0.0000	1.0000	0.0000	0.698	25.610	82.109	0.690
35	Radio, T.V. Phonographs	0.2788	0.4304	0.2909	0.0000	0.698	40.317	26.641	0.579
36	Motor Vehicles	0.0000	0.0000	1.0000	0.0000	0.607	22.695	461.000	0.316
37	Aerospace	0.0000	0.0000	0.6444	0.3556	-0.252	44.373	278.900	0.859
38	Ships and Boats	0.0000	0.5132	0.0000	0.4868	0.347	169.200	91.339	0.754
39	Other Transportation Equipme	1.0000	0.0000	0.0000	0.0000	0.409	112.000	42.606	0.886
40	Instruments	0.8768	0.1232	0.0000	0.0000	0.855	14.795	79.167	0.633
41	Miscellaneous Manufacturing	0.0000	0.0000	0.0000	1.0000	0.240	19.547	82.607	0.312
42	Railroads	1.0000	0.0000	0.0000	0.0000	0.385	25.058	747.100	0.536
43	Air Transport	0.8078	0.1922	0.0000	0.0000	0.596	35.226	1205.000	0.768
44	Trucking and Other Transport	0.1464	0.3260	0.1517	0.3758	0.815	30.992	888.600	0.839
45	Communications Services	0.0000	0.0000	0.0000	1.0000	0.750	14.021	1423.500	0.660
46	Electric Utilities	1.0000	0.0000	0.0000	0.0000	0.858	13.639	596.300	0.274
47	Gas, Water and Sanitation	0.4198	0.0000	0.5802	0.0000	-1.405	43.963	762.300	0.754
48	Wholesale and Retail Trade	0.0000	1.0000	0.0000	0.0000	0.849	12.625	1564.900	0.750
49	Finance and Insurance	0.1509	0.0000	0.1393	0.7098	0.818	20.918	485.800	0.806
50	Real Estate	0.0000	0.6977	0.3023	0.0000	0.407	83.475	1311.000	0.928
51	Hotels and repairs Minus Aut	0.0000	0.7188	0.0868	0.1944	0.729	12.925	376.400	0.826
52	Business Services	0.0131	0.6013	0.3089	0.0768	0.699	39.711	703.600	0.752
53	Auto repair	0.0000	0.0000	0.0000	1.0000	0.727	21.200	466.400	0.660
54	Movies and Amusements	0.0000	0.5554	0.3749	0.0698	0.889	11.894	126.300	0.645
55	Medical and Educational Serv	0.3584	0.0000	0.3821	0.2595	0.917	10.927	520.400	0.651

Table 4.13.a

Generalized Leontief putty-putty investment equation.   Estimated 53 to 85.

	Sector Title	INTCP	b[KK]	b[KL]	b[KE]	a[K1]	a[K2]	w[K0]	w[K1]	w[K2]	w[K3]
1	Agriculture, Forestry, Fisher	-0.7078	1.1535	0.0262	-0.0194	0.0050	0.0000	0.2733	0.3222	0.3222	0.0823
2	Crude Petroleum, Natural Gas	0.4930	0.2239	0.0249	-0.0176	0.0050	0.0000	0.4849	0.2576	0.2576	0.0000
3	Mining	0.1214	0.8868	-0.0080	0.0221	0.0050	0.0050	0.2810	0.3391	0.3162	0.0638
4	Construction	1.7943	0.4604	0.0001	0.0183	-0.0050	0.0000	0.1884	0.4015	0.3953	0.0148
5	Food, Tobacco	0.3511	0.1328	-0.0008	0.0017	-0.0050	-0.0050	0.3704	0.3648	0.2137	0.0510
6	Textiles	0.0362	0.3018	0.0007	0.0202	0.0050	0.0000	0.3099	0.3041	0.2748	0.1111
7	Knitting, Hosiery	0.0109	0.0156	0.0139	0.0753	0.0050	0.0000	0.4494	0.2468	0.2468	0.0571
8	Apparel and Household Textile	0.0266	0.0979	0.0007	0.0082	0.0050	0.0000	0.4357	0.2771	0.2771	0.0100
9	Paper	0.3138	0.4963	-0.0044	0.0104	0.0032	0.0050	0.1316	0.3454	0.3038	0.2192
10	Printing	0.1883	0.2337	-0.0040	0.0093	-0.0028	0.0022	0.3742	0.2667	0.2667	0.0923
11	Agricultural Fertilizers	0.0684	0.1979	0.0385	-0.0533	-0.0050	0.0000	0.0074	0.3309	0.3309	0.3309
12	Other Chemicals	-0.0590	0.4903	0.0056	0.0138	0.0050	0.0000	0.2444	0.2519	0.2519	0.2519
13	Petroleum Refining and Fuel	0.2499	0.0722	0.0045	0.0138	0.0050	0.0000	0.3030	0.2323	0.2323	0.2323
14	Rubber and Plastics	-0.1459	0.3599	0.0278	-0.0003	0.0050	0.0000	0.3125	0.2914	0.2914	0.1046
15	Footwear and Leather	0.0116	0.1491	-0.0035	0.0059	-0.0035	0.0015	0.3376	0.2824	0.2824	0.0977
16	Lumber	0.1372	0.2088	-0.0073	0.0138	-0.0037	-0.0050	0.2182	0.3016	0.3016	0.1786
17	Furniture	0.0004	0.2019	-0.0018	0.0090	0.0050	0.0000	0.3260	0.2794	0.2794	0.1152
18	Stone, Clay and Glass	0.2408	0.3261	-0.0025	0.0271	0.0033	0.0050	0.3004	0.2876	0.2876	0.1244
19	Iron and Steel	0.7130	0.4413	-0.0224	0.0580	0.0050	0.0050	0.2810	0.3052	0.2414	0.1724
20	Non Ferrous Metals	0.2015	0.2151	-0.0023	0.0316	0.0050	0.0000	0.1866	0.2752	0.2752	0.2629
21	Metal Products	0.1309	0.1785	0.0009	0.0359	0.0050	0.0000	0.2704	0.3354	0.3354	0.0588
22	Engines and Turbines	0.0630	0.1839	0.0008	0.0021	0.0050	0.0000	0.3484	0.3258	0.3258	0.0000
23	Agricultural Machinery	0.0215	0.1422	0.0047	0.0182	0.0050	0.0000	0.2528	0.3601	0.3601	0.0269
25	Metalworking Machinery	0.0322	0.2602	0.0138	0.0121	0.0050	0.0000	0.3056	0.3345	0.3345	0.0253
27	Special Industry Machinery	-0.0141	0.1697	0.0325	0.0285	0.0050	0.0000	0.3498	0.3036	0.3036	0.0431
28	Miscellaneous Non-Electrical	0.2156	0.2383	-0.0025	0.0123	0.0050	0.0000	0.3115	0.2558	0.2558	0.1770
29	Computers	-0.1451	0.2177	0.0600	-0.0045	0.0050	0.0000	0.1538	0.4231	0.4231	0.0000
30	Service Industry Machinery	-0.0111	0.1021	0.0170	0.0497	0.0050	0.0000	0.3229	0.3177	0.3177	0.0416
31	Communications Machinery	-0.1595	0.3888	0.0167	0.0046	0.0050	0.0000	0.3021	0.3463	0.3463	0.0053
32	Heavy Electrical Machinery	0.0682	0.2657	-0.0041	0.0078	0.0050	0.0000	0.3326	0.2681	0.2681	0.1311
33	Household Appliances	-0.0391	0.0205	0.0562	0.0198	0.0050	0.0000	0.2921	0.3190	0.3190	0.0700
34	Electrical Lighting and wiri	0.0586	0.2710	-0.0038	0.0102	0.0050	0.0000	0.2804	0.3052	0.3052	0.1093
35	Radio, T.V. Phonographs	-0.0052	0.2663	-0.0065	0.0119	0.0050	0.0000	0.2807	0.2826	0.2573	0.1794
36	Motor Vehicles	0.4970	0.2397	-0.0035	0.0083	0.0050	0.0000	0.2816	0.3647	0.3438	0.010
37	Aerospace	0.1205	0.1426	-0.0010	0.0042	0.0050	0.0050	0.3548	0.3151	0.3151	0.0149
38	Ships and Boats	0.0485	0.0668	0.0026	0.0139	-0.0050	0.0000	0.3762	0.2910	0.2910	0.0417
39	Other Transportation Equipme	0.0460	0.0271	0.0018	0.0267	0.0050	0.0000	0.5131	0.2103	0.2103	0.0664
40	Instruments	0.0417	0.1110	0.0352	-0.0047	0.0050	0.0000	0.3066	0.3110	0.2691	0.1133
41	Miscellaneous Manufacturing	0.0222	0.1930	0.0083	0.0152	0.0050	0.0000	0.4394	0.2673	0.2673	0.0259
42	Railroads	0.8550	2.0706	0.0214	-0.0527	0.0013	0.0050	0.3207	0.3230	0.3230	0.0333
43	Air Transport	-1.2255	0.4229	0.4983	-0.3860	0.0050	0.0000	0.1591	0.3750	0.3750	0.0910
44	Trucking and Other Transport	1.2201	-0.2689	0.1428	0.0341	-0.0042	-0.0030	0.3228	0.2436	0.2436	0.1899
45	Communications Services	-0.4833	2.0956	-0.0008	0.0023	0.0050	0.0000	0.3395	0.3303	0.3303	0.0000
46	Electric Utilities	-0.2330	1.3409	0.0015	0.0036	0.0050	0.0050	0.2166	0.5336	0.2451	0.0047
47	Gas, Water and Sanitation	0.5753	0.2269	0.0079	0.0188	0.0050	0.0000	0.0655	0.4520	0.4520	0.0306
48	Wholesale and Retail Trade	2.7397	0.2262	0.0272	-0.0500	-0.0050	0.0000	0.6449	0.3273	0.0139	0.0139
49	Finance and Insurance	0.8219	-0.0344	0.0555	-0.0094	-0.0050	0.0000	0.8706	0.0431	0.0431	0.0431
50	Real Estate	1.4526	0.1715	0.0013	-0.0022	-0.0050	0.0000	0.2895	0.5393	0.1713	0.0000
51	Hotels and repairs Minus Aut	0.5178	-0.0617	0.1707	-0.0857	0.0050	0.0000	0.2628	0.2613	0.2613	0.2146
52	Business Services	1.0479	0.1115	0.0141	-0.0268	-0.0050	0.0000	0.6888	0.1881	0.0615	0.0615
53	Auto repair	0.5734	0.1833	0.0816	-0.0124	0.0000	0.0050	0.5109	0.2947	0.1880	0.0065
54	Movies and Amusements	0.1648	0.2894	0.0894	-0.0661	0.0050	0.0000	0.2477	0.2589	0.2467	0.2467
55	Medical and Educational Serv	0.8194	0.0905	0.0660	-0.0281	-0.0050	0.0000	0.2918	0.4460	0.1311	0.1311

Table 4.13.b

Generalized Leontief putty-putty investment equation. Estimated 53 to 85.

	Sector Title	v[K0]	v[K1]	v[K2]	v[K3]	RSQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.0000	0.1991	0.0000	0.8008	-0.013	21.686	2179.700	0.597
2	Crude Petroleum, Natural Gas	0.0000	0.0000	0.0000	1.0000	-0.012	28.927	820.200	0.786
3	Mining	0.0000	0.0000	0.0000	1.0000	-0.088	26.661	666.800	0.850
4	Construction	0.0000	1.0000	0.0000	0.0000	0.788	31.630	2084.800	0.874
5	Food, Tobacco	1.0000	0.0000	0.0000	0.0000	0.792	13.906	426.300	0.751
6	Textiles	0.5548	0.1348	0.3104	0.0000	-0.226	18.837	238.100	0.766
7	Knitting, Hosiery	0.3276	0.5952	0.0772	0.0000	0.659	55.206	47.758	0.640
8	Apparel and Household Textile	1.0000	0.0000	0.0000	0.0000	-0.041	36.154	191.200	0.841
9	Paper	0.0000	0.0000	0.0000	1.0000	0.842	10.815	319.000	0.437
10	Printing	0.0000	1.0000	0.0000	0.0000	0.885	16.622	194.000	0.580
11	Agricultural Fertilizers	0.0000	0.0000	0.0000	1.0000	0.445	51.656	191.700	0.682
12	Other Chemicals	0.0000	0.0000	0.0000	1.0000	0.568	15.472	726.300	0.477
13	Petroleum Refining and Fuel	0.0000	0.0000	1.0000	0.0000	-0.018	59.898	658.100	0.855
14	Rubber and Plastics	0.0000	0.0000	0.0000	1.0000	-0.121	26.666	404.000	0.603
15	Footwear and Leather	0.1433	0.8567	0.0000	0.0000	0.187	22.681	29.851	0.739
16	Lumber	0.6206	0.3794	0.0000	0.0000	0.651	21.226	209.700	0.670
17	Furniture	0.0000	0.0000	0.6775	0.3225	0.577	15.400	54.557	0.430
18	Stone, Clay and Glass	0.6251	0.3749	0.0000	0.0000	0.817	13.059	172.500	0.587
19	Iron and Steel	0.0000	0.0000	0.0000	1.0000	-3.405	30.203	1053.700	0.789
20	Non Ferrous Metals	0.7440	0.0000	0.0000	0.2560	0.531	22.583	214.000	0.600
21	Metal Products	1.0000	0.0000	0.0000	0.0000	0.278	17.453	387.900	0.530
22	Engines and Turbines	0.0000	0.0000	1.0000	0.0000	0.611	42.412	73.241	0.712
23	Agricultural Machinery	1.0000	0.0000	0.0000	0.0000	0.151	29.649	64.060	0.496
25	Metalworking Machinery	0.0000	1.0000	0.0000	0.0000	-2.265	37.141	205.000	0.704
27	Special Industry Machinery	0.9645	0.0000	0.0000	0.0355	-9.765	51.671	137.800	0.794
28	Miscellaneous Non-Electrical	0.0000	0.4206	0.5017	0.0777	0.659	18.167	233.900	0.643
29	Computers	0.2717	0.7283	0.0000	0.0000	0.833	70.270	273.200	0.788
30	Service Industry Machinery	1.0000	0.0000	0.0000	0.0000	0.153	33.696	72.259	0.517
31	Communications Machinery	1.0000	0.0000	0.0000	0.0000	0.607	43.756	615.300	0.709
32	Heavy Electrical Machinery	0.0000	0.0000	0.0000	1.0000	0.374	25.062	129.300	0.633
33	Household Appliances	1.0000	0.0000	0.0000	0.0000	-0.681	34.212	71.816	0.567
34	Electrical Lighting and wiri	0.3974	0.0000	0.6026	0.0000	0.646	23.503	90.551	0.551
35	Radio, T.V. Phonographs	1.0000	0.0000	0.0000	0.0000	0.591	32.718	33.685	0.500
36	Motor Vehicles	1.0000	0.0000	0.0000	0.0000	0.208	29.989	903.400	0.448
37	Aerospace	0.0000	0.0000	0.2371	0.7629	0.080	42.854	303.900	0.834
38	Ships and Boats	0.0000	0.5740	0.4260	0.0000	0.477	137.200	79.329	0.709
39	Other Transportation Equipme	0.0000	0.2931	0.2228	0.4841	0.545	115.300	48.690	0.807
40	Instruments	1.0000	0.0000	0.0000	0.0000	0.685	17.425	154.900	0.538
41	Miscellaneous Manufacturing	0.1697	0.0000	0.0000	0.8303	-0.251	21.454	95.151	0.421
42	Railroads	0.0000	0.6083	0.3917	0.0000	0.513	30.778	1033.200	0.693
43	Air Transport	0.9016	0.0000	0.0000	0.0984	0.369	40.222	1619.000	0.648
44	Trucking and Other Transport	0.0514	0.5377	0.1023	0.3086	0.813	39.595	1204.100	0.911
45	Communications Services	0.0000	0.0000	1.0000	0.0000	0.837	16.295	2053.400	0.828
46	Electric Utilities	1.0000	0.0000	0.0000	0.0000	0.680	17.197	1250.700	0.393
47	Gas, Water and Sanitation	0.0000	0.0000	1.0000	0.0000	0.048	58.496	1165.500	0.909
48	Wholesale and Retail Trade	1.0000	0.0000	0.0000	0.0000	0.717	31.167	4825.400	0.870
49	Finance and Insurance	0.3000	0.0000	0.7000	0.0000	0.732	38.152	1440.800	0.680
50	Real Estate	0.0000	0.0000	0.0000	1.0000	0.597	112.500	1888.800	0.967
51	Hotels and repairs Minus Aut	0.2244	0.5433	0.1652	0.0671	0.723	13.784	410.600	0.797
52	Business Services	1.0000	0.0000	0.0000	0.0000	0.773	56.216	1383.500	0.842
53	Auto repair	0.0000	0.9977	0.0000	0.0023	0.824	25.765	659.800	0.686
54	Movies and Amusements	0.0000	0.0000	1.0000	0.0000	0.804	16.296	208.600	0.854
55	Medical and Educational Serv	0.9972	0.0028	0.0000	0.0000	0.841	15.242	1220.800	0.765

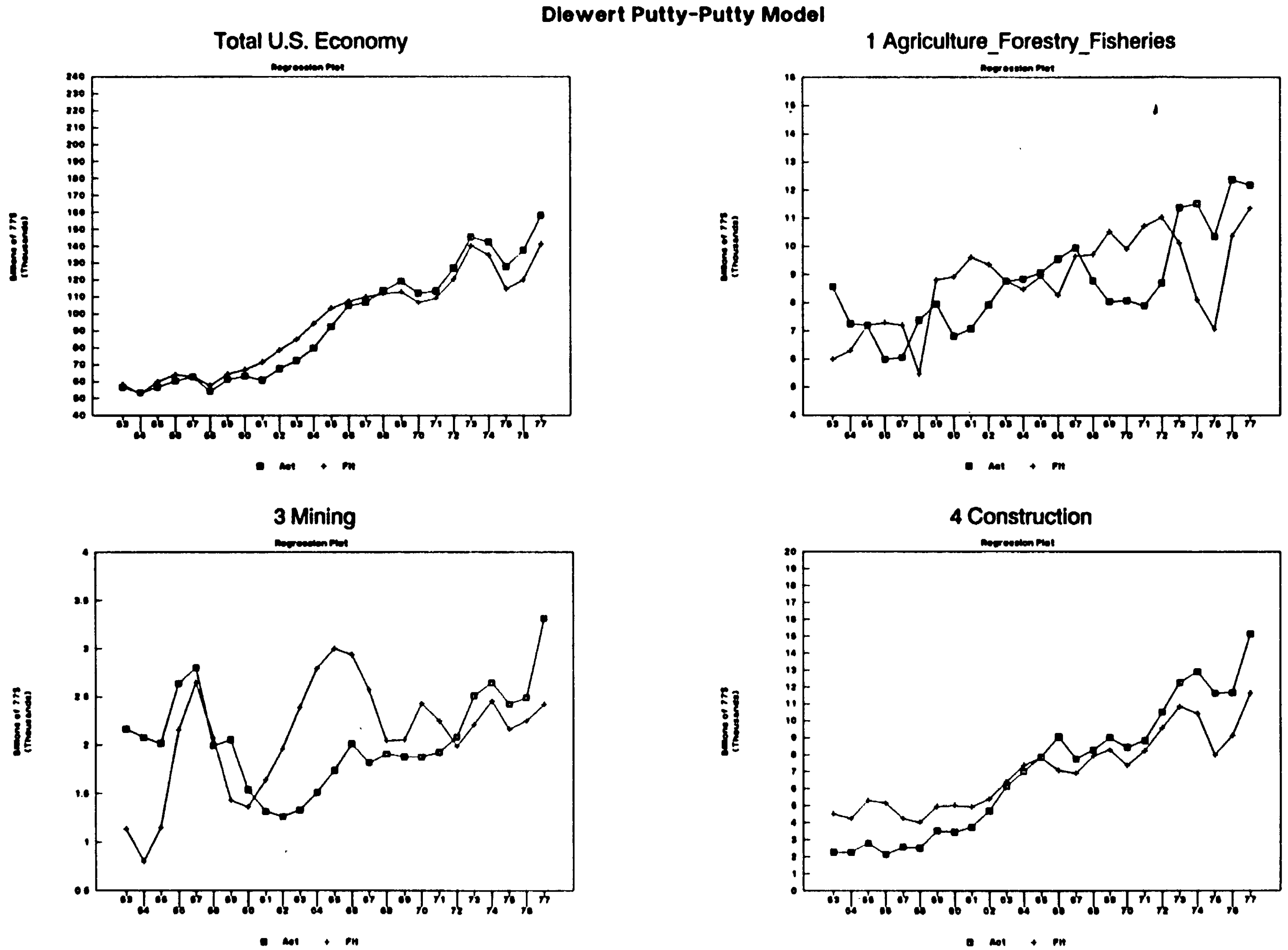


Figure 4.11.a - 1953 to 1977 Estimation

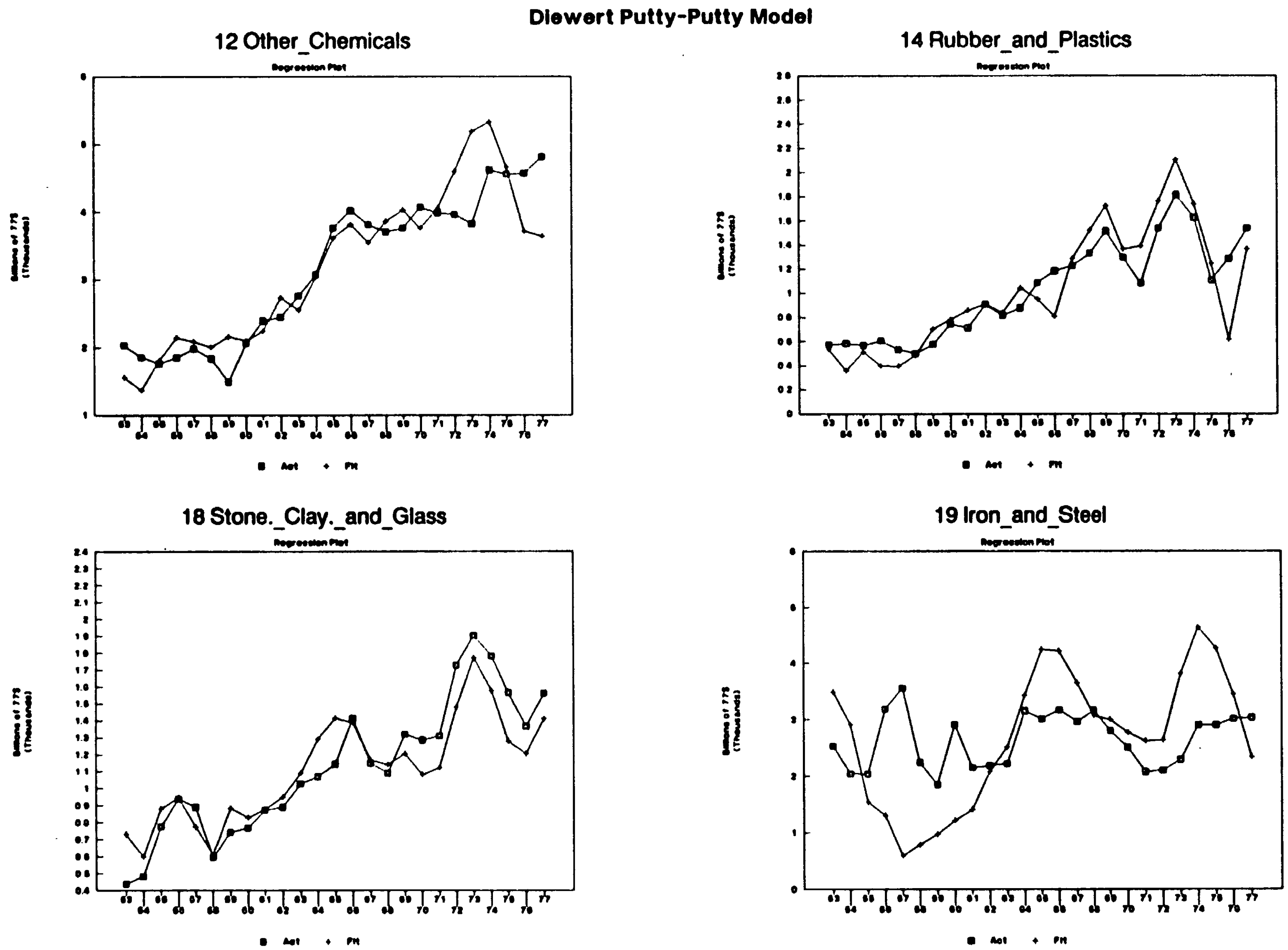


Figure 4.11.b - 1953 to 1977 Estimation

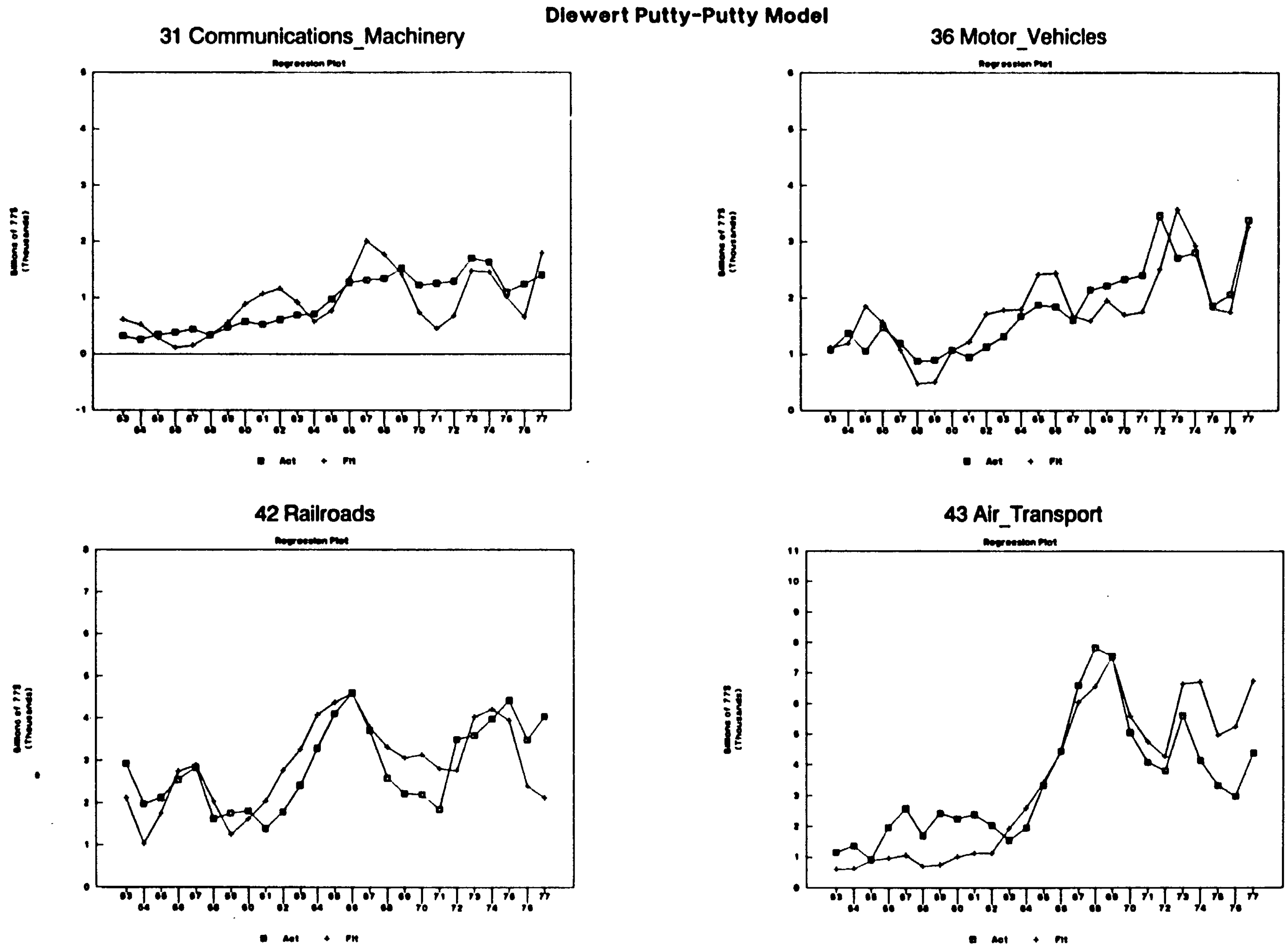


Figure 4.11.c - 1953 to 1977 Estimation

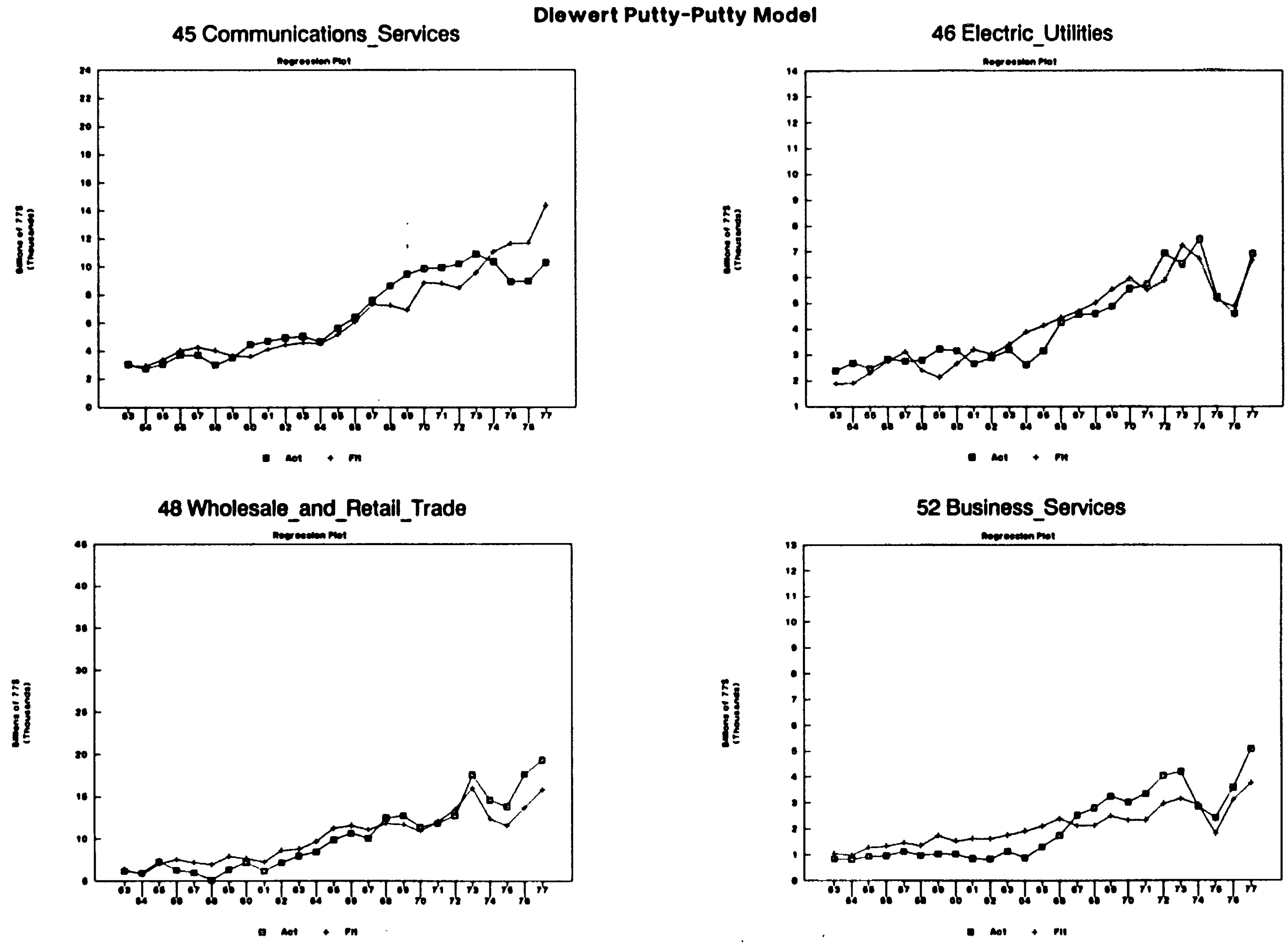


Figure 4.11.d - 1953 to 1977 Estimation

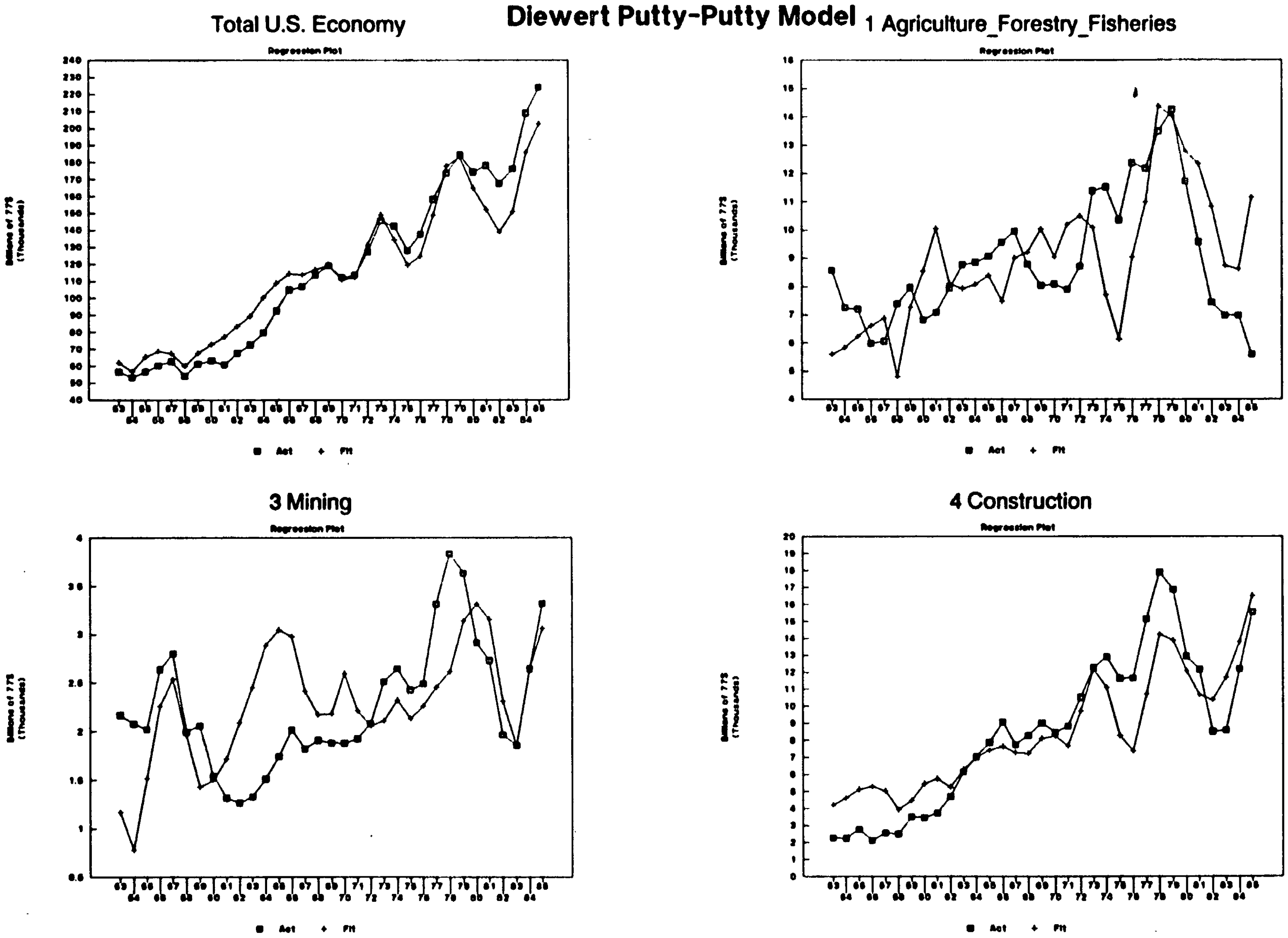


Figure 4.12.a - 1953 to 1985 Estimation

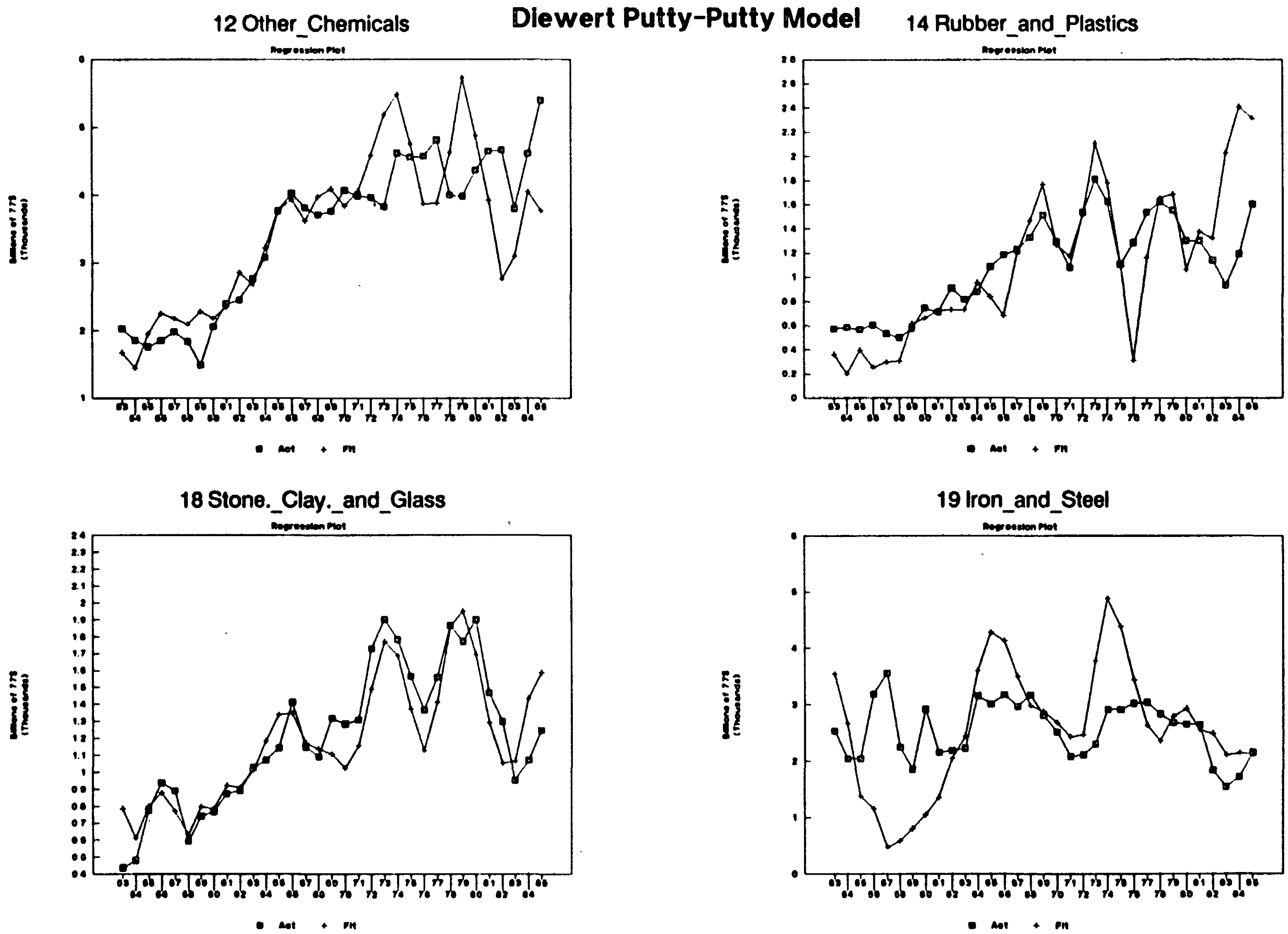
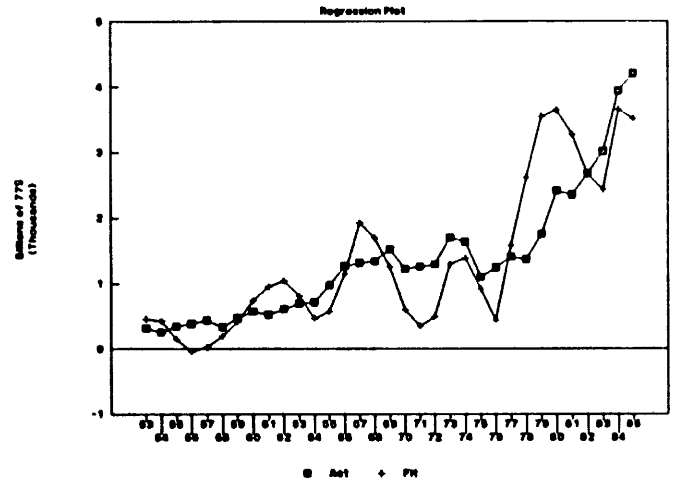


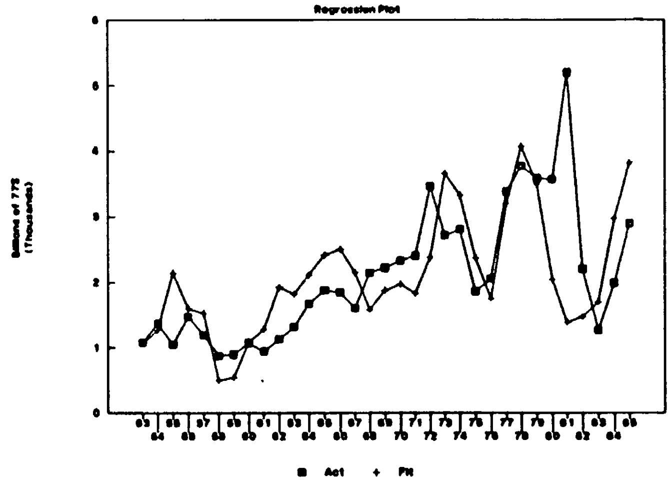
Figure 4.12.b - 1953 to 1985 Estimation

Diewert Putty-Putty Model

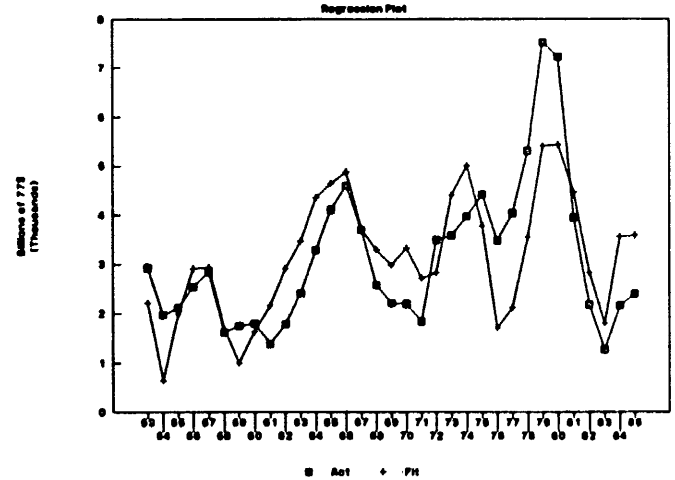
31 Communications_Machinery



36 Motor_Vehicles



42 Railroads



43 Air_Transport

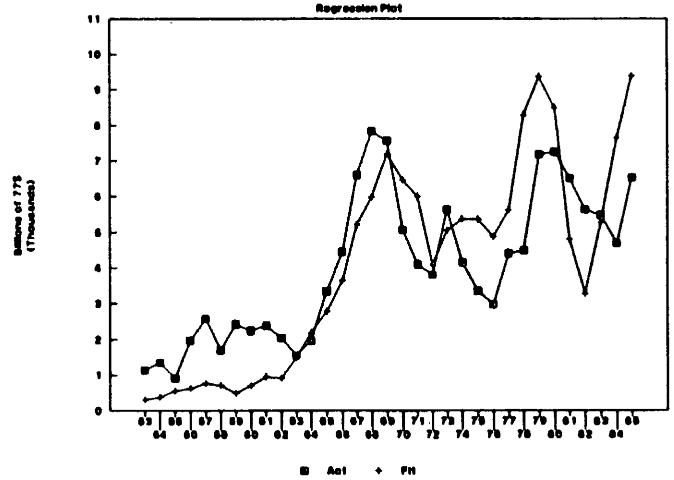


Figure 4.12.c - 1953 to 1985 Estimation

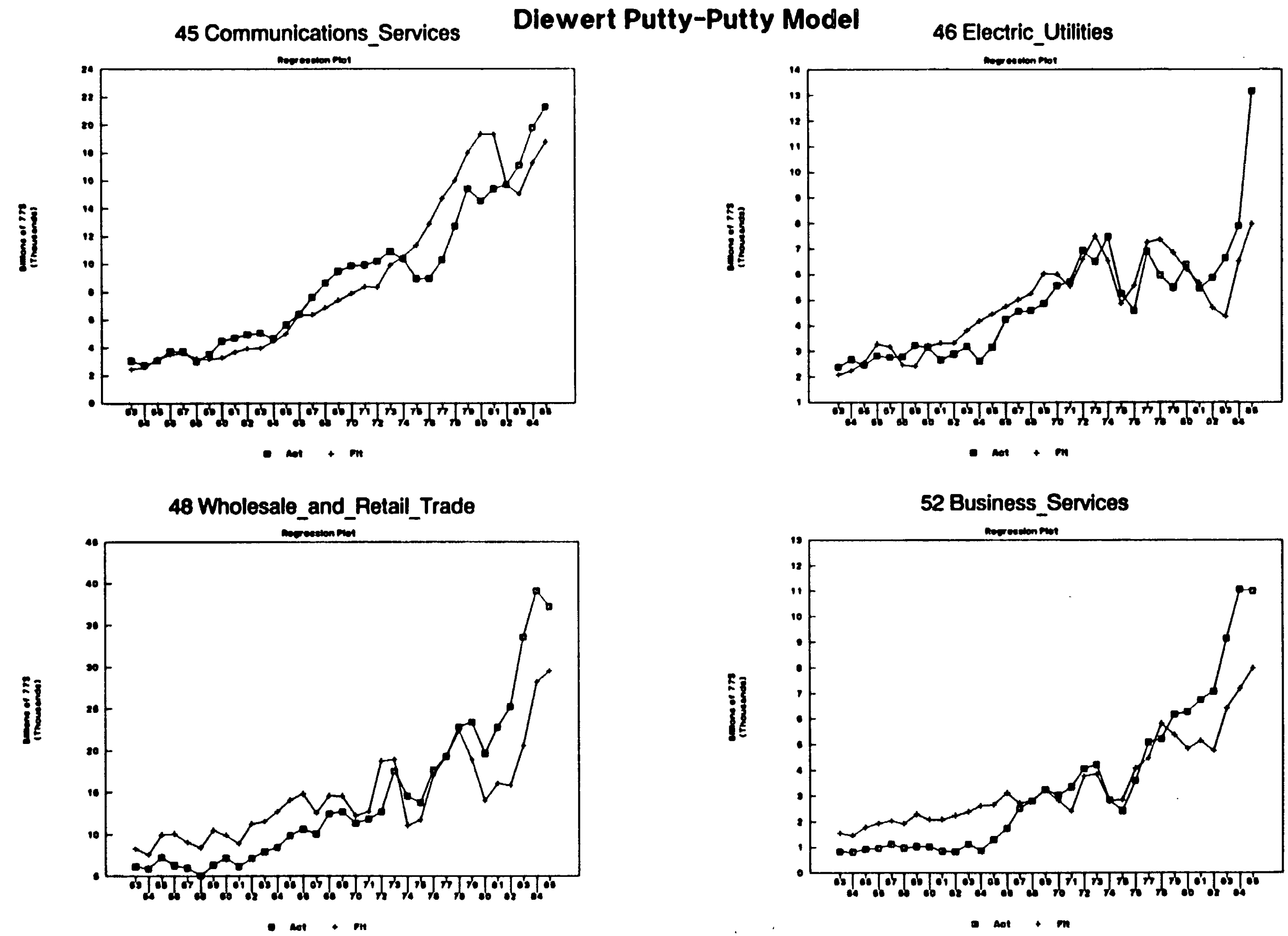


Figure 4.12.d - 1953 to 1985 Estimation

Table 4.14

CAPITAL DEMAND ELASTICITIES: 1953-1977

	INDUSTRY	ε_{KK}	ε_{KL}	ε_{KE}
1	Agriculture	0.000	0.026	-0.026
2	Crude Petroleum	0.000	0.147	-0.147
3	Mining	-0.114	0.028	0.086
4	Construction	-0.431	0.405	0.025
5	Food, Tobacco	-0.277	0.257	0.021
6	Textiles	-0.014	-0.028	0.043
7	Knitting, Hosiery	-0.470	0.187	0.284
8	Apparel	-0.038	-0.003	0.041
9	Paper	-0.091	0.065	0.026
10	Printing	-0.073	0.006	0.067
11	Agri. Fertilizers	-0.458	0.769	-0.311
12	Other Chemicals	-0.000	-0.000	0.000
13	Petroleum Refining	0.000	0.017	-0.017
14	Rubber & Plastics	-0.233	0.202	0.032
15	Footwear & Leather	0.000	0.036	-0.036
16	Lumber	-0.817	0.866	-0.048
17	Furniture	-0.066	0.005	0.060
18	Stone, Clay & Glass	-0.354	0.362	-0.008
19	Iron & Steel	0.000	0.007	-0.007
20	Non-Ferrous Metals	-0.083	0.123	-0.040
21	Metal Products	-0.165	0.059	0.107
22	Engines & Turbines	-0.454	0.651	-0.197
23	Agri. Machinery	-0.123	0.088	0.036
25	Metalworking Machinery	-0.167	0.140	0.027
27	Special industry Machinery	-0.523	0.442	0.081
28	Misc.nonelec. Machinery	-0.000	-0.014	0.014
29	Computers & Other	-0.063	0.028	0.034
30	Service Industry Machinery	-0.499	0.250	0.250
31	Communications Machinery	-0.018	-0.007	0.025
32	Heavy Electrical Machinery	0.000	0.033	-0.033
33	Household Appliances	-0.744	0.686	0.058
34	Elec. Lighting & Wiring Eq	-0.000	-0.025	0.025
35	Radio, T.V. Receiving, Phon	0.000	-0.284	0.284
36	Motor Vehicles	0.000	0.055	-0.055
37	Aerospace	-0.073	0.041	0.031
38	Ships & Boats	-0.192	0.130	0.062
39	Other Trans. Equip.	-0.309	0.227	0.081

Table 4.14 (cont)

CAPITAL DEMAND ELASTICITIES: 1953-1977

INDUSTRY	ε_{KK}	ε_{KL}	ε_{KE}
40 Instruments	-0.179	0.190	-0.011
41 Miscellaneous Manufacturin	-0.072	-0.025	0.097
42 Railroads	-0.082	0.128	-0.046
43 Air Transport	-0.331	0.166	0.166
44 Trucking & Other Transport	-0.710	0.685	0.025
45 Communications Services	0.000	0.001	-0.001
46 Electric Utilities	-0.006	0.003	0.003
47 Gas,water & Sanitation	-0.128	0.056	0.072
48 Wholesale & Retail trade	-0.017	0.097	-0.080
49 Finance, Insurance & Servi	-0.397	0.435	-0.038
50 Real Estate	-0.030	0.041	-0.011
51 Hotels & Repairs Minus Aut	-0.430	0.603	-0.173
52 Business Services	0.000	0.142	-0.142
53 Auto Repair	-0.351	0.371	-0.020
54 Movies & Amusements	-0.589	0.736	-0.147
55 Medical & Ed. Services	-0.465	0.554	-0.088

Table 4.15

CAPITAL DEMAND ELASTICITIES: 1953-1985

	INDUSTRY	ε_{KK}	ε_{KL}	ε_{KE}
1	Agriculture	-0.021	0.044	-0.023
2	Crude Petroleum	-0.067	0.096	-0.029
3	Mining	-0.000	-0.022	0.022
4	Construction	-0.019	0.000	0.019
5	Food, Tobacco	-0.000	-0.009	0.009
6	Textiles	-0.051	0.004	0.047
7	Knitting, Hosiery	-0.352	0.075	0.277
8	Apparel	-0.074	0.008	0.066
9	Paper	-0.000	-0.016	0.016
10	Printing	-0.000	-0.027	0.027
11	Agri. Fertilizers	-0.099	0.200	-0.101
12	Other Chemicals	-0.056	0.028	0.028
13	Petroleum Refining	-0.137	0.068	0.068
14	Rubber & Plastics	-0.153	0.154	-0.001
15	Footwear & Leather	-0.000	-0.026	0.026
16	Lumber	-0.000	-0.046	0.046
17	Furniture	-0.027	-0.015	0.041
18	Stone, Clay & Glass	-0.034	-0.008	0.042
19	Iron & Steel	0.000	-0.059	0.059
20	Non-Ferrous Metals	-0.054	-0.011	0.065
21	Metal Products	-0.119	0.006	0.113
22	Engines & Turbines	-0.008	0.004	0.004
23	Agri. Machinery	-0.067	0.025	0.042
25	Metalworking Machinery	-0.091	0.065	0.026
27	Special industry Machinery	-0.257	0.182	0.075
28	Misc.nonelec. Machinery	-0.015	-0.012	0.026
29	Computers & Other	-0.418	0.433	-0.015
30	Service Industry Machinery	-0.364	0.147	0.218
31	Communications Machinery	-0.132	0.119	0.013
32	Heavy Electrical Machinery	0.000	-0.022	0.022
33	Household Appliances	-0.593	0.432	0.161
34	Elec. Lighting & Wiring Eq	-0.005	-0.022	0.027
35	Radio, T.V. Receiving, Phon	0.000	-0.056	0.056
36	Motor Vehicles	0.000	-0.024	0.024
37	Aerospace	-0.008	-0.011	0.018
38	Ships & Boats	-0.060	0.017	0.043
39	Other Trans. Equip.	-0.095	0.014	0.082

Table 4.15 (cont)

CAPITAL DEMAND ELASTICITIES: 1953-1985

INDUSTRY	ε_{KK}	ε_{KL}	ε_{KE}
40 Instruments	-0.224	0.239	-0.015
41 Miscellaneous Manufacturin	-0.095	0.047	0.047
42 Railroads	0.000	0.023	-0.023
43 Air Transport	-0.676	0.951	-0.275
44 Trucking & Other Transport	-0.382	0.345	0.037
45 Communications Services	-0.000	-0.001	0.001
46 Electric Utilities	-0.006	0.003	0.003
47 Gas, water & Sanitation	-0.057	0.026	0.032
48 Wholesale & Retail trade	0.000	0.112	-0.112
49 Finance, Insurance & Servi	-0.321	0.353	-0.032
50 Real Estate	0.000	0.006	-0.006
51 Hotels & Repairs Minus Aut	-0.335	0.477	-0.143
52 Business Services	0.000	0.119	-0.119
53 Auto Repair	-0.175	0.192	-0.017
54 Movies & Amusements	-0.190	0.328	-0.138
55 Medical & Ed. Services	-0.228	0.291	-0.062

7. The Generalized Leontief Putty-Clay Model

This model, described in Chapter III section 7, was also estimated jointly as a three equation system of factor demands for net investment, labor and energy. The labor and energy equations were identical to those in the putty-putty model. The two models differ only in the formulation of the net investment equation, which is reproduced here for convenience.

$$N_t = e^{-a_{K1} t_1 + a_{K2} t_2} \left\{ \sum_m b_{Km} (P_m / P_K)_t^{1/2} \right\} \sum_{j=0}^{3} w_j^K \Delta Q_{t-j} \qquad (7.1)$$

where $m = E, K, L$

This system, like the previous one, was estimated in two stages, where optimal capital-output, labor-output, and energy-output ratios were estimated in the first stage, as functions of relative prices, and distributed lag weights on changes in output or prices were estimated in the second stage. The same set of constraints was placed on the estimated parameters. Since the first stage estimation for both models is the same, the estimated values for the *a*'s and *b*'s are the same. Therefore the elasticity estimates of these two models are also identical. The only difference is the pattern of response of investment to a change in the desired capital stock. Whereas the putty-clay model only adjusts to changes in output at the currently optimal capital-output ratio, the putty-putty model also adjusts to changes in price by generating investment that changes the capital-output ratio of previous vintages of capital.

Tables 4.16 and 4.17 contain the parameter estimates for this model. Column headings are the same as those for the previous model. Note that the estimates of the b_{Kj} parameters are also the same as those of the previous model. The intercept and the trend terms (a_{K1} and a_{K2}) are different. However, the general pattern of the trend terms is almost identical to that in the putty-putty model.

Table 4.16.a

Generalized Leontief putty-clay investment equation.   Estimated 53 to 77.

	Sector Title	INTCP	b[KK]	b[KL]	b[KE]	a[K1]	a[K2]	w[K1]	w[K2]	w[K3]	w[K4]
1	Agriculture, Forestry, Fisher	-0.4144	1.2047	0.0138	-0.0256	0.0050	0.0050	0.3110	0.2727	0.2727	0.1435
2	Crude Petroleum, Natural Gas	0.1730	0.2898	0.0184	-0.0531	0.0050	0.0000	0.6241	0.1548	0.1548	0.0664
3	Mining	0.1010	0.6953	0.0073	0.0684	0.0050	0.0050	0.2040	0.3944	0.3052	0.0965
4	Construction	1.5702	-0.2448	0.1114	0.0200	0.0050	0.0050	0.2954	0.4478	0.2154	0.0414
5	Food, Tobacco	0.1331	0.0300	0.0173	0.0037	-0.0050	0.0000	0.2984	0.3014	0.2659	0.1344
6	Textiles	0.0624	0.3391	-0.0040	0.0159	0.0050	0.0000	0.2026	0.3341	0.3341	0.1291
7	Knitting, Hosiery	-0.0146	0.0017	0.0241	0.0666	0.0016	-0.0034	0.5548	0.1897	0.1897	0.0659
8	Apparel and Household Textile	0.0510	0.1040	-0.0003	0.0067	0.0008	-0.0042	0.3038	0.3385	0.3385	0.0191
9	Paper	0.1308	0.3771	0.0132	0.0148	0.0050	0.0050	0.1877	0.2749	0.2687	0.2687
10	Printing	0.0802	0.1733	0.0007	0.0200	-0.0039	0.0011	0.3446	0.2402	0.2402	0.1750
11	Agricultural Fertilizers	0.0364	-0.1836	0.1441	-0.1738	-0.0050	0.0000	0.0000	0.3333	0.3333	0.3333
12	Other Chemicals	-0.4274	0.5524	0.0000	-0.0000	0.0050	0.0000	0.2289	0.2570	0.2570	0.2570
13	Petroleum Refining and Fuel	-0.0559	0.1281	0.0005	-0.0019	0.0050	0.0050	0.2997	0.2361	0.2321	0.2321
14	Rubber and Plastics	-0.0848	0.2927	0.0312	0.0130	0.0050	0.0000	0.3161	0.2590	0.2590	0.1660
15	Footwear and Leather	0.0088	0.1450	0.0029	-0.0064	-0.0007	0.0043	0.2566	0.3214	0.3214	0.1006
16	Lumber	0.1096	-0.2283	0.0972	-0.0136	0.0050	0.0050	0.2089	0.2637	0.2637	0.2637
17	Furniture	-0.0002	0.1818	0.0005	0.0130	0.0050	0.0000	0.3284	0.2804	0.2804	0.1108
18	Stone, Clay and Glass	0.1782	-0.0016	0.0672	-0.0042	0.0050	0.0050	0.3294	0.3207	0.2358	0.1141
19	Iron and Steel	0.5506	0.3962	0.0012	-0.0041	0.0050	0.0000	0.2698	0.3020	0.2388	0.1894
20	Non Ferrous Metals	0.1020	0.1955	0.0141	-0.0139	0.0050	0.0030	0.1359	0.2880	0.2880	0.2880
21	Metal Products	0.0866	0.1576	0.0063	0.0322	0.0050	0.0000	0.3182	0.2765	0.2721	0.1332
22	Engines and Turbines	0.0135	-0.0450	0.0560	-0.0529	-0.0004	-0.0050	0.3294	0.3353	0.3353	0.0000
23	Agricultural Machinery	0.0052	0.1483	0.0066	0.0082	0.0050	0.0000	0.3174	0.3013	0.3013	0.0801
25	Metalworking Machinery	0.0227	0.2277	0.0198	0.0111	0.0050	0.0000	0.3372	0.3161	0.3161	0.0305
27	Special Industry Machinery	-0.0394	0.0211	0.0569	0.0297	0.0050	0.0000	0.3326	0.3072	0.3072	0.0530
28	Miscellaneous Non-Electrical	0.0859	0.2393	-0.0015	0.0044	0.0050	0.0000	0.3281	0.2423	0.2423	0.1873
29	Computers	-0.0667	0.4636	0.0033	0.0114	0.0050	0.0000	0.2644	0.3414	0.3414	0.0527
30	Service Industry Machinery	-0.0224	0.0561	0.0219	0.0601	0.0050	0.0000	0.3816	0.3012	0.3012	0.0160
31	Communications Machinery	-0.1225	0.4833	-0.0008	0.0100	0.0050	0.0000	0.3435	0.3111	0.3111	0.0343
32	Heavy Electrical Machinery	0.0166	0.2560	0.0038	-0.0104	0.0050	0.0000	0.3485	0.2532	0.2532	0.1452
33	Household Appliances	-0.0484	-0.0133	0.0629	0.0175	0.0050	0.0000	0.3381	0.3037	0.3037	0.0545
34	Electrical Lighting and wiri	0.0427	0.2622	-0.0030	0.0084	0.0050	0.0000	0.2684	0.3680	0.2955	0.0681
35	Radio, T.V. Phonographs	0.0009	0.2242	-0.0243	0.0627	0.0050	0.0000	0.2319	0.4789	0.1990	0.0902
36	Motor Vehicles	0.2041	0.2199	0.0041	-0.0139	0.0050	0.0000	0.3496	0.4012	0.2342	0.0149
37	Aerospace	0.0466	0.0954	0.0032	0.0076	0.0050	0.0000	0.3977	0.2926	0.2926	0.0172
38	Ships and Boats	0.0393	-0.0094	0.0104	0.0138	-0.0050	0.0000	0.4067	0.2775	0.2775	0.0382
39	Other Transportation Equipme	0.0264	-0.0247	0.0112	0.0122	0.0050	0.0050	0.5111	0.1804	0.1804	0.1280
40	Instruments	-0.0078	0.1873	0.0208	-0.0032	0.0050	0.0000	0.3014	0.3040	0.3040	0.0905
41	Miscellaneous Manufacturing	0.0130	0.2213	-0.0026	0.0251	0.0050	0.0000	0.3595	0.3047	0.3047	0.0312
42	Railroads	0.5938	1.6136	0.0821	-0.0999	0.0050	0.0000	0.2707	0.3179	0.3179	0.0935
43	Air Transport	-1.2989	2.2493	0.0669	0.2434	0.0050	0.0000	0.3611	0.3891	0.2498	0.0000
44	Trucking and Other Transport	0.2847	-0.4172	0.1617	0.0176	-0.0050	0.0000	0.3517	0.3040	0.3040	0.0403
45	Communications Services	-0.4942	2.0024	0.0004	-0.0013	0.0050	0.0000	0.0000	0.5000	0.5000	0.0000
46	Electric Utilities	-0.8646	1.3693	0.0008	0.0026	0.0050	0.0000	0.1618	0.4414	0.3937	0.0031
47	Gas, Water and Sanitation	-0.0424	0.2493	0.0060	0.0218	0.0050	0.0000	0.0245	0.4268	0.4268	0.1220
48	Wholesale and Retail Trade	-0.3787	0.2254	0.0135	-0.0275	-0.0050	0.0000	0.4206	0.3276	0.1259	0.1259
49	Finance and Insurance	0.0395	-0.0021	0.0434	-0.0108	-0.0050	0.0000	0.3220	0.3173	0.3173	0.0433
50	Real Estate	0.5862	0.1035	0.0042	-0.0030	-0.0050	0.0000	0.1839	0.5851	0.2196	0.0115
51	Hotels and repairs Minus Aut	0.2849	-0.0844	0.1747	-0.1079	0.0050	0.0000	0.0446	0.3185	0.3185	0.3185
52	Business Services	0.2802	0.1024	0.0106	-0.0290	-0.0050	0.0000	0.8292	0.0569	0.0569	0.0569
53	Auto repair	0.2716	0.0594	0.1076	-0.0138	0.0050	0.0000	0.3588	0.4078	0.2180	0.0154
54	Movies and Amusements	0.1058	-0.1624	0.2038	-0.0975	0.0050	0.0000	0.2977	0.3304	0.1910	0.1808
55	Medical and Educational Serv	0.2011	0.0076	0.0859	-0.0349	0.0050	0.0000	0.4462	0.4784	0.0616	0.0138

Table 4.16.b

Generalized Leontief putty-clay investment equation.   Estimated 53 to 77.

	Sector Title	RSQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.025	17.366	1713.500	0.635
2	Crude Petroleum, Natural Gas	-3.064	23.360	446.100	0.724
3	Mining	-0.395	25.650	573.500	0.822
4	Construction	0.807	29.448	1684.600	0.807
5	Food, Tobacco	0.850	12.099	340.900	0.768
6	Textiles	0.585	16.217	156.400	0.536
7	Knitting, Hosiery	0.854	38.444	32.644	0.351
8	Apparel and Household Textile	0.634	27.916	126.300	0.699
9	Paper	0.796	10.294	256.300	0.379
10	Printing	0.869	14.381	136.800	0.724
11	Agricultural Fertilizers	0.599	48.160	173.200	0.671
12	Other Chemicals	0.770	12.364	513.400	0.526
13	Petroleum Refining and Fuel	0.279	40.802	337.400	0.714
14	Rubber and Plastics	0.668	17.311	224.900	0.340
15	Footwear and Leather	0.385	15.698	23.576	0.512
16	Lumber	0.836	17.979	141.000	0.354
17	Furniture	0.618	15.395	51.733	0.361
18	Stone, Clay and Glass	0.849	12.659	151.400	0.728
19	Iron and Steel	-3.967	31.531	1056.700	0.727
20	Non Ferrous Metals	0.581	22.937	204.900	0.597
21	Metal Products	0.491	15.573	342.300	0.690
22	Engines and Turbines	0.883	28.687	34.790	0.524
23	Agricultural Machinery	0.160	29.517	59.992	0.436
25	Metalworking Machinery	-1.713	36.702	204.900	0.654
27	Special Industry Machinery	-9.864	53.494	139.000	0.727
28	Miscellaneous Non-Electrical	0.774	16.890	153.100	0.617
29	Computers	0.309	43.172	143.800	0.740
30	Service Industry Machinery	0.478	33.055	60.045	0.521
31	Communications Machinery	0.393	39.562	359.400	0.517
32	Heavy Electrical Machinery	0.499	21.674	91.654	0.580
33	Household Appliances	-0.222	28.957	68.417	0.509
34	Electrical Lighting and wiri	0.785	21.576	69.270	0.587
35	Radio, T.V. Phonographs	0.795	33.632	21.948	0.407
36	Motor Vehicles	0.601	22.199	464.100	0.256
37	Aerospace	-0.155	42.013	267.800	0.834
38	Ships and Boats	0.498	138.300	80.059	0.667
39	Other Transportation Equipme	0.573	92.325	36.249	0.878
40	Instruments	0.858	15.447	78.178	0.630
41	Miscellaneous Manufacturing	0.283	18.556	80.215	0.230
42	Railroads	0.465	23.221	697.100	0.494
43	Air Transport	0.605	37.448	1191.800	0.785
44	Trucking and Other Transport	0.935	15.039	528.900	0.646
45	Communications Services	0.740	13.850	1451.100	0.669
46	Electric Utilities	0.864	13.138	581.700	0.203
47	Gas, Water and Sanitation	-1.339	42.467	751.700	0.731
48	Wholesale and Retail Trade	0.915	9.702	1175.500	0.529
49	Finance and Insurance	0.907	14.073	346.700	0.567
50	Real Estate	0.610	67.920	1063.600	0.917
51	Hotels and repairs Minus Aut	0.778	15.409	340.800	0.723
52	Business Services	0.804	29.417	567.700	0.629
53	Auto repair	0.735	20.887	459.500	0.617
54	Movies and Amusements	0.777	16.812	179.000	0.755
55	Medical and Educational Serv	0.894	11.609	586.700	0.728

Table 4.17.a

Generalized Leontief putty-clay investment equation. Estimated from 53 to 85.

	Sector Title	INTCP	b[KK]	b[KL]	b[KE]	a[K1]	a[K2]	w[K1]	w[K2]	w[K3]	w[K4]
1	Agriculture, Forestry, Fisher	-1.0011	1.1536	0.0262	-0.0194	0.0050	0.0000	0.2798	0.3139	0.3139	0.0924
2	Crude Petroleum, Natural Gas	0.3732	0.2239	0.0249	-0.0176	0.0050	0.0000	0.4857	0.2571	0.2571	0.0000
3	Mining	0.0693	0.8868	-0.0081	0.0221	0.0050	0.0050	0.3037	0.3412	0.2900	0.0651
4	Construction	0.8955	0.4604	0.0001	0.0183	-0.0050	0.0000	0.2266	0.4094	0.3495	0.0144
5	Food, Tobacco	0.1417	0.1328	-0.0008	0.0017	-0.0027	-0.0050	0.3760	0.3451	0.2080	0.0708
6	Textiles	0.0137	0.3018	0.0008	0.0201	0.0050	0.0000	0.3120	0.3096	0.2622	0.1162
7	Knitting, Hosiery	0.0027	0.0154	0.0140	0.0753	0.0050	0.0000	0.4590	0.2347	0.2347	0.0716
8	Apparel and Household Textile	0.0073	0.0979	0.0007	0.0082	0.0050	0.0000	0.4480	0.2701	0.2701	0.0117
9	Paper	0.1704	0.4963	-0.0044	0.0104	0.0050	0.0050	0.1252	0.3527	0.2959	0.2261
10	Printing	0.0991	0.2337	-0.0040	0.0093	0.0014	0.0050	0.3785	0.2476	0.2476	0.1263
11	Agricultural Fertilizers	0.0214	0.2575	0.0193	-0.0332	-0.0050	0.0000	0.0000	0.3333	0.3333	0.3333
12	Other Chemicals	-0.2856	0.4904	0.0056	0.0138	0.0050	0.0000	0.2305	0.2565	0.2565	0.2565
13	Petroleum Refining and Fuel	0.1717	0.0725	0.0045	0.0137	0.0050	0.0000	0.3118	0.2294	0.2294	0.2294
14	Rubber and Plastics	-0.2067	0.3599	0.0278	-0.0003	0.0050	0.0000	0.2936	0.2903	0.2903	0.1258
15	Footwear and Leather	0.0082	0.1491	-0.0035	0.0059	-0.001	-0.0050	0.3355	0.2713	0.2658	0.1274
16	Lumber	0.0624	0.2088	-0.0073	0.0138	-0.0026	-0.0050	0.2146	0.3016	0.3016	0.1823
17	Furniture	-0.0090	0.2019	-0.0018	0.0090	0.0050	0.0000	0.3345	0.2764	0.2764	0.1127
18	Stone, Clay and Glass	0.1595	0.3261	-0.0025	0.0271	0.0044	0.0008	0.3252	0.2776	0.2776	0.1197
19	Iron and Steel	0.5954	0.4413	-0.0224	0.0580	0.0050	0.0000	0.2977	0.3005	0.2267	0.1751
20	Non Ferrous Metals	0.1359	0.2151	-0.0023	0.0316	0.0050	0.0000	0.1898	0.2782	0.2782	0.2539
21	Metal Products	0.0677	0.1785	0.0009	0.0359	0.0050	0.0000	0.3126	0.3108	0.3108	0.0657
22	Engines and Turbines	0.0457	0.1840	0.0008	0.0020	0.0050	0.0000	0.3636	0.3182	0.3182	0.0000
23	Agricultural Machinery	0.0134	0.1422	0.0047	0.0182	0.0050	0.0000	0.2613	0.3525	0.3525	0.0338
25	Metalworking Machinery	0.0255	0.2602	0.0138	0.0121	0.0050	0.0000	0.3367	0.3153	0.3153	0.0326
27	Special Industry Machinery	-0.0067	0.1719	0.0321	0.0285	0.0050	0.0000	0.3554	0.2960	0.2960	0.0527
28	Miscellaneous Non-Electrical	0.1417	0.2383	-0.0025	0.0123	0.0050	0.0000	0.3214	0.2473	0.2473	0.1841
29	Computers	-0.2086	0.2203	0.0594	-0.0045	0.0050	0.0000	0.1860	0.4070	0.4070	0.0000
30	Service Industry Machinery	-0.0196	0.1024	0.0170	0.0497	0.0050	0.0000	0.3375	0.3069	0.3069	0.0487
31	Communications Machinery	-0.2733	0.3891	0.0167	0.0046	0.0050	0.0000	0.3153	0.3383	0.3383	0.0081
32	Heavy Electrical Machinery	0.0427	0.2657	-0.0041	0.0078	0.0050	0.0000	0.3378	0.2637	0.2582	0.1403
33	Household Appliances	-0.0372	0.0206	0.0562	0.0199	0.0050	0.0000	0.3365	0.2892	0.2892	0.0851
34	Electrical Lighting and wiri	0.0331	0.2710	-0.0038	0.0102	0.0050	0.0000	0.2874	0.2998	0.2998	0.1129
35	Radio, T.V. Phonographs	-0.0128	0.2663	-0.0065	0.0119	0.0050	0.0000	0.2849	0.2848	0.2413	0.1890
36	Motor Vehicles	0.3215	0.2397	-0.0035	0.0083	0.0050	0.0000	0.2920	0.3659	0.3319	0.0102
37	Aerospace	0.0737	0.1427	-0.0010	0.0042	0.0050	0.0038	0.3756	0.3037	0.3037	0.0169
38	Ships and Boats	0.0311	0.0668	0.0026	0.0139	-0.0050	0.0000	0.4126	0.2699	0.2699	0.0476
39	Other Transportation Equipme	0.0362	0.0271	0.0018	0.0267	0.0050	0.0000	0.5242	0.1947	0.1947	0.0863
40	Instruments	0.0094	0.1110	0.0352	-0.0047	0.0050	0.0000	0.3205	0.2884	0.2781	0.1130
41	Miscellaneous Manufacturing	0.0090	0.1930	0.0083	0.0152	0.0050	0.0000	0.4234	0.2673	0.2673	0.0420
42	Railroads	0.5253	2.0706	0.0214	-0.0527	0.0013	0.0050	0.3363	0.3176	0.3176	0.0286
43	Air Transport	-1.5087	0.3992	0.4966	-0.3680	0.0050	0.0000	0.2423	0.3318	0.3318	0.0941
44	Trucking and Other Transport	0.7776	-0.2689	0.1428	0.0341	-0.0002	0.0048	0.3062	0.2519	0.2519	0.1899
45	Communications Services	-1.2247	2.0956	-0.0008	0.0023	0.0050	0.0000	0.3516	0.3242	0.3242	0.0000
46	Electric Utilities	-0.6017	1.3409	0.0015	0.0036	0.0050	0.0050	0.2316	0.5344	0.2294	0.0047
47	Gas, Water and Sanitation	0.4166	0.2269	0.0079	0.0188	0.0050	0.0000	0.0763	0.4461	0.4461	0.0314
48	Wholesale and Retail Trade	1.1273	0.2262	0.0272	-0.0500	-0.0050	0.0000	0.7096	0.2799	0.0052	0.0052
49	Finance and Insurance	0.3691	-0.0344	0.0555	-0.0094	-0.0050	0.0000	0.8813	0.0395	0.0395	0.0395
50	Real Estate	0.9668	0.1715	0.0013	-0.0022	-0.0050	0.0000	0.3013	0.5205	0.1771	0.0010
51	Hotels and repairs Minus Aut	0.3243	-0.0618	0.1708	-0.0857	0.0050	0.0050	0.3361	0.2757	0.2757	0.1125
52	Business Services	0.6389	0.1115	0.0141	-0.0268	-0.0050	0.0000	0.7396	0.1253	0.0675	0.0675
53	Auto repair	0.3282	0.1833	0.0816	-0.0124	0.0002	0.0050	0.5124	0.3206	0.1602	0.0069
54	Movies and Amusements	0.0696	0.2894	0.0894	-0.0661	0.0050	0.0000	0.2891	0.2871	0.2119	0.2119
55	Medical and Educational Serv	0.2907	0.0905	0.0660	-0.0281	-0.0006	0.0044	0.4299	0.4555	0.0573	0.0573

Table 4.17.b

Generalized Leontief putty-clay investment equation. Estimated 53 to 85.

	Sector Title	RSQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	0.099	20.182	2055.900	0.601
2	Crude Petroleum, Natural Gas	0.066	27.907	788.000	0.767
3	Mining	0.183	22.714	577.800	0.779
4	Construction	0.863	23.298	1675.300	0.822
5	Food, Tobacco	0.843	11.802	370.100	0.671
6	Textiles	-0.094	18.393	224.900	0.746
7	Knitting, Hosiery	0.748	43.214	41.031	0.477
8	Apparel and Household Textile	0.249	29.179	162.400	0.778
9	Paper	0.863	9.911	296.900	0.395
10	Printing	0.920	13.563	161.800	0.509
11	Agricultural Fertilizers	0.571	43.525	168.500	0.604
12	Other Chemicals	0.502	16.025	780.200	0.513
13	Petroleum Refining and Fuel	0.127	54.501	609.600	0.821
14	Rubber and Plastics	0.038	25.485	374.300	0.604
15	Footwear and Leather	0.465	17.984	24.213	0.632
16	Lumber	0.737	18.384	181.900	0.628
17	Furniture	0.618	13.895	51.813	0.327
18	Stone, Clay and Glass	0.858	11.529	151.800	0.550
19	Iron and Steel	-2.889	28.808	990.000	0.746
20	Non Ferrous Metals	0.566	21.977	205.900	0.587
21	Metal Products	0.282	17.065	386.800	0.571
22	Engines and Turbines	0.645	36.764	69.931	0.663
23	Agricultural Machinery	0.210	28.647	61.792	0.453
25	Metalworking Machinery	-1.719	34.492	187.100	0.647
27	Special Industry Machinery	-9.471	52.247	135.900	0.798
28	Miscellaneous Non-Electrical	0.694	17.220	221.400	0.593
29	Computers	0.781	88.267	313.000	0.842
30	Service Industry Machinery	0.097	33.709	74.586	0.496
31	Communications Machinery	0.626	42.758	600.100	0.706
32	Heavy Electrical Machinery	0.438	23.383	122.500	0.615
33	Household Appliances	-0.858	35.820	75.511	0.585
34	Electrical Lighting and wiri	0.710	20.767	81.869	0.452
35	Radio, T.V. Phonographs	0.624	28.337	32.280	0.441
36	Motor Vehicles	0.266	28.852	869.900	0.394
37	Aerospace	0.160	40.300	290.300	0.815
38	Ships and Boats	0.595	101.800	69.810	0.603
39	Other Transportation Equipme	0.651	92.054	42.653	0.739
40	Instruments	0.643	18.229	164.800	0.577
41	Miscellaneous Manufacturing	-0.294	21.563	96.789	0.380
42	Railroads	0.552	29.773	990.400	0.658
43	Air Transport	0.315	44.527	1686.800	0.713
44	Trucking and Other Transport	0.882	28.096	954.700	0.795
45	Communications Services	0.832	19.303	2084.900	0.849
46	Electric Utilities	0.681	16.586	1247.900	0.383
47	Gas, Water and Sanitation	0.201	54.073	1067.800	0.886
48	Wholesale and Retail Trade	0.796	24.007	4099.300	0.858
49	Finance and Insurance	0.792	27.895	1268.900	0.633
50	Real Estate	0.748	88.589	1492.900	0.947
51	Hotels and repairs Minus Aut	0.673	16.916	446.300	0.760
52	Business Services	0.835	43.817	1182.500	0.814
53	Auto repair	0.835	22.922	638.100	0.612
54	Movies and Amusements	0.775	18.529	223.400	0.841
55	Medical and Educational Serv	0.842	14.902	1217.900	0.815

Diewert Putty-Clay Model

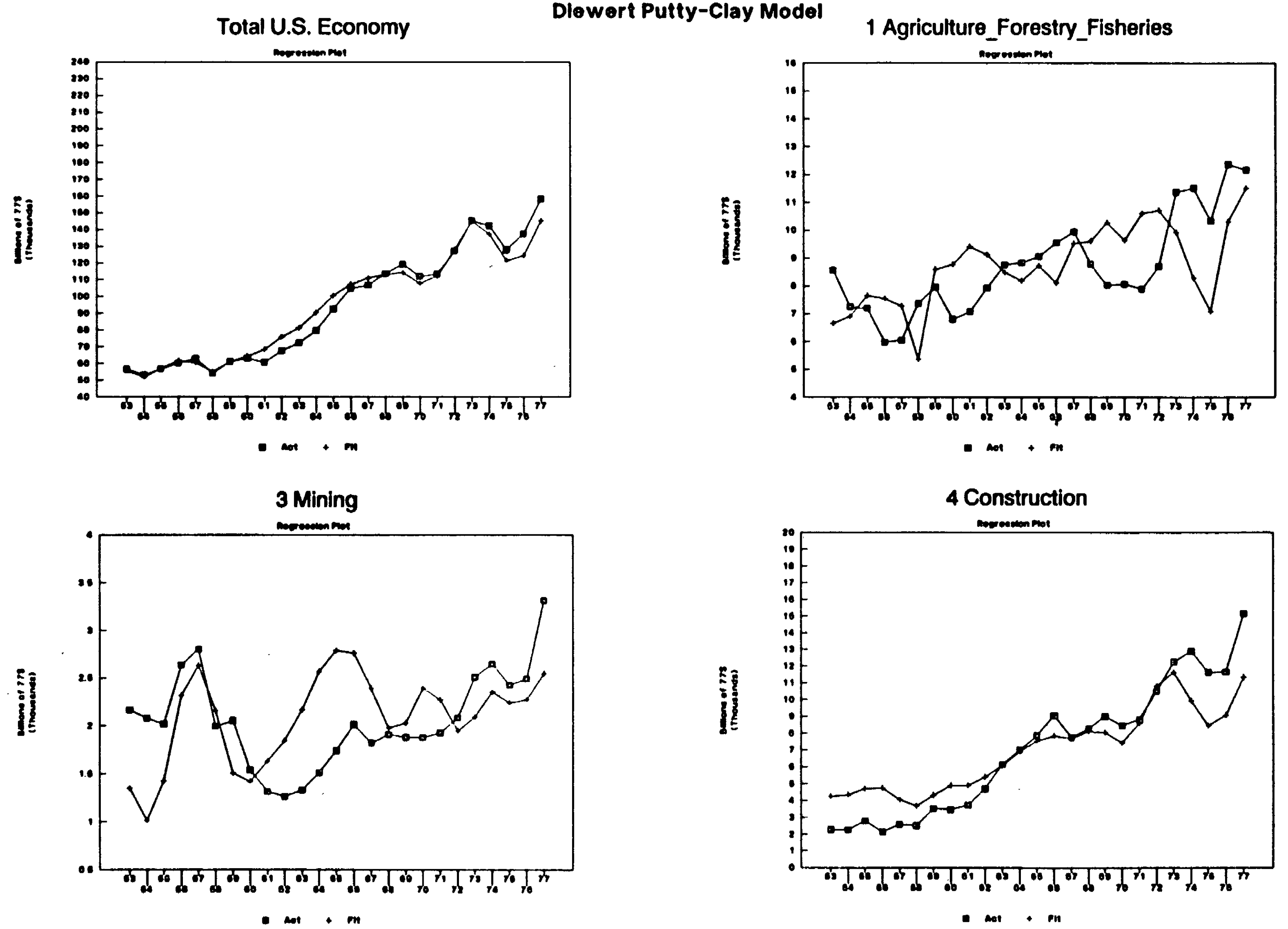


Figure 4.13.a - 1953 to 1977 Estimation

Diewert Putty-Clay Model

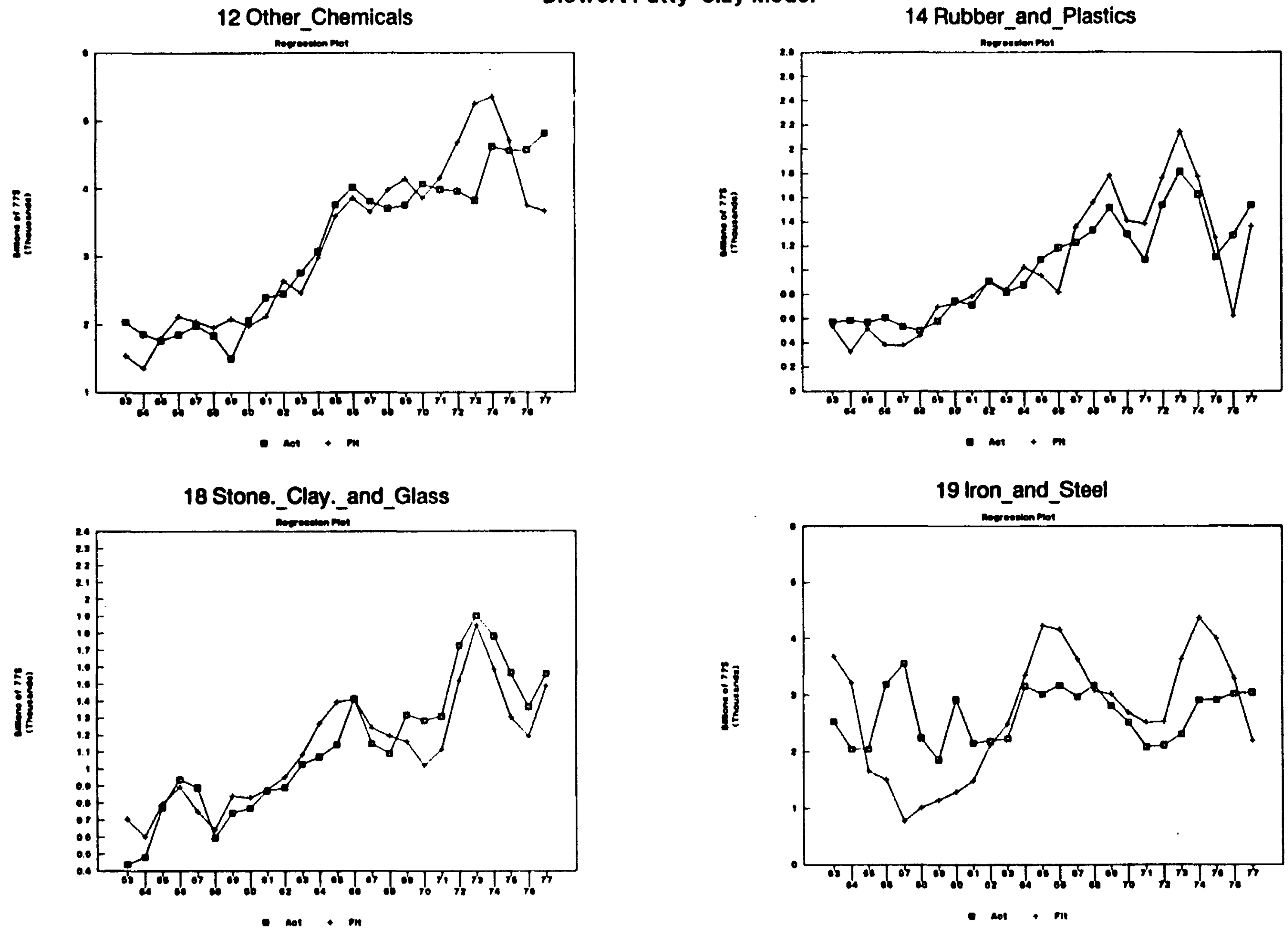
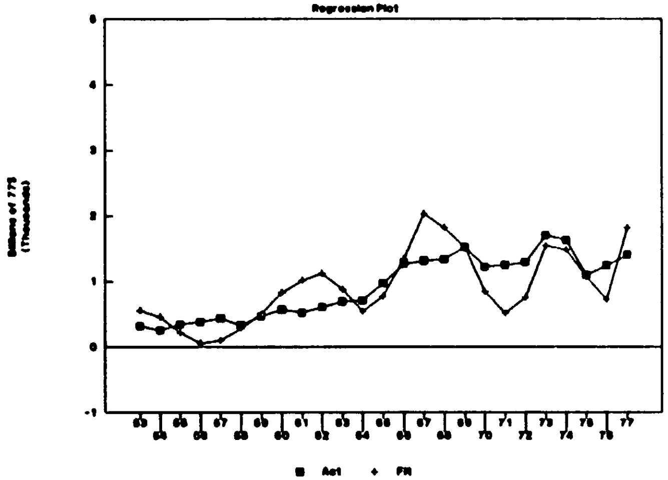


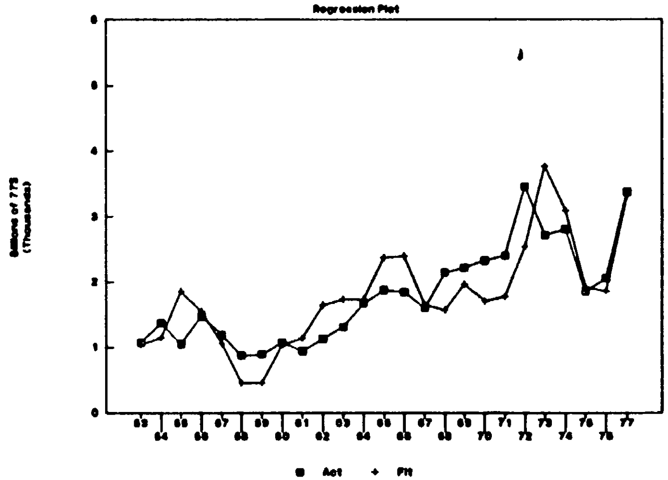
Figure 4.13.b - 1953 to 1977 Estimation

Diewert Putty-Clay Model

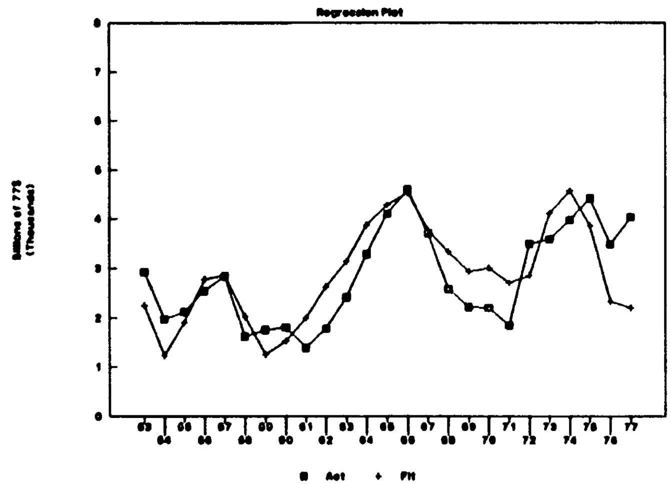
31 Communications_Machinery



36 Motor_Vehicles



42 Railroads



43 Air_Transport

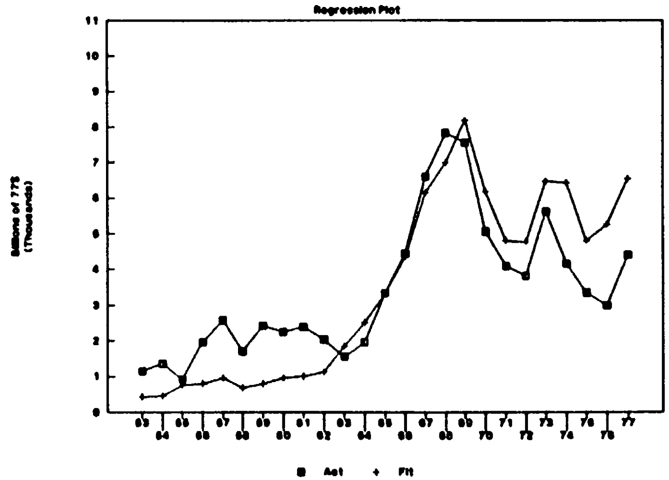


Figure 4.13.c - 1953 to 1977 Estimation

Diewert Putty-Clay Model

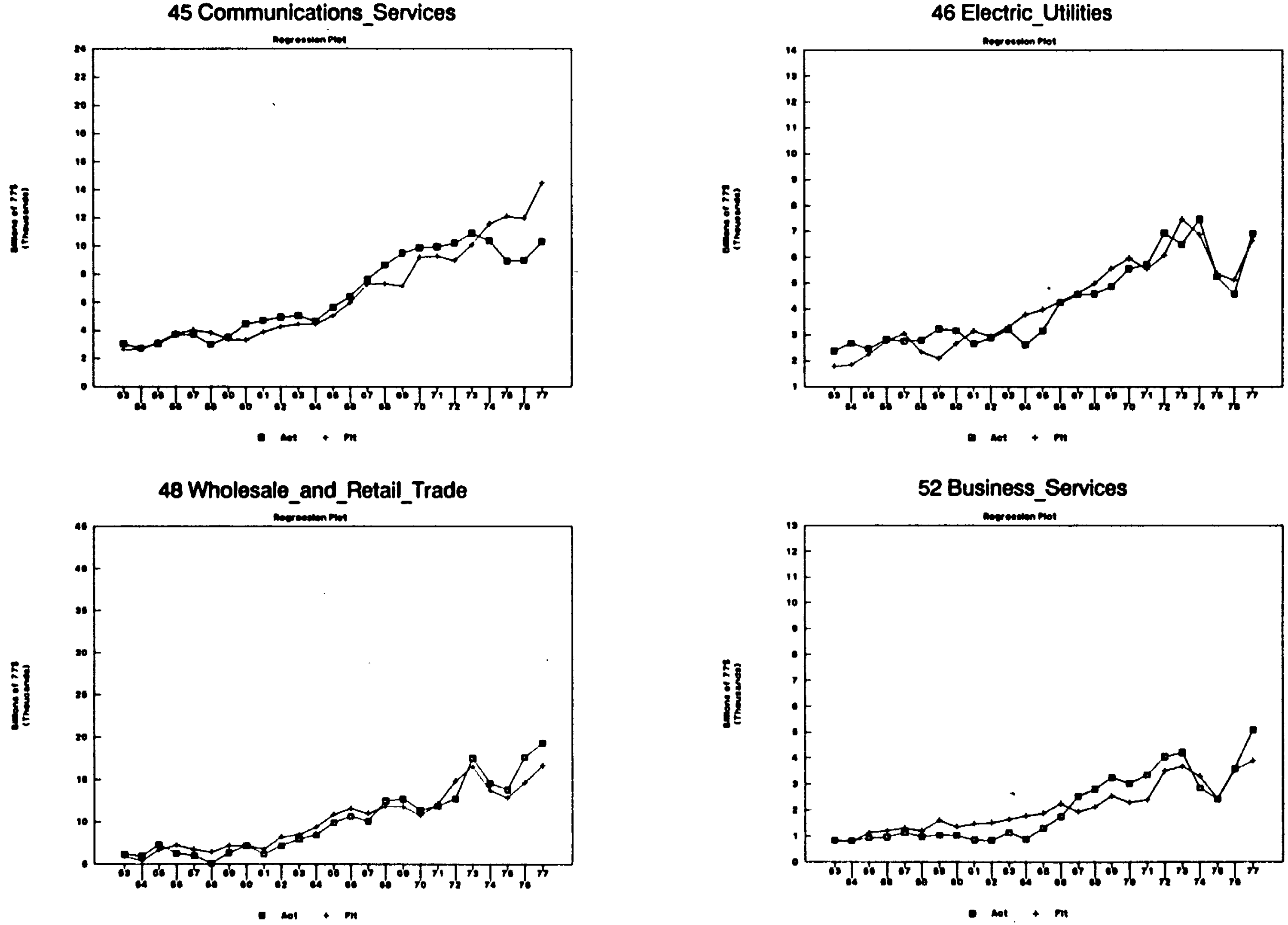


Figure 4.13.d - 1953 to 1977 Estimation

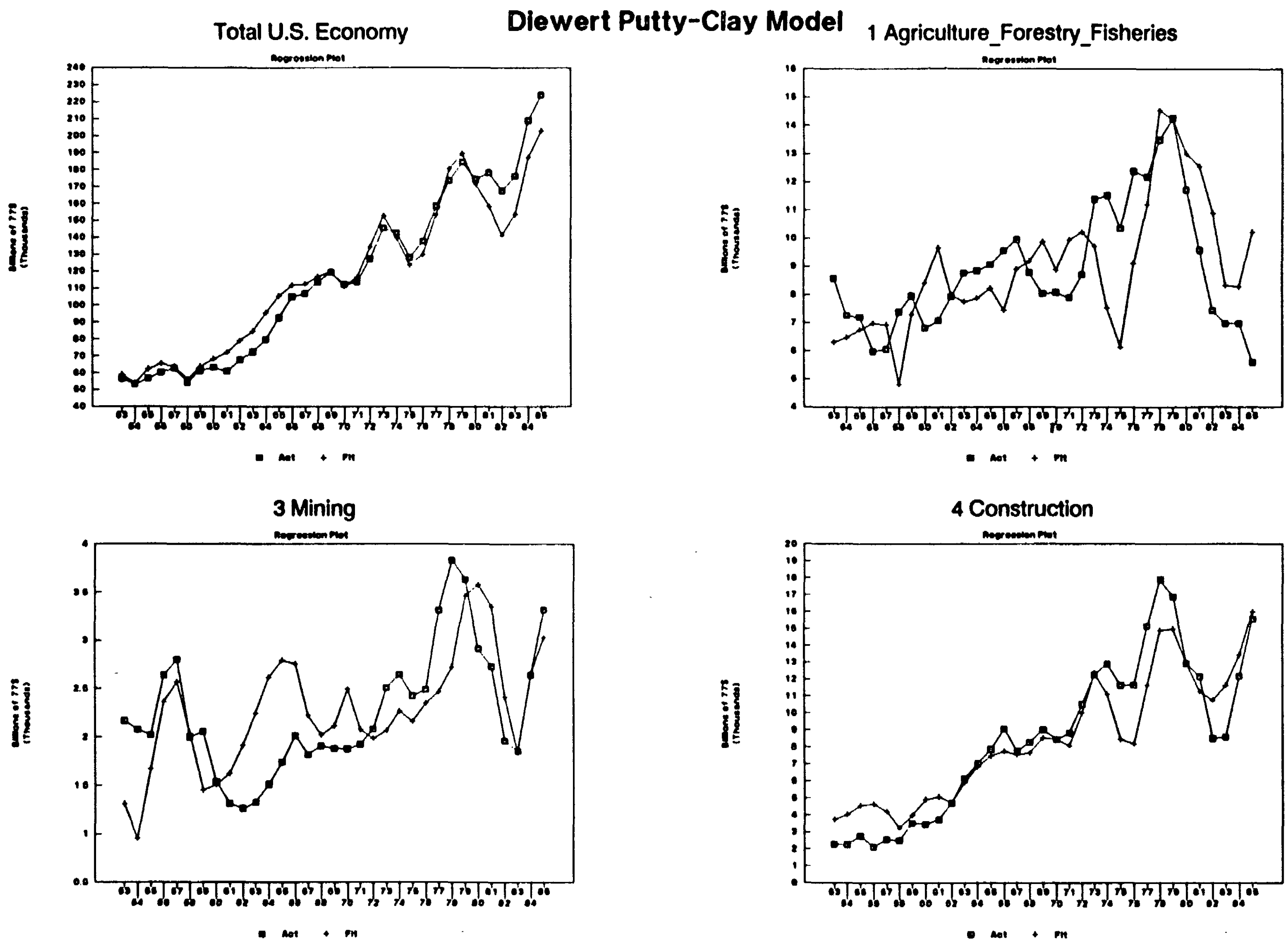


Figure 4.14.a - 1953 to 1985 Estimation

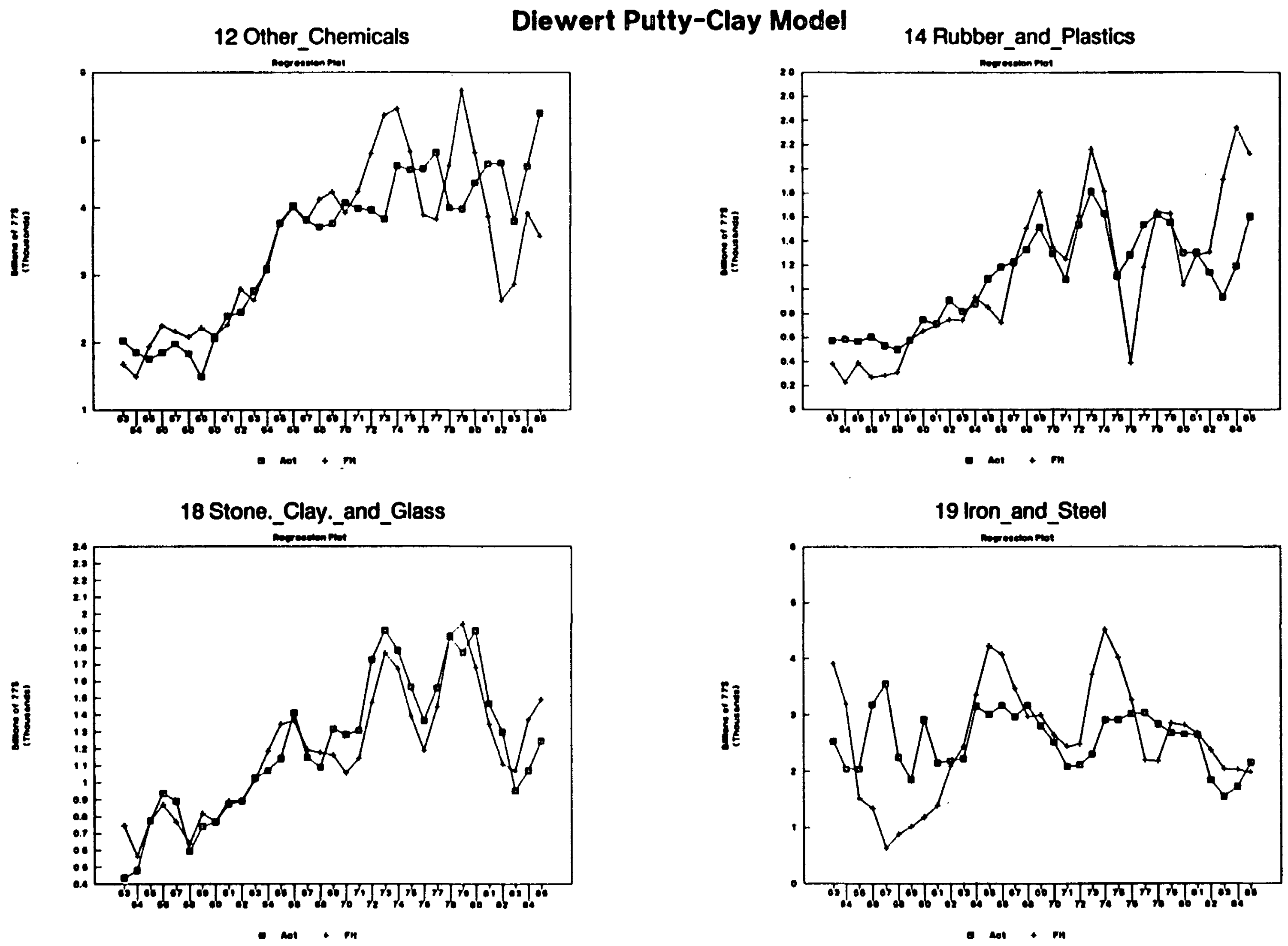


Figure 4.14.b - 1953 to 1985 Estimation

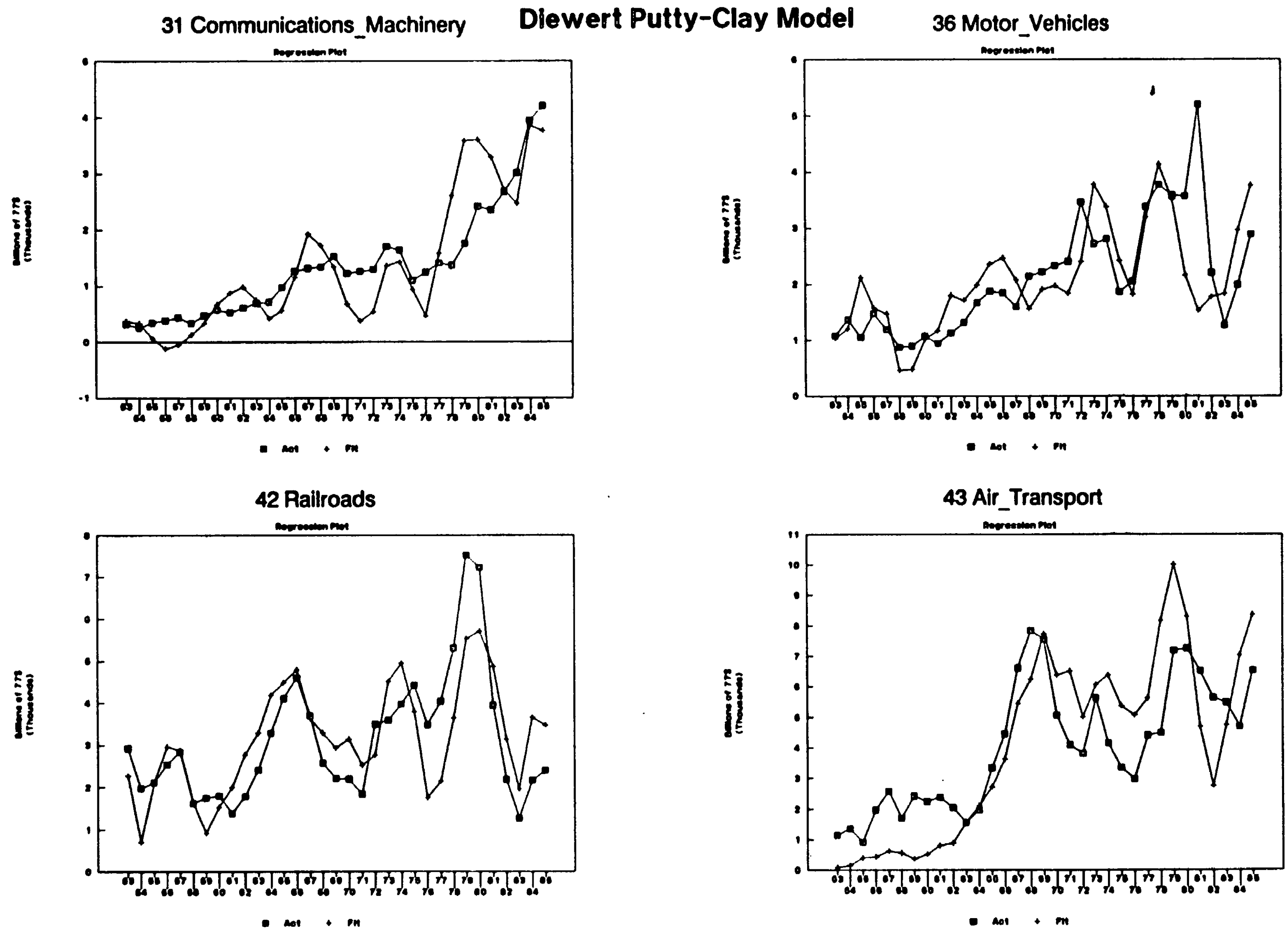


Figure 4.14.c - 1953 to 1985 Estimation

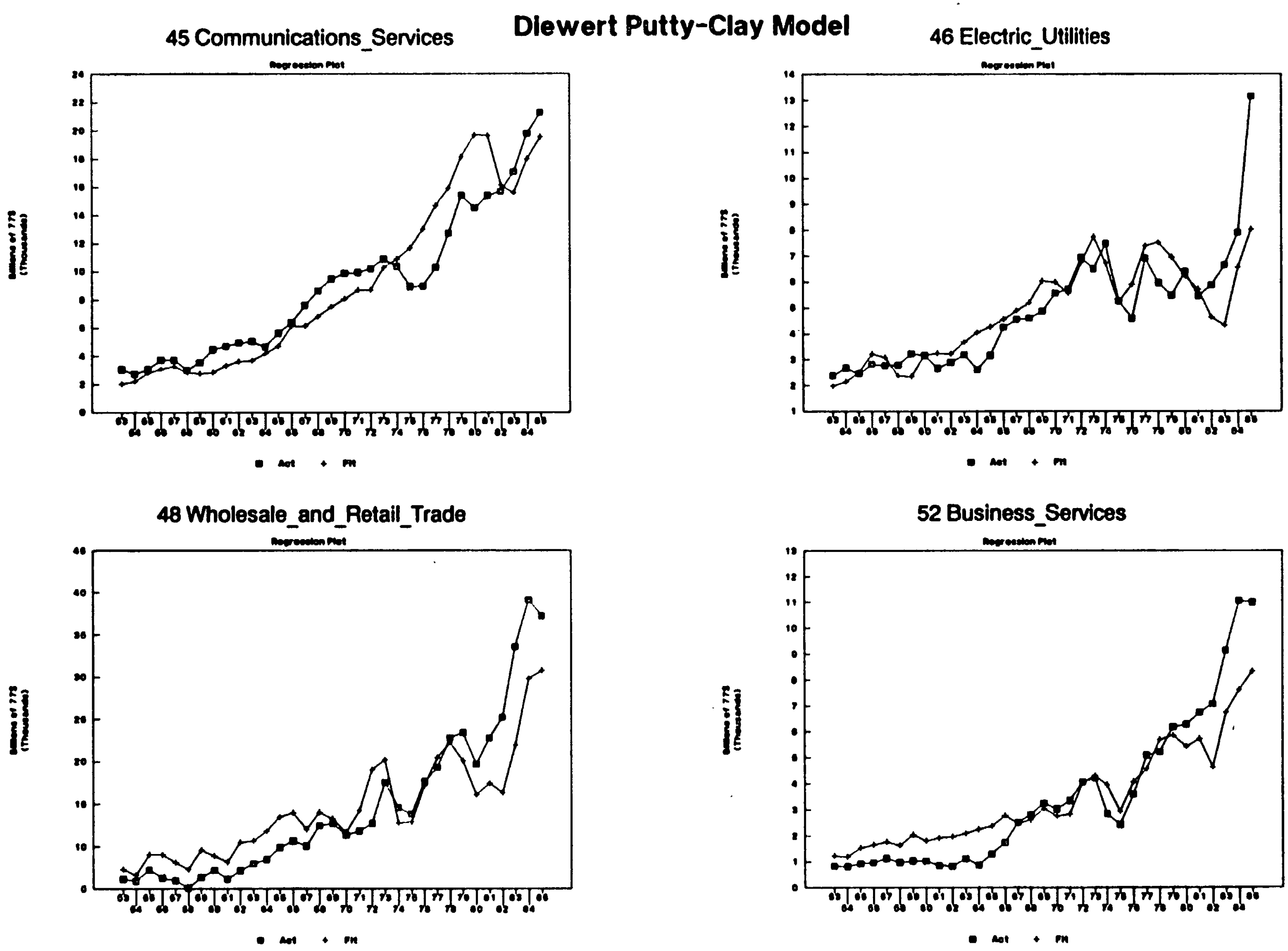


Figure 4.14.d - 1953 to 1985 Estimation

The output weights (w_is) in this model followed a similar pattern to those in the putty-putty model, and were of comparable magnitude. Both models showed roughly the same level and distribution of R^2s. As with the putty-putty model, a few industries had very poor fits for the putty-clay model, again probably because of inequality constraints and cross-equation constraints. In the 53 to 77 estimation, 8 industries had negative R^2s, and 24 industries had R^2s less than .6. In the 53 to 85 estimation, 6 industries had negative R^2s, and 26 industries had R^2s less than .6. The general impression is that this model fits slightly better than the putty-putty model, but the regression plots in figures 4.13 and 4.14 are almost exactly like those in figures 4.11 and 4.12.

Probably the most important difference between the putty-putty and the putty-clay models is the pattern of response to changes in output versus changes in relative prices. In Chapter V the behavior of the two models' will be compared in a dynamic simulation, to see if this distinction is relevant in a forecasting framework.

8. The Dynamic Factor Demand Model

The three equations comprising the dynamic factor demand system are reproduced below as equations (8.1) to (8.3).

$$(8.1)\quad L = \alpha_L + \gamma_{LL}\hat{P}_L + \gamma_{LQ}Q + \gamma_{LK}K + \alpha_{Lt}t$$

$$(8.2)\quad E = \alpha_0 + \alpha_{0t}t - \tfrac{1}{2}\gamma_{LL}\hat{P}_L^2 + \gamma_{KQ}QK + \alpha_Q Q + \tfrac{1}{2}\gamma_{QQ}Q^2 + \alpha_K K + \alpha_{Kt}Kt$$

$$+ \tfrac{1}{2}\gamma_{KK}K^2 + \tfrac{1}{2}(\Delta K)^2$$

$$(8.3)\quad N = \frac{1}{2}\left[r - \left(r^2 + \frac{4\gamma_{KK}}{\gamma_{\ddot{K}\ddot{K}}}\right)^{\frac{1}{2}} \right]$$

$$\cdot \left[\frac{-1}{\gamma_{KK}} \left\{\alpha_K + \gamma_{LK}\hat{P}_L + \gamma_{QK}Q + \alpha_{Kt}t + P_K\right\} - K_{t-1} \right]$$

The equations (8.1) to (8.3) form a simultaneous system of equations which can be estimated using nonlinear system techniques. This system was estimated using *SHAZAM* version 6.0 on the PC, for the intervals 1953 to 1977 and 1953 to 1985.

Before discussing the results of these estimations, it would be useful to state some restrictions on the parameters implied by economic theory. For the short-run own-price elasticities of the variable factors to be negative, it is necessary and sufficient for γ_{LL} to be negative. For the long-run own price elasticity of capital to be negative, it is necessary that γ_{KK} be positive. Also, for marginal costs of adjustment to be increasing, it is necessary that $\gamma_{\ddot{K}\ddot{K}}$ be positive. For the adjustment parameter β^* to be in the range $0 < \beta^* < 1$, it is sufficient that $0 < \gamma_{KK} < \gamma_{\ddot{K}\ddot{K}}$. Finally, for output elasticities to be positive, it is necessary that γ_{LQ} be positive and that γ_{QK} be negative. In summary, the parameter restrictions implied by economic theory are:

(8.4) γ_{LL}, $\gamma_{QK} < 0$, $\gamma_{LQ} > 0$, and $0 < \gamma_{KK} < \gamma_{\dot{K}\dot{K}}$

Preliminary trials, using parameter starting values similar to results found by Berndt, Fuss and Waverman (*BFW*), were unsuccessful. Not only were parameter values unreasonable, but the parameters γ_{KK} and $\gamma_{\dot{K}\dot{K}}$ tended to take on values that would make the expression $\left(r^2+\frac{4G_{KK}}{G_{\dot{K}\dot{K}}}\right)$ negative, causing the square root to be undefined. In a footnote, *BFW* admit that they also had convergence problems on the first estimation attempt. They tried setting $\beta^* = 0.3$ on the first trial, and using the other estimated parameters first pass values as starting values for a second stage estimation, using the full equation. In other cases, they tried setting $\gamma_{\dot{K}\dot{K}} = 1.0$ on the first pass, and using the other estimated parameters as starting values for a second pass estimate.

The best results were obtained in this model by setting β^* equal to 0.3 in the first stage, and using the parameter results from the first stage as starting values for a second stage estimation. However, γ_{KK} and $\gamma_{\dot{K}\dot{K}}$ still took on negative values, and caused the solution to fail to converge. The parameter γ_{KK} was forced to be positive by making it equal to the square of a dummy parameter. Two alternatives were tried for keeping $\gamma_{\dot{K}\dot{K}}$ positive. The first was to make it equal to $exp(g)$, where g is a dummy parameter, the second was to make it equal to $1.0 + exp(g)$. The latter constraint forces $\gamma_{\dot{K}\dot{K}}$ to be greater than 1.0.

Although the fits obtained with this version were acceptable, and the parameter values for many industries were reasonable, the model gave nonsense results in simulations. Upon examining the simulation model more closely, the problem was traced to the fact that there were no constraints forcing the expression for K^* to be in the neighborhood of actual K. A nonsense estimate for the parameters determining K^* was usually associated with an offsetting nonsense value for β^*. Therefore, a fourth equation was added to the system, expressing K as a regression on the expression for K^*:

$$(8.5) \qquad K = \frac{-1}{\gamma_{KK}} \left\{ \alpha_K + \gamma_{LK} \hat{P}_L + \gamma_{QK} Q + \alpha_{Kt} t + P_K \right\}$$

This made the estimates for K^* in the forecast much more stable, and yielded more intuitively sensible values for β^*, the speed of adjustment. However, the equation adds the undesirable side effect of assuming that desired capital stock has been equal to actual capital stock on average.

Tables 4.18 through 4.19 display parameter estimates, statistics, and elasticities for the 53 to 77 and 53 to 85 estimations, respectively. The most obvious conclusion to be gleaned both from these tables and from the plots in figures 4.15 and 4.16 are that the fits are extremely poor, with 27 industries showing negative R^2s in the 53 to 77 period, and 26 showing negative R^2s in the 53 to 85 period. These poor showings are due to the fact that the parameters in the investment equation also appear in the labor and energy equations, and the equations are fighting each other. In many industries, a fairly good fit (for this model) in the investment equation often came at the expense of a good fit for the energy or employment equation.

Since this model is based on a flexible functional form, elasticities and cross-elasticities are not constrained to any *a priori* sign. In fact, the elasticities are different for each year in the sample. The results calculated below are for the year 1977. The structure of the dynamic factor demand model allows for the calculation of short-run (no adjustment in capital) and long-run (full adjustment of capital) elasticities. The short-run elasticities can be calculated as shown in equations (8.6) to (8.15) below (where: ε_{ij} is the elasticity representing the percentage change in variable *i* resulting from a given percentage change in variable *j*, holding *K* fixed.):

Short-Run Price Elasticities

(where $K = \bar{K}$)

$$(8.6) \qquad \varepsilon_{LL} = \left[\frac{\partial L}{\partial P_L} \cdot \frac{P_L}{L}\right]_{K=\bar{K}} = \frac{\gamma_{LL}\hat{P}_L}{L}$$

$$(8.7) \qquad \varepsilon_{LE} = \frac{-\gamma_{LL}\hat{P}_L}{L}$$

$$(8.8) \qquad \varepsilon_{EE} = \frac{\gamma_{LL}\hat{P}^2_L}{E}$$

$$(8.9) \qquad \varepsilon_{EL} = \frac{-\gamma_{LL}\hat{P}_L^2}{E}$$

Short-Run Output Elasticities

$$(8.10) \qquad \varepsilon_{LQ} = \frac{\gamma_{LQ}Q}{L}$$

$$(8.11) \qquad \varepsilon_{EQ} = \left(\frac{Q}{E}\right)\cdot\left(\alpha_Q + \gamma_{QQ}Q + \gamma_{QK}K\right)$$

Short-Run Elasticities with respect to Capital Stock

$$(8.12) \qquad \varepsilon_{LK} = (K/L)\gamma_{LK}$$

$$(8.13) \qquad \varepsilon_{EK} = (K/E)\left(\alpha_K + \alpha_{Kt}t + \gamma_{KK}K + \gamma_{QK}Q\right)$$

Technology Elasticities

$$(8.14) \qquad \varepsilon_{Lt} = \alpha_{Lt}/L$$

$$(8.15) \qquad \varepsilon_{Et} = (\alpha_{0t} + \alpha_{Kt}K)/E$$

Tables 4.18.c and 4.19.c show the results of these calculations for the two estimations. (The columns labeled ELS and EES are the values for ε_{LK} and ε_{EK}.) The calculated elasticities, like the fits, are disappointing. In the 53 to 77 estimation, only 14 industries have the expected negative own price elasticities for labor and energy. (Of course, when there are only two variable factors, the cross-price elasticities are exactly the negatives of the own-price elasticities, so that when these appear as complements, own-price elasticities have the wrong sign.) About half of the industries have positive labor-output elasticities, and more than two thirds show positive energy-output elasticities. The capital stock elasticities are also a mixed story, with about half of both the labor-stock and energy-stock elasticities showing positive signs. Finally, the time trend terms are predominantly negative, implying that labor and energy productivity have been on the rise during this period. Results for the 53 to 85 estimation (see Table 4.19.c) show a similar pattern in signs.

Long-run elasticities are formulated conditional on capital stock having adjusted to its long-run, desired value. They are calculated as shown in equations 8.16 to 8.24.

Long-Run Price Elasticities

$$(8.16) \qquad \varepsilon^{L}_{LL} = \left(\frac{P_L}{L}\right)\cdot\left(\left.\frac{\partial L}{\partial P_L}\right|_{K=\bar{K}} + \frac{\partial L}{\partial K^*}\frac{\partial K^*}{\partial P_L}\right) = \left(\frac{\hat{P}_L}{L}\right)\cdot\left(\gamma_{LL} - (\gamma^2_{LK}/\gamma_{KK})\right)$$

(8.17) $$\varepsilon^{L}_{LE} = \left(\frac{-1}{L}\right)\cdot\left(\gamma_{LL}\hat{P}_{L} - \frac{\gamma_{LK}}{\gamma_{KK}}\cdot\left[\gamma_{LK}\hat{P}_{L} + \hat{P}_{K}\right]\right)$$

(8.18) $$\varepsilon^{L}_{EE} = \left(\frac{1}{E}\right)\cdot\left[\gamma_{LL}\hat{P}^{2}_{L} + \left[\frac{\gamma_{LK}\hat{P}_{L}+\hat{P}_{K}}{\gamma_{KK}}\right]\cdot\left(\alpha_{K} + \alpha_{Kt}t + \gamma_{KK}K + \gamma_{QK}Q\right)\right]$$

(8.19) $$\varepsilon^{L}_{EL} = \left(\frac{-\hat{P}_{L}}{E}\right)\cdot\left(\gamma_{LL}\hat{P}^{2}_{L} + \left(\frac{\gamma_{LK}}{\gamma_{KK}}\right)\cdot\left(\alpha_{K} + \alpha_{Kt}t + \gamma_{KK}K + \gamma_{QK}Q\right)\right)$$

(8.20) $$\varepsilon^{L}_{LK} = \left(\frac{\hat{P}_{K}}{L}\right)\cdot\left[\left.\frac{\partial L}{\partial P_{K}}\right|_{K=\bar{K}} + \frac{\partial L}{\partial K^{*}}\cdot\frac{\partial K^{*}}{\partial P_{K}}\right] = \left(\frac{-\hat{P}_{K}}{L}\right)\cdot\frac{\gamma_{LK}}{\gamma_{KK}}$$

(8.21) $$\varepsilon^{L}_{EK} = \left(\frac{-\hat{P}_{K}}{E}\right)\cdot\frac{1}{\gamma_{KK}}\cdot\left(\alpha_{K} + \alpha_{Kt}t + \gamma_{KK}K + \gamma_{QK}Q\right)$$

(8.22) $$\varepsilon^{L}_{KK} = \left(\frac{\hat{P}_{K}}{\gamma_{KK}K^{*}}\right)$$

(8.23) $$\varepsilon^{L}_{KL} = \left(\frac{-\hat{P}_{L}}{K^{*}}\right)\cdot\left(\frac{\gamma_{LK}}{\gamma_{KK}}\right)$$

(8.24) $$\varepsilon^{L}_{KE} = \frac{\gamma_{LK}\hat{P}_{L} + \hat{P}_{K}}{K^{*}}$$

Tables 4.18.d and 4.19.d display the implied value of these elasticities for 1977 in both estimation periods, based on the estimated parameters. The long-run own-price elasticities for labor and energy are the correct sign for more than half the industries, although the own-price elasticity for capital is never the right sign! Note that the long run cross price elasticity between energy and capital and capital and energy don't always have to take the same sign. The values estimated for β^* seem low, suggesting unrealistically slow capital adjustment speeds.

Despite the effort invested, this model appears to be a complete failure at explaining the vagaries of equipment investment at the industry level, or of yielding parameters that make economic sense.

Table 4.18.a

The Dynamic Factor Demand Model. Estimated 53 to 77.

	Sector Title	AL	GLL	GLQ	GKL	ALT	AO	AOT	GKQ	AQ	GQQ
1	Agriculture, Forestry, Fisher	2.52	-12.57	7.80e+00	-6.46e+00	-53.58	1.00	0.10	-4.20e-01	8.05	5.07e-01
2	Crude Petroleum, Natural Gas	1.02	14.36	-1.72e-02	1.29e-01	-63.46	1.0	-0.07	-1.16e-04	1.14	1.75e-04
3	Mining	39.75	-28.09	3.71e-02	2.36e-02	-18.72	1.05	6.56	9.21e-04	8.86	2.44e-04
4	Construction	8.15	70.08	6.33e-02	-1.28e-01	262.29	1.0	0.31	-5.45e-04	-66.88	2.18e-03
5	Food, Tobacco	5.10	24.41	-6.94e-02	6.55e-01	-42.79	1.00	0.10	-1.14e-03	8.93	1.11e-04
6	Textiles	15.36	110.99	-1.41e+00	2.85e+00	-165.04	1.00	0.15	-3.52e-02	-5.17	2.22e-02
7	Knitting, Hosiery	-15.66	77.11	-5.96e-01	1.62e+00	50.51	-0.02	0.02	-1.39e-02	1.08	3.23e-03
8	Apparel and Household Textile	2.78	6.63	1.80e-01	-6.79e-01	18.38	1.0	0.15	-1.68e-03	-3.15	4.42e-04
9	Paper	23.26	34.65	2.14e-01	-3.55e-01	35.28	1.0	0.53	-9.36e-03	-7.81	6.24e-03
10	Printing	1.95	16.17	1.03e-01	-9.94e-02	-12.48	1.0	0.31	-1.21e-03	-0.92	4.67e-04
11	Agricultural Fertilizers	884.80	41.95	-1.06e-01	1.09e+00	-108.29	-6.19	235.93	-3.16e-03	3.42	2.49e-03
12	Other Chemicals	69.36	55.44	-1.98e-01	5.42e-01	-154.81	1.06	0.63	-4.38e-03	35.47	2.03e-03
13	Petroleum Refining and Fuel	35.31	20.15	2.56e-03	2.51e-02	-16.09	1.00	0.07	-1.58e-02	-5.23	1.83e-03
14	Rubber and Plastics	32.34	42.99	2.34e-01	-4.52e-01	37.30	0.99	0.16	-2.31e-03	12.04	8.51e-04
15	Footwear and Leather	1.67	4.71	1.14e-01	-6.23e-02	-9.10	1.00	1.33	-3.25e-03	-3.45	1.63e-03
16	Lumber	1960.02	-3.52	-8.94e-03	2.09e-01	-87.32	-106.98	11937.60	-1.33e-03	-9.97	7.45e-04
17	Furniture	13.92	87.69	2.09e-01	-7.23e-01	3.70	0.98	-1.23	-1.31e-03	-0.44	3.01e-04
18	Stone, Clay and Glass	11.64	30.90	2.95e-01	-5.58e-01	2.10	1.0	0.21	-5.50e-03	2.34	2.65e-03
19	Iron and Steel	2.75	-14.44	9.48e-02	-1.09e-01	7.54	1.02	0.11	-1.22e-03	-5.43	1.23e-03
20	Non Ferrous Metals	9.36	29.33	6.02e-02	-2.03e-01	18.28	1.0	0.16	-7.84e-04	0.89	3.13e-04
21	Metal Products	10.52	220.95	-9.20e-01	2.67e+00	-171.39	1.26	-0.01	-1.14e-02	25.74	4.22e-03
22	Engines and Turbines	179.61	-0.86	1.76e-02	1.68e-02	-4.68	-15.70	422.53	-5.76e-04	-0.65	1.67e-04
23	Agricultural Machinery	218.52	4.79	4.55e-02	-1.54e-01	-3.08	-3.32	208.50	-7.76e-04	-0.15	1.68e-04
25	Metalworking Machinery	34.05	-5.80	3.86e-02	4.91e-02	-1.57	0.96	5.19	-1.12e-05	0.58	3.40e-04
27	Special Industry Machinery	13.58	4.10	1.95e-03	9.43e-02	-0.25	1.37	3.32	-1.48e-04	6.87	-5.96e-04
28	Miscellaneous Non-Electrical	33.82	85.00	1.14e-01	-3.70e-01	43.06	0.95	0.77	-4.76e-04	4.07	1.17e-04
29	Computers	-1188.23	279.68	7.06e-01	-2.97e+00	93.24	-11.89	-508.88	-7.93e-03	8.11	1.66e-03
30	Service Industry Machinery	-565.07	35.66	-1.10e-01	8.14e-01	-8.96	-173.41	-1002.64	-2.88e-03	9.18	6.70e-05
31	Communications Machinery	15.75	217.73	-3.08e-01	6.30e-01	-45.86	1.06	0.79	-1.06e-03	19.67	-4.75e-05
32	Heavy Electrical Machinery	29.79	97.08	3.18e-01	-1.16e+00	42.64	0.97	0.66	-3.86e-03	-0.40	1.47e-03
33	Household Appliances	-1272.60	68.07	-1.37e-01	9.45e-01	-17.09	4.94	-14.41	-2.36e-03	10.35	-1.31e-04
34	Electrical Lighting and wiri	25.56	92.65	-1.74e-01	7.49e-01	-37.26	0.85	1.44	-1.79e-03	2.16	7.93e-04
35	Radio, T.V. Phonographs	-23.29	38.56	8.86e-02	-4.36e-01	4.17	-94.99	160.10	-8.96e-04	-0.62	3.71e-04
36	Motor Vehicles	38.77	176.85	-4.17e-01	1.51e+00	-126.83	1.00	0.18	-4.58e-03	11.99	1.32e-03
37	Aerospace	3.36	-53.03	7.59e-02	-2.90e-01	61.34	1.0	0.11	-7.10e-04	1.19	9.48e-05
38	Ships and Boats	1169.78	117.58	-5.41e-01	2.04e+00	14.02	35.33	-174.17	-1.06e-02	-2.21	2.31e-03
39	Other Transportation Equipme	-40.79	22.13	1.84e-02	1.41e-01	-6.69	-4.29	85.29	1.75e-05	0.09	-8.10e-06
40	Instruments	-150.49	77.38	-5.91e-01	2.02e+00	-13.41	-0.45	19.60	-1.63e-02	11.04	4.85e-03
41	Miscellaneous Manufacturing	33.85	131.97	-2.28e-01	1.14e+00	-51.79	1.10	12.01	-2.12e-03	2.52	6.99e-04
42	Railroads	4.99	-12.34	1.84e+00	-5.54e-01	-108.53	1.0	0.10	-1.77e-01	-7.33	5.26e-01
43	Air Transport	38.39	11.07	-7.91e-01	4.32e-01	-142.78	0.95	0.27	-1.76e-02	2.72	5.54e-02
44	Trucking and Other Transport	3.74	23.11	9.99e-02	-6.76e-02	18.57	1.0	0.12	-1.15e-03	-1.35	1.72e-03
45	Communications Services	385.39	-11.04	-3.74e+00	1.92e+00	63.70	1.06	0.32	-7.26e-01	430.80	1.39e+00
46	Electric Utilities	-0.24	0.49	-8.32e-02	7.64e-02	16.62	1.01	0.24	-4.40e-03	168.04	3.76e-04
47	Gas, Water and Sanitation	7.56	32.30	2.82e-02	-9.05e-02	5.56	1.0	0.10	-6.02e-03	-1.91	2.13e-03
48	Wholesale and Retail Trade	2.31	-2.56	-8.48e-01	4.27e+00	-2.18	1.00	0.10	-7.99e-03	74.24	1.36e-03
49	Finance and Insurance	4.30	8.87	8.06e-02	-4.83e-02	-53.33	1.00	0.06	-2.77e-03	-3.98	3.06e-04
50	Real Estate	1.59	-4.52	1.54e-01	-8.81e-01	-1.97	0.99	0.11	-5.26e-04	0.83	2.86e-04
51	Hotels and repairs Minus Aut	23.64	154.27	2.48e-01	-6.63e-01	379.77	1.02	-0.76	-1.10e-03	-4.07	1.36e-03
52	Business Services	-0.47	-35.31	1.98e-02	3.92e-02	17.05	0.97	-1.23	-8.11e-04	4.35	9.99e-06
53	Auto repair	78.76	-8.10	2.02e-02	-1.03e-01	83.28	1.01	0.32	-9.38e-04	-1.81	1.25e-03
54	Movies and Amusements	228.93	150.37	-1.64e+00	2.39e+00	-158.24	1.16	4.51	-2.62e-02	51.25	2.09e-02
55	Medical and Educational Serv	5.63	-10.06	-5.81e-01	1.60e+00	38.00	1.0	0.18	-1.03e-02	80.93	4.05e-03

Table 4.18.b

The Dynamic Factor Demand Model. Estimated 53 to 77.

	Sector Title	AK	AKT	GKK	GNN	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	4.72	-26.20	3.57e-01	1.00e+00	0.4440	62.66	5591.3	1.0438
2	Crude Petroleum, Natural Gas	-3.72	-0.43	9.13e-04	1.00e+00	0.0522	33.76	649.2	0.9694
3	Mining	-40.87	-0.54	1.21e-03	1.00e+00	0.0003	22.04	581.3	0.8847
4	Construction	62.02	-2.85	1.36e-03	1.00e+00	0.9382	42.33	3592.7	1.7711
5	Food, Tobacco	-71.42	-0.36	1.08e-02	1.00e+00	0.7943	38.55	1366.5	1.1160
6	Textiles	-8.29	-2.20	6.63e-02	1.00e+00	0.3160	49.59	417.5	1.1435
7	Knitting, Hosiery	-10.09	1.22	3.70e-02	1.00e+00	0.9248	19.32	39.0	3.8546
8	Apparel and Household Textile	23.56	-0.41	7.67e-03	1.00e+00	0.7640	31.33	197.9	1.4630
9	Paper	35.91	-1.61	1.61e-02	1.00e+00	0.7910	38.65	799.7	1.3211
10	Printing	17.71	0.20	1.52e-03	1.00e+00	0.9718	31.82	358.8	1.7971
11	Agricultural Fertilizers	22.70	-3.09	3.16e-02	1.00e+00	0.3886	65.19	308.4	1.3042
12	Other Chemicals	-21.82	-3.10	1.15e-02	1.00e+00	0.8778	44.97	1484.1	1.3293
13	Petroleum Refining and Fuel	-17.86	0.30	1.44e-01	1.40e+00	0.1363	57.86	519.4	1.1067
14	Rubber and Plastics	3.52	-0.48	5.14e-03	1.00e+00	0.8643	41.44	450.0	1.4444
15	Footwear and Leather	2.18	-0.16	1.47e-02	1.02e+00	0.4204	14.91	28.1	1.0333
16	Lumber	21.78	-1.74	7.05e-03	1.00e+00	0.9212	36.15	341.7	1.5459
17	Furniture	4.30	-0.03	5.14e-03	1.00e+00	0.8610	19.70	66.4	1.8256
18	Stone, Clay and Glass	14.72	-0.68	1.23e-02	1.00e+00	0.9134	21.76	331.0	1.5761
19	Iron and Steel	-1.71	-0.81	2.58e-03	1.04e+00	0.0999	22.70	755.7	0.8666
20	Non Ferrous Metals	5.71	-0.56	3.62e-03	1.00e+00	0.6553	38.48	403.2	1.1657
21	Metal Products	-14.62	-1.47	3.17e-02	1.00e+00	0.8838	11.76	258.3	4.5064
22	Engines and Turbines	1.46	-0.07	2.18e-03	1.00e+00	0.8009	41.63	92.2	1.5513
23	Agricultural Machinery	-0.51	-0.14	6.65e-03	1.00e+00	0.8319	26.01	60.1	1.4236
25	Metalworking Machinery	-9.27	-0.15	2.26e-03	1.00e+00	0.0890	27.59	163.8	0.6892
27	Special Industry Machinery	-16.85	-0.09	5.40e-03	1.00e+00	0.0014	15.96	46.5	0.6333
28	Miscellaneous Non-Electrical	3.24	-0.32	2.08e-03	1.00e+00	0.8983	35.81	360.2	1.4962
29	Computers	15.98	-1.25	3.54e-02	1.00e+00	0.8084	27.05	125.4	2.1257
30	Service Industry Machinery	-15.05	-0.12	1.68e-02	1.00e+00	0.6689	28.96	82.0	1.2224
31	Communications Machinery	-2.33	-0.23	2.18e-03	1.00e+00	0.8139	43.68	482.1	1.4322
32	Heavy Electrical Machinery	4.96	-0.45	1.45e-02	1.00e+00	0.8261	19.13	100.5	1.9571
33	Household Appliances	-22.89	-0.20	1.42e-02	1.00e+00	0.2117	27.80	67.4	0.9656
34	Electrical Lighting and wiri	-2.26	-0.32	6.65e-03	1.00e+00	0.8004	25.79	139.9	1.3911
35	Radio, T.V. Phonographs	3.50	-0.20	7.33e-03	1.00e+00	0.7287	41.12	44.9	1.3397
36	Motor Vehicles	-9.20	-0.75	1.57e-02	1.00e+00	0.6077	23.27	648.7	1.3278
37	Aerospace	20.02	-1.20	5.04e-03	1.00e+00	0.1901	37.76	288.5	1.0618
38	Ships and Boats	18.02	0.33	3.71e-02	1.00e+00	0.5517	86.84	105.9	1.2060
39	Other Transportation Equipme	-0.90	-0.07	1.97e-03	1.00e+00	0.8151	47.21	56.9	1.3467
40	Instruments	-19.26	-0.18	5.32e-02	1.00e+00	0.7488	34.98	208.5	1.5039
41	Miscellaneous Manufacturing	-6.12	-0.33	9.31e-03	1.00e+00	0.7678	32.99	125.1	1.2417
42	Railroads	-7.83	-0.04	5.99e-02	1.00e+00	0.1693	23.67	1131.7	1.1213
43	Air Transport	-3.78	-3.49	9.48e-03	1.00e+00	0.4352	33.65	1805.2	1.3092
44	Trucking and Other Transport	40.75	-0.44	9.89e-04	1.00e+00	0.9229	36.69	1817.1	1.6571
45	Communications Services	-253.65	19.83	3.70e-01	1.00e+00	0.8268	42.85	3164.7	1.4528
46	Electric Utilities	-40.31	1.88	3.37e-03	1.01e+00	0.8086	42.92	2039.1	1.2660
47	Gas, Water and Sanitation	18.14	-2.91	2.35e-02	1.01e+00	0.0650	59.03	1002.1	1.0908
48	Wholesale and Retail Trade	-64.63	6.03	3.50e-02	1.00e+00	0.9328	14.43	2635.4	2.6308
49	Finance and Insurance	84.80	4.81	4.03e-03	1.00e+00	0.9353	29.23	855.5	2.0587
50	Real Estate	7.20	0.49	2.64e-03	1.00e+00	0.8402	39.58	1773.9	1.3122
51	Hotels and repairs Minus Aut	27.54	-2.09	3.29e-03	1.00e+00	0.7639	34.42	749.3	1.5969
52	Business Services	27.84	1.85	1.52e-03	1.00e+00	0.7974	39.53	1130.5	1.7552
53	Auto repair	24.78	-2.63	4.85e-03	1.00e+00	0.7466	28.43	656.7	2.1836
54	Movies and Amusements	-8.16	-2.35	3.70e-02	1.00e+00	0.6394	22.41	231.0	2.5135
55	Medical and Educational Serv	-54.24	-4.71	2.74e-02	1.00e+00	0.9163	23.24	994.4	3.1060

Table 4.18.c

The Dynamic Factor Demand Model. Estimated 53 to 77. Calculated Elasticities

	Sector Title	ELL	ELE	EEE	EEL	ELQ	EEQ	ELS	EES	ELT	EET
1	Agriculture, Forestry, Fisher	-5.85e-03	5.85e-03	-1.85e-02	1.85e-02	1.37e+02	-2.00e+04	-1.40e+02	3.13e+04	-7.28e-03	-5.22e+02
2	Crude Petroleum, Natural Gas	2.83e-01	-2.83e-01	6.39e-01	-6.39e-01	-1.99e+00	2.23e+02	6.85e+00	-3.41e+01	-1.50e-01	-6.19e+00
3	Mining	-2.65e-01	2.65e-01	-1.30e+00	1.30e+00	1.13e+00	6.92e+02	6.99e-01	5.78e+01	-1.95e-02	-8.62e+00
4	Construction	5.80e-02	-5.80e-02	1.44e+00	-1.44e+00	8.26e-01	6.25e+03	-1.38e+00	1.64e+03	2.59e-02	-9.14e+01
5	Food, Tobacco	4.64e-02	-4.64e-02	3.59e-01	-3.59e-01	-3.91e+00	-1.11e+03	7.75e+00	2.00e+03	-1.14e-02	-4.66e+00
6	Textiles	5.32e-01	-5.32e-01	4.83e+00	-4.83e+00	-3.49e+01	6.60e+03	3.28e+01	-3.57e+03	-1.15e-01	-3.34e+01
7	Knitting, Hosiery	6.48e-01	-6.48e-01	2.62e+00	-2.62e+00	-1.17e+01	-1.79e+01	7.87e+00	-7.84e+01	1.07e-01	6.02e+00
8	Apparel and Household Textile	9.66e-03	-9.66e-03	1.61e+00	-1.61e+00	2.79e+00	1.46e+03	-1.95e+00	3.26e+01	6.84e-03	-4.98e+01
9	Paper	1.84e-01	-1.84e-01	6.85e-01	-6.85e-01	7.27e+00	2.99e+01	-7.79e+00	4.07e+02	2.35e-02	-1.66e+01
10	Printing	5.05e-02	-5.05e-02	1.38e+00	-1.38e+00	2.13e+00	1.13e+02	-7.17e-01	-2.63e+02	-5.18e-03	5.32e+00
11	Agricultural Fertilizers	2.41e+00	-2.41e+00	2.99e+00	-2.99e+00	-8.10e+00	1.60e+02	4.07e+01	3.48e+02	-7.37e-01	-1.66e+01
12	Other Chemicals	2.42e-01	-2.42e-01	4.41e-01	-4.41e-01	-1.03e+01	2.09e+02	1.40e+01	1.46e+02	-7.30e-02	-1.58e+01
13	Petroleum Refining and Fuel	5.82e-01	-5.82e-01	5.34e-01	-5.34e-01	7.53e-01	3.85e+02	7.69e-01	-2.37e+02	-3.69e-02	6.69e-01
14	Rubber and Plastics	1.99e-01	-1.99e-01	2.21e+00	-2.21e+00	6.15e+00	1.65e+02	-5.42e+00	-1.82e+02	2.46e-02	-9.05e+00
15	Footwear and Leather	4.46e-02	-4.46e-02	1.75e+00	-1.75e+00	1.70e+00	3.05e+02	-2.43e-01	5.48e+01	-1.78e-02	-4.94e+00
16	Lumber	-1.41e-02	1.41e-02	-1.66e-01	1.66e-01	-2.41e-01	2.37e+02	1.69e+00	1.85e+01	-5.56e-02	-1.23e+01
17	Furniture	4.97e-01	-4.97e-01	1.17e+01	-1.17e+01	3.48e+00	-3.98e+01	-2.86e+00	3.10e+01	3.73e-03	-5.20e-01
18	Stone, Clay and Glass	1.62e-01	-1.62e-01	6.53e-01	-6.53e-01	7.07e+00	-6.68e+00	-6.66e+00	9.85e+01	1.45e-03	-4.27e+00
19	Iron and Steel	-8.65e-02	8.65e-02	-2.58e-01	2.58e-01	3.44e+00	2.44e+02	-2.54e+00	1.03e+01	4.16e-03	-5.18e+00
20	Non Ferrous Metals	3.24e-01	-3.24e-01	1.36e+00	-1.36e+00	2.99e+00	5.72e+01	-3.51e+00	6.29e+01	2.22e-02	-4.47e+00
21	Metal Products	5.43e-01	-5.43e-01	1.05e+01	-1.05e+01	-2.54e+01	4.67e+03	2.42e+01	-3.33e+03	-5.43e-02	-3.33e+01
22	Engines and Turbines	-3.16e-02	3.16e-02	-7.35e-01	7.35e-01	7.16e-01	-3.99e+01	1.73e-01	-2.61e+01	-1.75e-02	1.99e+00
23	Agricultural Machinery	1.20e-01	-1.20e-01	2.97e+00	-2.97e+00	1.47e+00	-6.44e+00	-1.03e+00	3.91e+01	-8.73e-03	-9.38e-01
25	Metalworking Machinery	-6.59e-02	6.59e-02	-3.34e+00	3.34e+00	7.22e-01	5.89e+02	3.70e-01	-7.36e+01	-2.12e-03	-6.97e+00
27	Special Industry Machinery	8.21e-02	-8.21e-02	2.80e+00	-2.80e+00	4.27e-02	9.99e+01	8.55e-01	-4.62e+01	-6.10e-04	-3.36e+00
28	Miscellaneous Non-Electrical	3.68e-01	-3.68e-01	1.05e+01	-1.05e+01	2.78e+00	2.11e+02	-2.84e+00	4.50e+01	2.24e-02	-8.39e+00
29	Computers	3.37e+00	-3.37e+00	6.04e+01	-6.04e+01	1.72e+01	-1.74e+01	-2.00e+01	1.05e+02	1.43e-01	-2.10e+01
30	Service Industry Machinery	7.59e-01	-7.59e-01	1.33e+01	-1.33e+01	-3.56e+00	1.13e+02	6.73e+00	-4.81e+01	-2.53e-02	-8.92e+00
31	Communications Machinery	9.47e-01	-9.47e-01	3.83e+01	-3.83e+01	-6.36e+00	6.17e+01	5.67e+00	-6.29e+02	-2.54e-02	-1.05e+01
32	Heavy Electrical Machinery	8.39e-01	-8.39e-01	2.06e+01	-2.06e+01	6.61e+00	2.33e+02	-7.86e+00	1.52e+02	4.83e-02	-9.85e+00
33	Household Appliances	1.31e+00	-1.31e+00	3.21e+01	-3.21e+01	-3.79e+00	1.64e+02	7.74e+00	-2.81e+02	-4.56e-02	-5.70e+00
34	Electrical Lighting and Wiri	9.39e-01	-9.39e-01	2.27e+01	-2.27e+01	-3.87e+00	4.21e+02	5.25e+00	-1.56e+02	-4.92e-02	-7.11e+00
35	Radio, T.V. Phonographs	9.92e-01	-9.92e-01	5.83e+00	-5.83e+00	2.04e+00	6.89e+00	-2.36e+00	1.07e+01	1.61e-02	-4.08e-01
36	Motor Vehicles	9.53e-01	-9.53e-01	3.02e+01	-3.02e+01	-2.34e+01	4.08e+03	2.21e+01	-3.57e+03	-5.98e-02	-3.06e+01
37	Aerospace	-4.49e-01	4.49e-01	-1.47e+01	1.47e+01	1.93e+00	-1.24e+02	-1.91e+00	1.61e+01	5.18e-02	-2.57e+01
38	Ships and Boats	1.91e+00	-1.91e+00	6.37e+01	-6.37e+01	-1.06e+01	-1.58e+02	8.58e+00	5.72e+01	2.96e-02	4.42e+00
39	Other Transportation Equipme	5.49e-01	-5.49e-01	1.87e+01	-1.87e+01	4.20e-01	3.62e+00	4.63e-01	-7.00e+00	-1.79e-02	-3.49e-02
40	Instruments	5.09e-01	-5.09e-01	1.50e+01	-1.50e+01	-1.30e+01	7.68e+02	1.34e+01	-8.29e+02	-1.17e-02	-4.54e+00
41	Miscellaneous Manufacturing	7.91e-01	-7.91e-01	1.57e+01	-1.57e+01	-4.66e+00	3.61e+02	6.21e+00	-1.70e+02	-5.34e-02	-6.02e+00
42	Railroads	-1.12e-01	1.12e-01	-5.74e-01	5.74e-01	3.34e+01	-9.86e+03	-3.28e+01	1.12e+04	-8.74e-02	-1.08e+00
43	Air Transport	1.84e-01	-1.84e-01	4.28e-01	-4.28e-01	-2.47e+01	2.78e+03	2.68e+01	-8.91e+02	-1.80e-01	-3.80e+01
44	Trucking and Other Transport	4.67e-02	-4.67e-02	1.79e-01	-1.79e-01	1.90e+00	6.22e+02	-8.84e-01	-6.47e+01	4.35e-03	-2.57e+00
45	Communications Services	-5.05e-02	5.05e-02	-3.03e+00	3.03e+00	-9.39e+01	-2.34e+05	9.46e+01	8.77e+04	2.60e-02	5.24e+03
46	Electric Utilities	4.33e-03	-4.33e-03	1.71e-01	-1.71e-01	-4.49e+00	-2.93e+04	4.96e+00	-9.97e+02	1.41e-02	4.57e+02
47	Gas, Water and Sanitation	3.90e-01	-3.90e-01	2.66e+00	-2.66e+00	2.61e+00	-2.20e+03	-3.54e+00	5.52e+03	8.71e-03	-1.01e+02
48	Wholesale and Retail Trade	-4.25e-04	4.25e-04	-3.77e-03	3.77e-03	-1.10e+01	-4.38e+03	1.39e+01	2.34e+03	-6.00e-05	2.89e+01
49	Finance and Insurance	9.95e-03	-9.95e-03	3.33e-01	-3.33e-01	1.43e+00	-3.60e+03	-2.04e-01	2.68e+01	-7.36e-03	8.36e+01
50	Real Estate	-1.30e-02	1.30e-02	-2.39e-01	2.39e-01	1.02e+01	4.09e+03	-1.65e+01	2.97e+03	-8.91e-04	2.68e+01
51	Hotels and repairs Minus Aut	1.26e-01	-1.26e-01	9.76e-01	-9.76e-01	2.01e+00	3.93e+02	-3.17e+00	1.14e+01	6.67e-02	-1.67e+01
52	Business Services	-5.42e-02	5.42e-02	-8.94e-01	8.94e-01	6.74e-01	-1.47e+03	2.55e-01	3.72e-01	3.53e-03	2.68e+01
53	Auto repair	-3.00e-02	3.00e-02	-6.01e-01	6.01e-01	5.83e-01	3.54e+03	-1.34e+00	-1.38e+02	5.54e-02	-1.23e+02
54	Movies and Amusements	5.29e-01	-5.29e-01	4.11e+00	-4.11e+00	-2.50e+01	3.45e+03	2.25e+01	-2.06e+03	-9.68e-02	-3.00e+01
55	Medical and Educational Serv	-4.42e-03	4.42e-03	-4.91e-02	4.91e-02	-6.40e+00	1.68e+03	6.85e+00	-9.88e+02	2.58e-03	-3.47e+01

Table 4.18.d

The Dynamic Factor Demand Model. Estimated 53 to 77. Calculated Elasticities

	Sector Title	LELL	LELE	LEEE	LEEL	LELK	LEEK	LEKK	LEKL	LEKE	BSTAR
1	Agriculture, Forestry, Fisher	-6.03e-02	5.98e-02	-1.21e+01	1.22e+01	-5.47e-04	-1.22e-01	4.02e-06	4.00e-04	-1.41e-04	5.58e-01
2	Crude Petroleum, Natural Gas	-7.87e-02	1.64e-01	-1.59e+00	-3.54e+00	8.49e-02	4.23e-01	1.18e-02	-5.03e-02	5.67e-05	1.01e-02
3	Mining	-2.70e-01	2.75e-01	-4.68e-01	1.14e+01	5.70e-03	-4.71e-01	9.25e-03	-7.06e-03	1.98e-05	1.30e-02
4	Construction	4.81e-02	-5.09e-02	-7.01e+00	-2.67e-01	-2.77e-03	-3.29e+00	3.02e-03	1.08e-02	-1.06e-05	1.44e-02
5	Food, Tobacco	-2.91e-02	3.33e-02	2.09e+01	-2.20e+01	4.24e-03	-1.10e+00	8.23e-04	-1.46e-02	1.67e-04	7.13e-02
6	Textiles	-5.60e-02	6.31e-02	-5.99e+01	3.07e+01	7.13e-03	7.76e-01	1.82e-04	-1.50e-02	1.00e-03	2.21e-01
7	Knitting, Hosiery	5.15e-02	-2.95e-02	-3.55e+00	-4.45e+00	2.20e-02	2.19e-01	2.52e-03	-6.84e-02	2.62e-03	1.56e-01
8	Apparel and Household Textile	-7.78e-02	6.95e-02	2.84e-01	-4.84e+00	-8.27e-03	-1.38e-01	4.09e-03	4.33e-02	-3.01e-04	5.63e-02
9	Paper	1.42e-01	-1.46e-01	-1.28e+00	-3.28e+00	-3.73e-03	-1.95e-01	5.15e-04	5.71e-03	-8.37e-05	9.31e-02
10	Printing	3.02e-02	-3.73e-02	6.22e+00	-1.78e+01	-7.05e-03	2.58e+00	7.03e-03	2.02e-02	-2.01e-05	1.59e-02
11	Agricultural Fertilizers	2.32e-01	-1.61e-01	2.23e+01	-4.40e+01	7.07e-02	-6.05e-01	3.03e-03	-9.34e-02	3.04e-03	1.42e-01
12	Other Chemicals	1.31e-01	-1.25e-01	1.66e+00	-5.24e+00	5.62e-03	-5.85e-02	4.25e-04	-8.40e-03	1.02e-04	7.46e-02
13	Petroleum Refining and Fuel	5.82e-01	-5.82e-01	4.58e-01	-6.68e+00	1.18e-04	3.65e-02	1.46e-04	-1.56e-04	4.35e-05	2.84e-01
14	Rubber and Plastics	1.47e-02	-2.92e-02	7.92e+00	-2.18e+01	-1.46e-02	4.88e-01	2.37e-03	3.00e-02	-1.42e-04	4.21e-02
15	Footwear and Leather	4.21e-02	-4.41e-02	1.64e+00	-7.93e+00	-2.02e-03	-4.55e-01	8.81e-03	1.09e-02	-3.13e-05	8.66e-02
16	Lumber	-3.87e-02	4.39e-02	1.61e-01	7.74e-01	5.20e-03	-5.69e-02	3.18e-03	-1.51e-02	1.29e-04	5.30e-02
17	Furniture	-7.87e-02	4.10e-02	5.84e+00	-5.94e+01	-3.78e-02	-4.10e-01	1.21e-02	1.84e-01	-8.84e-04	4.21e-02
18	Stone, Clay and Glass	2.95e-02	-3.87e-02	-1.17e+00	-3.01e+00	-9.23e-03	-1.37e-01	1.47e-03	2.10e-02	-2.41e-04	7.80e-02
19	Iron and Steel	-1.14e-01	1.08e-01	-3.46e-01	2.92e+00	-6.01e-03	-2.43e-02	2.38e-03	1.10e-02	-2.23e-05	2.39e-02
20	Non Ferrous Metals	1.99e-01	-2.17e-01	-5.56e-01	-1.01e+01	-1.87e-02	-3.35e-01	6.08e-03	4.07e-02	-1.26e-04	3.23e-02
21	Metal Products	-1.03e-02	1.74e-02	-6.64e+01	-5.55e+00	7.10e-03	9.74e-01	2.57e-04	-2.00e-02	6.44e-04	1.43e-01
22	Engines and Turbines	-3.64e-02	4.51e-02	-2.78e+00	7.96e+00	8.70e-03	1.32e+00	4.57e-02	-2.52e-02	1.55e-04	2.15e-02
23	Agricultural Machinery	3.09e-02	-5.01e-02	3.09e-01	-2.30e+01	-1.92e-02	-7.27e-01	1.99e-02	9.27e-02	-4.84e-04	5.08e-02
25	Metalworking Machinery	-7.81e-02	8.60e-02	-7.34e+00	3.06e+01	7.96e-03	1.58e+00	2.00e-02	-3.06e-02	1.14e-04	2.21e-02
27	Special Industry Machinery	4.91e-02	-3.79e-02	4.11e-01	-2.08e+01	1.12e-02	6.05e-01	1.30e-02	-3.82e-02	2.76e-04	4.37e-02
28	Miscellaneous Non-Electrical	8.37e-02	-1.09e-01	6.37e+00	-8.29e+01	-2.51e-02	-3.98e-01	8.53e-03	9.67e-02	-1.84e-04	2.07e-02
29	Computers	3.70e-01	-4.11e-01	4.49e+01	-4.58e+02	-4.17e-02	-2.19e-01	1.89e-03	1.36e-01	-4.74e-03	1.52e-01
30	Service Industry Machinery	-8.01e-02	1.17e-01	7.06e+00	-9.43e+01	3.65e-02	2.61e-01	5.89e-03	-1.35e-01	2.37e-03	9.56e-02
31	Communications Machinery	1.55e-01	-1.14e-01	-5.41e+01	-2.13e+02	4.14e-02	4.60e+00	5.91e-03	-1.13e-01	2.59e-04	2.15e-02
32	Heavy Electrical Machinery	3.80e-02	-6.20e-02	5.57e+00	-1.42e+02	-2.40e-02	-4.66e-01	3.00e-03	1.00e-01	-1.41e-03	8.71e-02
33	Household Appliances	9.58e-02	-5.09e-02	-1.38e+01	-1.88e+02	4.49e-02	1.63e+00	5.41e-03	-1.47e-01	2.16e-03	8.55e-02
34	Electrical Lighting and wiri	8.46e-02	-4.27e-02	-3.91e+00	-1.49e+02	4.19e-02	1.24e+00	7.76e-03	-1.58e-01	1.10e-03	5.08e-02
35	Radio, T.V. Phonographs	3.25e-01	-3.86e-01	3.07e+00	-3.58e+01	-6.04e-02	-2.74e-01	2.46e-02	2.72e-01	-1.81e-03	5.45e-02
36	Motor Vehicles	1.75e-01	-1.64e-01	-9.72e+01	-2.19e+02	1.17e-02	1.88e+00	4.61e-04	-3.07e-02	4.90e-04	9.16e-02
37	Aerospace	-5.90e-01	5.76e-01	-1.57e+01	1.48e+02	-1.32e-02	-1.12e-01	6.61e-03	7.06e-02	-3.22e-04	4.15e-02
38	Ships and Boats	8.23e-02	-4.80e-02	7.61e+01	-5.02e+02	3.43e-02	-2.29e-01	5.39e-03	-2.87e-01	1.08e-02	1.57e-01
39	Other Transportation Equipme	2.98e-01	-2.42e-01	1.40e+01	-1.69e+02	5.58e-02	8.43e-01	2.08e-01	-9.35e-01	2.25e-03	1.97e-02
40	Instruments	6.66e-03	2.80e-03	-1.66e+01	-8.23e+01	9.45e-03	5.84e-01	6.77e-04	-3.59e-02	1.95e-03	1.94e-01
41	Miscellaneous Manufacturing	-4.92e-02	8.44e-02	-8.29e+00	-6.81e+01	3.53e-02	9.65e-01	5.43e-03	-1.29e-01	1.25e-03	6.45e-02
42	Railroads	-1.59e-01	1.57e-01	-1.59e+01	2.23e+01	-1.27e-03	-4.32e-01	4.27e-05	1.56e-03	-9.09e-05	2.08e-01
43	Air Transport	-1.43e-01	1.59e-01	-1.10e+01	5.21e+00	1.56e-02	5.17e-01	5.00e-04	-1.05e-02	1.04e-04	6.53e-02
44	Trucking and Other Transport	3.74e-02	-4.18e-02	5.37e-01	-2.22e+00	-4.44e-03	3.25e-01	4.16e-03	8.75e-03	-4.53e-06	1.09e-02
45	Communications Services	-9.62e-02	9.67e-02	3.98e+01	-8.48e+00	4.91e-04	-4.55e-01	5.24e-06	-4.87e-04	1.82e-04	5.69e-01
46	Electric Utilities	-1.11e-02	1.53e-02	-3.77e+00	1.31e+00	4.15e-03	8.35e-01	8.27e-04	-3.08e-03	1.31e-05	3.03e-02
47	Gas, Water and Sanitation	3.85e-01	-3.87e-01	-1.96e+00	-1.39e+01	-1.24e-03	-1.94e+00	4.82e-04	1.63e-03	-2.70e-05	1.18e-01
48	Wholesale and Retail Trade	-8.70e-02	8.83e-02	1.48e+01	-1.45e+01	1.28e-03	-2.15e-01	1.05e-04	-7.09e-03	2.52e-04	1.51e-01
49	Finance and Insurance	9.30e-03	-9.87e-03	3.22e-01	-2.63e+00	-5.63e-04	-7.39e-02	2.79e-03	3.23e-03	-1.76e-06	3.50e-02
50	Real Estate	-8.56e-01	8.18e-01	-1.45e+02	1.53e+02	-3.81e-02	-6.85e+00	4.19e-03	9.27e-02	-2.34e-04	2.51e-02
51	Hotels and repairs Minus Aut	1.67e-02	-2.72e-02	6.23e-01	-4.13e+00	-1.06e-02	-3.79e-02	3.28e-03	3.39e-02	-1.01e-04	2.99e-02
52	Business Services	-5.57e-02	5.74e-02	-8.89e-01	6.62e+00	1.68e-03	-2.44e-03	6.66e-03	-6.15e-03	1.95e-05	1.59e-02
53	Auto repair	-3.81e-02	3.24e-02	-3.44e-01	2.50e+00	-5.65e-03	5.84e-01	4.09e-03	5.89e-03	-8.71e-06	4.03e-02
54	Movies and Amusements	-1.39e-02	2.47e-02	-4.65e+01	2.60e+01	1.09e-02	9.93e-01	3.82e-04	-1.91e-02	7.22e-04	1.57e-01
55	Medical and Educational Serv	-4.52e-02	4.63e-02	-6.09e+00	6.20e+00	1.11e-03	1.60e-01	1.51e-04	-5.56e-03	1.57e-04	1.30e-01

Table 4.19.a

The Dynamic Factor Demand Model. Estimated 53 to 85.

	Sector Title	AL	GLL	GLQ	GKL	ALT	AO	AOT	GKQ	AQ	GQQ
1	Agriculture, Forestry, Fisher	2.99	-9.14	-6.30e+00	5.40e+00	-60.74	1.00	0.1	-1.24e-01	16.05	1.41e-01
2	Crude Petroleum, Natural Gas	19.10	-48.43	-6.90e-02	2.61e-01	-80.73	1.00	0.15	-3.38e-03	44.07	1.39e-03
3	Mining	592.55	13.55	5.07e-01	-5.09e-01	6.39	1.06	-8.31	-8.21e-03	-11.99	8.86e-03
4	Construction	1.12	-8.30	4.68e-01	-2.07e-01	-1.40	1.0	0.10	-2.32e-04	0.23	-4.44e-04
5	Food, Tobacco	7.92	-46.29	1.30e-01	-4.87e-01	-118.14	0.95	0.00	-1.19e-02	-41.69	2.91e-03
6	Textiles	63.92	7.63	-2.35e-01	7.08e-01	-71.03	1.05	2.61	-7.73e-03	4.54	3.87e-03
7	Knitting, Hosiery	20.30	187.60	-2.90e+00	9.87e+00	-32.38	0.88	1.51	-1.67e-01	13.55	5.27e-02
8	Apparel and Household Textile	4.33	10.00	2.37e-01	-8.21e-01	-44.36	1.01	0.15	-4.85e-03	-5.69	8.96e-04
9	Paper	9.00	37.26	1.08e-01	-1.88e-01	53.53	1.0	0.26	-1.77e-03	11.21	1.30e-03
10	Printing	1.85	1.01	1.03e-01	-9.63e-02	-23.64	0.98	0.54	-5.82e-03	-20.33	2.61e-03
11	Agricultural Fertilizers	361.36	16.98	-1.02e-02	5.63e-01	-85.31	0.90	0.66	-5.65e-04	12.43	1.31e-03
12	Other Chemicals	18.23	36.00	-2.82e-01	6.08e-01	-30.10	1.00	0.12	-1.31e-02	49.34	6.27e-03
13	Petroleum Refining and Fuel	546.67	-4.49	3.41e-03	-3.85e-02	-0.47	0.99	0.44	-3.24e-04	-0.03	1.10e-04
14	Rubber and Plastics	13.31	0.94	-7.53e-02	3.53e-01	-55.08	1.05	0.60	-2.60e-03	19.24	9.78e-04
15	Footwear and Leather	8.29	32.41	2.19e-01	-6.68e-01	-1.02	1.04	16.69	-1.69e-03	-1.45	6.79e-04
16	Lumber	6.51	-19.92	1.04e-01	-2.38e-01	13.68	1.00	0.24	-1.29e-03	-5.90	7.00e-04
17	Furniture	96.72	178.49	-8.16e-01	3.37e+00	-14.51	1.06	0.30	-1.77e-02	2.43	4.68e-03
18	Stone, Clay and Glass	0.87	8.98	2.02e-01	-2.82e-01	-7.71	1.0	0.09	-3.40e-03	0.1	1.41e-03
19	Iron and Steel	10.40	20.52	-4.90e-02	2.50e-01	-114.97	1.0	0.22	-6.69e-04	-21.54	1.01e-03
20	Non Ferrous Metals	8.96	10.62	-9.20e-03	1.63e-01	-37.85	1.0	0.31	-3.88e-04	4.54	2.08e-04
21	Metal Products	1.72	-6.83	1.62e-01	-3.68e-01	-2.92	1.0	0.10	-2.11e-03	-6.55	9.17e-04
22	Engines and Turbines	33.57	2.96	2.13e-02	-8.70e-02	7.42	-0.06	57.47	-6.69e-07	0.90	-8.86e-05
23	Agricultural Machinery	12.56	30.99	-8.03e-02	6.25e-01	-20.56	0.99	9.86	-2.16e-03	1.57	6.81e-04
25	Metalworking Machinery	393.49	-1.46	3.98e-02	-4.28e-02	1.83	0.84	188.04	-1.87e-05	-1.79	3.95e-04
27	Special Industry Machinery	7.52	1.56	5.90e-03	9.25e-02	-0.13	1.26	-1.85	-3.11e-04	5.47	-4.67e-04
28	Miscellaneous Non-Electrical	4.54	48.81	8.55e-02	-1.58e-01	31.35	0.99	0.31	-2.60e-04	4.35	5.52e-05
29	Computers	22.62	172.46	2.65e-01	-7.52e-01	-35.14	-3.94	-70.41	-1.05e-03	7.73	-6.43e-04
30	Service Industry Machinery	46.80	6.75	1.86e-02	1.01e-01	-7.43	2.49	5.55	-7.53e-05	1.00	-1.39e-05
31	Communications Machinery	17.22	172.18	-9.15e-02	4.71e-01	-114.97	0.82	-1.33	-4.33e-04	35.52	-7.17e-04
32	Heavy Electrical Machinery	17.63	62.29	-1.66e-01	6.09e-01	-8.07	1.04	0.88	-2.22e-03	2.72	7.86e-04
33	Household Appliances	333.57	9.01	3.78e-02	-7.72e-02	-5.99	9.05	-54.42	-7.88e-04	2.22	-1.32e-05
34	Electrical Lighting and wiri	39.91	154.54	-4.59e-01	1.54e+00	-29.40	0.97	1.29	-5.13e-03	1.54	2.00e-03
35	Radio, T.V. Phonographs	162.82	14.25	7.18e-03	-2.06e-02	-1.67	-2673.73	296.54	-2.54e-04	0.50	8.83e-05
36	Motor Vehicles	6.51	26.85	1.55e-01	-4.45e-01	-15.97	0.97	0.08	-2.50e-03	-2.25	8.34e-04
37	Aerospace	21.51	159.30	-4.27e-02	-9.70e-01	280.92	1.01	2.14	3.49e-04	6.98	-2.55e-04
38	Ships and Boats	90.71	276.68	-4.08e-01	1.98e+00	-50.01	1.15	3.21	-3.34e-03	0.59	1.60e-03
39	Other Transportation Equipme	-121.28	29.63	2.66e-02	2.08e-01	-8.74	-4390.17	181.20	1.19e-05	1.27	-1.80e-04
40	Instruments	-8.12	21.08	-1.51e-01	6.51e-01	8.07	4.70	44.08	-1.24e-02	12.10	2.74e-03
41	Miscellaneous Manufacturing	94.42	85.52	-4.04e+00	1.42e+01	-3.36	1.01	0.26	-5.48e-01	22.28	1.57e-01
42	Railroads	4.09	14.71	-3.40e+00	1.03e+00	-60.26	1.00	0.1	-1.45e-01	1.92	4.79e-01
43	Air Transport	-45.76	113.64	-1.20e+00	1.29e+00	-672.32	1.00	0.18	-1.32e-02	19.27	2.94e-02
44	Trucking and Other Transport	12.67	374.31	-3.14e-01	9.20e-01	-209.16	1.01	0.07	-6.66e-04	38.64	-2.70e-04
45	Communications Services	44.41	354.88	-3.35e+00	1.59e+00	-818.03	1.03	0.72	-1.89e-02	753.88	3.08e-02
46	Electric Utilities	1.72	-10.25	-8.07e-02	8.27e-02	-1.12	1.00	0.09	-7.12e-04	4.59	2.27e-03
47	Gas, Water and Sanitation	38.03	3.98	1.72e-02	-3.64e-02	14.25	1.00	0.13	-9.35e-04	20.76	2.62e-05
48	Wholesale and Retail Trade	1.67	-4.60	3.21e-01	-1.08e+00	-3.25	1.00	0.10	-1.11e-03	6.61	6.75e-04
49	Finance and Insurance	20.13	823.11	-4.71e-02	1.96e+00	-109.65	0.97	-0.55	-3.16e-04	2.48	-4.98e-04
50	Real Estate	15.54	3059.61	8.08e-01	1.61e+00	-341.93	1.86	-55.12	4.14e-04	129.03	-3.27e-04
51	Hotels and repairs Minus Aut	14.62	-256.34	3.45e-01	-4.82e-01	134.49	1.07	0.07	-3.07e-03	-16.59	2.03e-03
52	Business Services	9.07	550.60	-1.26e-01	6.56e-01	1.54	1.35	1.63	-2.57e-04	2.66	5.12e-05
53	Auto repair	18.76	-29.23	3.71e-02	-9.11e-02	61.95	1.0	0.43	-1.01e-03	26.00	-3.20e-05
54	Movies and Amusements	7.09	7.73	1.33e-01	-2.09e-01	18.55	1.0	0.29	-3.17e-03	2.90	1.74e-03
55	Medical and Educational Serv	10.50	193.06	-1.63e+00	3.89e+00	114.30	0.97	0.13	-1.84e-02	105.29	7.43e-03

Table 4.19.b

The Dynamic Factor Demand Model.   Estimated 53 to 85.

	Sector Title	AK	AKT	GKK	GNN	R-SQUARE	AAPE	SEE	RHO
1	Agriculture, Forestry, Fisher	-7.23	16.32	1.02e-01	1.00e+00	-2.5273	43.57	4068.0	0.9132
2	Crude Petroleum, Natural Gas	-21.38	-3.54	1.15e-02	1.00e+00	-0.1593	25.66	877.7	0.8536
3	Mining	0.86	-0.31	8.65e-03	1.00e+00	0.0234	19.86	631.8	0.8392
4	Construction	3.72	-0.02	1.26e-04	1.00e+00	0.3946	30.26	3520.5	0.9062
5	Food, Tobacco	28.46	-10.02	6.90e-02	1.07e+00	-0.5551	40.42	1165.6	1.0190
6	Textiles	-12.97	-0.33	1.73e-02	1.00e+00	-0.0375	15.90	219.0	0.8983
7	Knitting, Hosiery	-20.49	-1.64	5.66e-01	1.00e+00	-9.9234	208.14	270.2	0.9434
8	Apparel and Household Textile	45.56	-0.17	2.33e-02	1.00e+00	-0.0967	30.85	196.3	0.9184
9	Paper	14.43	-1.16	3.54e-03	1.00e+00	-0.3851	40.19	943.2	1.0221
10	Printing	88.61	0.19	1.02e-02	1.00e+00	0.5043	28.14	402.3	1.0962
11	Agricultural Fertilizers	10.08	-3.33	2.22e-02	1.00e+00	0.1640	34.08	235.2	0.8117
12	Other Chemicals	-51.47	-1.07	2.75e-02	1.00e+00	-0.1401	32.48	1180.1	0.9056
13	Petroleum Refining and Fuel	-22.18	-2.09	1.02e-02	1.00e+00	-0.1035	41.14	685.2	0.9593
14	Rubber and Plastics	-13.51	-1.64	9.66e-03	1.00e+00	-0.6099	39.75	484.2	0.9371
15	Footwear and Leather	1.58	-0.11	9.20e-03	1.00e+00	0.3052	19.53	27.6	0.7949
16	Lumber	23.47	-0.83	4.40e-03	1.00e+00	0.1102	33.94	334.8	0.9172
17	Furniture	-8.44	-0.23	7.05e-02	1.00e+00	0.5068	16.28	58.9	0.6715
18	Stone, Clay and Glass	15.02	-0.20	5.82e-03	1.00e+00	0.4448	19.59	300.6	0.8422
19	Iron and Steel	-4.13	-0.94	2.28e-03	1.00e+00	-2.3760	29.45	922.4	0.8453
20	Non Ferrous Metals	-6.23	-0.53	2.62e-03	1.00e+00	-0.1600	27.35	336.6	0.8409
21	Metal Products	16.87	-0.89	6.71e-03	1.02e+00	-0.0751	24.10	473.3	0.8786
22	Engines and Turbines	1.25	-0.1	8.05e-04	1.00e+00	0.2880	41.83	99.1	0.8991
23	Agricultural Machinery	-4.20	-0.31	1.26e-02	1.00e+00	0.3865	24.60	54.5	0.7002
25	Metalworking Machinery	-4.80	-0.05	1.20e-03	1.00e+00	-0.7039	24.72	148.1	0.7413
27	Special Industry Machinery	-13.13	-0.01	4.35e-03	1.00e+00	-0.1416	16.31	44.9	0.6689
28	Miscellaneous Non-Electrical	2.64	-0.24	8.83e-04	1.00e+00	0.1150	32.15	376.7	0.9322
29	Computers	0.45	0.21	3.01e-03	1.00e+00	0.4207	39.08	509.4	1.1676
30	Service Industry Machinery	-1.46	-0.08	1.44e-03	1.00e+00	-0.1411	28.29	83.9	0.8798
31	Communications Machinery	-1.94	-0.57	2.04e-03	1.00e+00	0.1063	47.52	927.3	1.1131
32	Heavy Electrical Machinery	-4.42	-0.16	7.47e-03	1.00e+00	0.1550	25.38	150.2	0.9845
33	Household Appliances	-6.41	0.01	4.82e-03	1.00e+00	-0.1483	24.89	59.4	0.7843
34	Electrical Lighting and wiri	-2.42	-0.26	1.60e-02	1.00e+00	0.2970	21.95	127.5	0.9126
35	Radio, T.V. Phonographs	2.10	-0.37	7.61e-03	1.00e+00	0.1786	37.07	47.7	0.8457
36	Motor Vehicles	18.51	-0.56	8.45e-03	1.00e+00	-0.0839	31.23	1057.0	0.7570
37	Aerospace	7.03	-1.65	5.32e-03	1.02e+00	-0.7644	52.47	420.9	0.9463
38	Ships and Boats	-0.61	-0.34	1.45e-02	1.00e+00	0.3667	34.39	87.3	0.8207
39	Other Transportation Equipme	-0.95	-0.11	2.33e-03	1.00e+00	0.2283	45.03	63.4	1.0073
40	Instruments	-35.62	0.93	4.46e-02	1.00e+00	0.0479	36.26	269.0	1.0151
41	Miscellaneous Manufacturing	-99.61	1.58	1.90e+00	1.00e+00	-25.7496	93.91	440.0	0.6840
42	Railroads	-20.97	2.02	4.17e-02	1.00e+00	-0.1983	52.16	1620.0	0.8249
43	Air Transport	-2.73	-7.55	1.42e-02	1.00e+00	-0.4105	48.63	2421.0	0.9248
44	Trucking and Other Transport	-5.18	-0.91	2.09e-03	1.00e+00	0.2612	36.15	2391.9	0.9597
45	Communications Services	-8.47	-4.29	8.89e-03	1.00e+00	0.4255	35.29	3860.2	1.0696
46	Electric Utilities	-8.95	-0.27	7.84e-04	1.00e+00	-0.2745	41.93	2495.4	1.0658
47	Gas, Water and Sanitation	24.68	-1.85	3.60e-03	1.00e+00	-0.3941	47.90	1410.0	0.9506
48	Wholesale and Retail Trade	78.40	0.87	3.96e-03	1.00e+00	0.5287	24.77	6231.1	1.0332
49	Finance and Insurance	-0.48	-0.15	4.94e-03	1.00e+00	0.0796	60.40	2669.7	1.1839
50	Real Estate	-1.16	-0.10	8.43e-04	1.00e+00	-0.3621	115.18	3471.3	1.0105
51	Hotels and repairs Minus Aut	62.54	-0.47	3.54e-03	1.00e+00	0.1538	29.82	717.7	0.9706
52	Business Services	2.20	0.21	8.80e-04	1.00e+00	0.4255	40.65	2203.3	1.0646
53	Auto repair	20.87	-1.27	3.06e-03	1.00e+00	0.5601	29.04	1043.4	0.9109
54	Movies and Amusements	19.40	-1.04	7.71e-03	1.00e+00	-0.4403	48.37	565.5	1.0024
55	Medical and Educational Serv	-33.82	-1.91	4.31e-02	1.00e+00	0.6855	25.95	1716.0	1.0072

Table 4.19.c

The Dynamic Factor Demand Model. Estimated 53 to 85. Calculated Elasticities

	Sector Title	ELL	ELE	EEE	EEL	ELQ	EEQ	ELS	EES	ELT	EET
1	Agriculture, Forestry, Fisher	-4.26e-03	4.26e-03	-1.34e-02	1.34e-02	-1.11e+02	-2.46e+04	1.17e+02	1.29e+04	-8.25e-03	3.25e+02
2	Crude Petroleum, Natural Gas	-9.56e-01	9.56e-01	-2.16e+00	2.16e+00	-7.99e+00	1.14e+03	1.38e+01	-5.62e+02	-1.90e-01	-5.04e+01
3	Mining	1.28e-01	-1.28e-01	6.26e-01	-6.26e-01	1.54e+01	2.15e+02	-1.51e+01	-3.84e+01	6.67e-03	-4.91e+00
4	Construction	-6.87e-03	6.87e-03	-1.70e-01	1.70e-01	6.11e+00	-3.24e+03	-2.25e+00	-4.38e+02	-1.39e-04	-5.24e-01
5	Food, Tobacco	-8.80e-02	8.80e-02	-6.81e-01	6.81e-01	7.31e+00	2.76e+03	-5.76e+00	3.31e+03	-3.16e-02	-1.29e+02
6	Textiles	3.65e-02	-3.65e-02	3.32e-01	-3.32e-01	-5.82e+00	4.74e+02	8.13e+00	-2.00e+02	-4.94e-02	-5.07e+00
7	Knitting, Hosiery	1.58e+00	-1.58e+00	6.36e+00	-6.36e+00	-5.69e+01	2.34e+03	4.79e+01	-1.59e+03	-6.85e-02	-8.08e+00
8	Apparel and Household Textile	1.46e-02	-1.46e-02	2.43e+00	-2.43e+00	3.67e+00	-3.88e+03	-2.36e+00	2.34e+03	-1.65e-02	-2.06e+01
9	Paper	1.97e-01	-1.97e-01	7.37e-01	-7.37e-01	3.66e+00	3.03e+02	-4.12e+00	4.86e+01	3.57e-02	-1.20e+01
10	Printing	3.17e-03	-3.17e-03	8.64e-02	-8.64e-02	2.15e+00	7.21e+02	-6.94e-01	-5.18e+02	-9.82e-03	5.01e+00
11	Agricultural Fertilizers	9.77e-01	-9.77e-01	1.21e+00	-1.21e+00	-7.79e-01	2.70e+02	2.09e+01	1.19e+02	-5.80e-01	-1.81e+01
12	Other Chemicals	1.57e-01	-1.57e-01	2.86e-01	-2.86e-01	-1.47e+01	2.68e+02	1.57e+01	-1.74e+02	-1.42e-02	-5.44e+00
13	Petroleum Refining and Fuel	-1.30e-01	1.30e-01	-1.19e-01	1.19e-01	1.00e+00	2.08e+02	-1.18e+00	1.87e+01	-1.09e-03	-4.65e+00
14	Rubber and Plastics	4.36e-03	-4.36e-03	4.85e-02	-4.85e-02	-1.97e+00	4.52e+02	4.23e+00	1.48e+02	-3.63e-02	-3.10e+01
15	Footwear and Leather	3.07e-01	-3.07e-01	1.21e+01	-1.21e+01	3.27e+00	4.53e+01	-2.61e+00	1.18e+02	-2.00e-03	-3.14e+00
16	Lumber	-7.95e-02	7.95e-02	-9.41e-01	9.41e-01	2.81e+00	3.75e+02	-1.93e+00	-1.26e+01	8.70e-03	-1.27e+01
17	Furniture	1.01e+00	-1.01e+00	2.38e+01	-2.38e+01	-1.36e+01	7.31e+02	1.33e+01	-5.30e+02	-1.46e-02	-3.74e+00
18	Stone, Clay and Glass	4.71e-02	-4.71e-02	1.90e-01	-1.90e-01	4.86e+00	-1.24e+02	-3.36e+00	-5.64e+01	-5.31e-03	-1.24e+00
19	Iron and Steel	1.23e-01	-1.23e-01	3.67e-01	-3.67e-01	-1.78e+00	1.69e+02	5.79e+00	1.19e+02	-6.35e-02	-5.97e+00
20	Non Ferrous Metals	1.17e-01	-1.17e-01	4.91e-01	-4.91e-01	-4.57e-01	1.71e+02	2.81e+00	-8.97e+00	-4.60e-02	-4.19e+00
21	Metal Products	-1.68e-02	1.68e-02	-3.25e-01	3.25e-01	4.47e+00	9.02e+02	-3.33e+00	-6.34e+01	-9.25e-04	-2.02e+01
22	Engines and Turbines	1.09e-01	-1.09e-01	2.55e+00	-2.55e+00	8.69e-01	-5.94e+00	-8.93e-01	1.21e+01	2.78e-02	-1.80e+00
23	Agricultural Machinery	7.79e-01	-7.79e-01	1.92e+01	-1.92e+01	-2.60e+00	3.80e+02	4.20e+00	-1.64e+02	-5.82e-02	-5.75e+00
25	Metalworking Machinery	-1.66e-02	1.66e-02	-8.43e-01	8.43e-01	7.44e-01	4.04e+02	-3.22e-01	-2.37e-01	2.47e-03	-8.87e-01
27	Special Industry Machinery	3.12e-02	-3.12e-02	1.06e+00	-1.06e+00	1.29e-01	1.99e+01	8.40e-01	-1.79e+01	-3.19e-04	-5.84e-01
28	Miscellaneous Non-Electrical	2.11e-01	-2.11e-01	6.02e+00	-6.02e+00	2.09e+00	2.60e+02	-1.22e+00	-1.03e+02	1.63e-02	-6.26e+00
29	Computers	2.08e+00	-2.08e+00	3.73e+01	-3.73e+01	6.45e+00	-3.92e+02	-5.07e+00	5.38e+01	-5.41e-02	2.96e+00
30	Service Industry Machinery	1.44e-01	-1.44e-01	2.52e+00	-2.52e+00	6.00e-01	4.70e+01	8.33e-01	-1.18e+01	-2.10e-02	-1.52e+00
31	Communications Machinery	7.49e-01	-7.49e-01	3.03e+01	-3.03e+01	-1.89e+00	1.86e+02	4.24e+00	-1.20e+02	-6.36e-02	-2.66e+01
32	Heavy Electrical Machinery	5.38e-01	-5.38e-01	1.32e+01	-1.32e+01	-3.45e+00	2.59e+02	4.12e+00	-1.20e+02	-9.14e-03	-3.45e+00
33	Household Appliances	1.74e-01	-1.74e-01	4.25e+00	-4.25e+00	1.05e+00	-3.12e+01	-6.32e-01	1.37e+01	-1.60e-02	-2.34e-01
34	Electrical Lighting and wiri	1.57e+00	-1.57e+00	3.78e+01	-3.78e+01	-1.02e+01	5.60e+02	1.08e+01	-2.68e+02	-3.88e-02	-5.72e+00
35	Radio, T.V. Phonographs	3.67e-01	-3.67e-01	2.15e+00	-2.15e+00	1.65e-01	1.36e+01	-1.11e-01	-1.20e+00	-6.43e-03	-7.63e-01
36	Motor Vehicles	1.45e-01	-1.45e-01	4.58e+00	-4.58e+00	8.69e+00	3.00e+03	-6.54e+00	-1.34e+03	-7.53e-03	-2.30e+01
37	Aerospace	1.35e+00	-1.35e+00	4.40e+01	-4.40e+01	-1.08e+00	1.68e+02	-6.38e+00	1.69e+02	2.37e-01	-3.54e+01
38	Ships and Boats	4.49e+00	-4.49e+00	1.50e+02	-1.50e+02	-8.02e+00	7.51e+02	8.32e+00	-2.43e+02	-1.06e-01	-6.11e+00
39	Other Transportation Equipme	7.35e-01	-7.35e-01	2.50e+01	-2.50e+01	6.06e-01	-2.04e+01	6.84e-01	-1.86e+01	-2.34e-02	3.97e-01
40	Instruments	1.39e-01	-1.39e-01	4.08e+00	-4.08e+00	-3.34e+00	-1.14e+03	4.34e+00	5.49e+02	7.02e-03	2.44e+01
41	Miscellaneous Manufacturing	5.13e-01	-5.13e-01	1.01e+01	-1.01e+01	-8.27e+01	1.64e+04	7.70e+01	-1.66e+04	-3.47e-03	2.92e+01
42	Railroads	1.34e-01	-1.34e-01	6.84e-01	-6.84e-01	-6.18e+01	1.13e+03	6.14e+01	-3.95e+03	-4.85e-02	5.43e+01
43	Air Transport	1.89e+00	-1.89e+00	4.39e+00	-4.39e+00	-3.75e+01	5.29e+02	8.03e+01	1.48e+03	-8.46e-01	-8.21e+01
44	Trucking and Other Transport	7.57e-01	-7.57e-01	2.90e+00	-2.90e+00	-5.95e+00	-1.72e+02	1.20e+01	1.72e+02	-4.91e-02	-5.26e+00
45	Communications Services	1.62e+00	-1.62e+00	9.75e+01	-9.75e+01	-8.41e+01	5.06e+04	7.84e+01	-6.03e+04	-3.34e-01	-1.14e+03
46	Electric Utilities	-9.15e-02	9.15e-02	-3.61e+00	3.61e+00	-4.36e+00	1.92e+04	5.38e+00	-6.08e+02	-9.52e-04	-6.52e+01
47	Gas, Water and Sanitation	4.80e-02	-4.80e-02	3.28e-01	-3.28e-01	1.58e+00	-8.42e+01	-1.42e+00	7.34e+01	2.23e-02	-6.41e+01
48	Wholesale and Retail Trade	-7.64e-04	7.64e-04	-6.77e-03	6.77e-03	4.19e+00	3.72e+03	-3.53e+00	2.25e+02	-8.93e-05	4.14e+00
49	Finance and Insurance	9.24e-01	-9.24e-01	3.10e+01	-3.10e+01	-8.35e-01	-5.20e+03	8.29e+00	1.84e+03	-1.51e-02	-2.54e+00
50	Real Estate	8.78e+00	-8.78e+00	1.61e+02	-1.61e+02	5.38e+01	1.89e+04	3.03e+01	4.98e+03	-1.55e-01	-5.77e+00
51	Hotels and repairs Minus Aut	-2.09e-01	2.09e-01	-1.62e+00	1.62e+00	2.80e+00	-8.39e+01	-2.30e+00	2.33e+01	2.36e-02	-3.75e+00
52	Business Services	8.45e-01	-8.45e-01	1.39e+01	-1.39e+01	-4.26e+00	2.24e+02	4.27e+00	-8.56e+01	3.19e-04	3.00e+00
53	Auto repair	-1.08e-01	1.08e-01	-2.17e+00	2.17e+00	1.07e+00	5.22e+02	-1.18e+00	-1.14e+02	4.12e-02	-5.92e+01
54	Movies and Amusements	2.72e-02	-2.72e-02	2.11e-01	-2.11e-01	2.03e+00	-5.44e+01	-1.97e+00	3.47e+02	1.13e-02	-1.32e+01
55	Medical and Educational Serv	8.48e-02	-8.48e-02	9.42e-01	-9.42e-01	-1.80e+01	2.84e+03	1.67e+01	-2.57e+03	7.76e-03	-1.41e+01

Table 4.19.d

The Dynamic Factor Demand Model. Estimated 53 to 85. Calculated Elasticities

	Sector Title	LELL	LELE	LEEE	LEEL	LELK	LEEK	LEKK	LEKL	LEKE	BSTAR
1	Agriculture, Forestry, Fisher	-1.38e-01	1.39e-01	1.49e+01	-1.47e+01	1.60e-03	-1.77e-01	1.43e-05	-1.19e-03	1.23e-04	2.82e-01
2	Crude Petroleum, Natural Gas	-1.07e+00	1.09e+00	-7.48e+00	2.28e+01	1.36e-02	5.54e-01	8.63e-04	-7.43e-03	9.52e-05	7.44e-02
3	Mining	-1.55e-01	1.38e-01	1.30e+00	-6.39e+00	-1.72e-02	4.38e-02	1.11e-03	1.83e-02	-1.49e-04	6.13e-02
4	Construction	-2.89e-01	2.40e-01	4.54e+01	-5.36e+01	-4.86e-02	9.49e+00	1.03e-02	6.00e-02	-6.26e-06	1.54e-03
5	Food, Tobacco	-9.45e-02	9.40e-02	-4.16e+00	8.60e+00	-4.95e-04	-2.85e-01	9.36e-05	1.24e-03	-7.89e-05	2.18e-01
6	Textiles	-1.02e-01	1.09e-01	-3.25e+00	1.13e+00	6.79e-03	1.67e-01	8.12e-04	-1.66e-02	3.01e-04	9.73e-02
7	Knitting, Hosiery	1.30e-01	-1.21e-01	-4.19e+01	2.26e+01	8.74e-03	2.89e-01	1.50e-04	-2.48e-02	1.41e-02	7.13e-01
8	Apparel and Household Textile	-2.75e-02	2.42e-02	-3.61e+01	3.23e+01	-3.29e-03	-3.27e+00	1.53e-03	1.96e-02	-4.22e-04	1.18e-01
9	Paper	1.45e-01	-1.54e-01	2.22e-01	-5.23e+00	-8.97e-03	-1.06e-01	2.24e-03	1.32e-02	-3.87e-05	3.17e-02
10	Printing	3.31e-04	-1.35e-03	1.44e+00	-2.77e+00	-1.02e-03	7.62e-01	1.32e-03	3.67e-03	-2.40e-05	6.86e-02
11	Agricultural Fertilizers	1.54e-01	-1.02e-01	6.18e+00	-1.49e+01	5.18e-02	-2.95e-01	3.18e-03	-5.05e-02	1.19e-03	1.14e-01
12	Other Chemicals	9.82e-02	-9.56e-02	-3.96e-01	-2.00e+00	2.65e-03	2.94e-02	1.66e-04	-3.68e-03	1.05e-04	1.30e-01
13	Petroleum Refining and Fuel	-1.34e-01	1.31e-01	-1.45e-01	1.56e+00	-2.56e-03	-4.04e-02	2.30e-03	3.78e-03	-1.51e-05	6.88e-02
14	Rubber and Plastics	-5.54e-02	6.15e-02	2.35e+00	-2.43e+00	6.04e-03	-2.12e-01	1.52e-03	-1.50e-02	1.60e-04	6.61e-02
15	Footwear and Leather	-1.53e-01	1.18e-01	-7.16e+00	-3.77e+01	-3.45e-02	-1.56e+00	1.38e-02	1.84e-01	-1.56e-03	6.38e-02
16	Lumber	-1.31e-01	1.22e-01	-6.67e-01	5.57e+00	-9.51e-03	6.19e-02	4.75e-03	2.58e-02	-9.25e-05	3.74e-02
17	Furniture	9.80e-02	-8.52e-02	-1.31e+01	-9.74e+01	1.29e-02	5.11e-01	9.22e-04	-6.55e-02	4.68e-03	2.28e-01
18	Stone, Clay and Glass	-2.44e-02	1.45e-02	1.22e+00	-2.64e+00	-9.88e-03	1.66e-01	2.66e-03	1.92e-02	-9.64e-05	4.61e-02
19	Iron and Steel	-4.11e-02	5.66e-02	4.06e+00	-7.36e+00	1.55e-02	-3.20e-01	3.46e-03	-3.66e-02	9.13e-05	2.23e-02
20	Non Ferrous Metals	5.81e-03	1.50e-02	6.86e-02	-4.10e+00	2.08e-02	6.63e-02	7.51e-03	-4.04e-02	1.25e-04	2.49e-02
21	Metal Products	-6.62e-02	6.16e-02	5.28e-01	1.58e+00	-4.62e-03	8.78e-02	1.35e-03	1.44e-02	-8.78e-05	5.03e-02
22	Engines and Turbines	-2.38e-01	1.16e-01	-5.04e-01	-2.04e+01	-1.22e-01	-1.65e+00	1.33e-01	3.79e-01	-1.98e-04	9.04e-03
23	Agricultural Machinery	-2.01e-03	4.33e-02	-1.30e+01	-1.40e+02	4.13e-02	1.62e+00	8.94e-03	-1.69e-01	2.24e-03	7.91e-02
25	Metalworking Machinery	-3.39e-02	2.09e-02	-8.40e-01	7.09e+00	-1.30e-02	9.60e-03	3.98e-02	5.30e-02	-1.58e-05	1.29e-02
27	Special Industry Machinery	-8.30e-03	2.20e-02	-6.93e-02	-7.72e+00	1.37e-02	2.91e-01	1.68e-02	-4.87e-02	2.85e-04	3.71e-02
28	Miscellaneous Non-Electrical	8.82e-02	-1.14e-01	1.43e+01	-6.06e+01	-2.53e-02	2.15e+00	1.51e-02	7.33e-02	-5.14e-05	9.82e-03
29	Computers	-1.83e-01	5.93e-02	1.46e+01	-2.68e+02	-1.24e-01	-1.32e+00	2.11e-02	3.86e-01	-1.10e-03	2.79e-02
30	Service Industry Machinery	-6.40e-03	5.92e-02	-3.46e-01	-1.69e+01	5.28e-02	7.46e-01	7.03e-02	-2.00e-01	3.88e-04	1.51e-02
31	Communications Machinery	2.76e-01	-2.43e-01	1.59e+01	-2.25e+02	3.31e-02	9.38e-01	8.12e-03	-1.16e-01	2.54e-04	2.04e-02
32	Heavy Electrical Machinery	1.10e-01	-8.54e-02	8.94e-02	-8.85e+01	2.45e-02	7.12e-01	5.88e-03	-1.03e-01	8.11e-04	5.52e-02
33	Household Appliances	1.50e-01	-1.61e-01	3.96e+00	-3.02e+01	-1.08e-02	-2.34e-01	1.73e-02	3.82e-02	-1.01e-04	4.01e-02
34	Electrical Lighting and wiri	5.99e-02	-2.39e-02	-4.33e-01	-2.53e+02	3.59e-02	8.91e-01	3.33e-03	-1.40e-01	2.28e-03	9.25e-02
35	Radio, T.V. Phonographs	3.65e-01	-3.68e-01	2.14e+00	-1.44e+01	-2.75e-03	2.96e-02	2.44e-02	1.27e-02	8.87e-05	5.60e-02
36	Motor Vehicles	1.82e-02	-2.46e-02	2.92e+01	-7.83e+01	-6.41e-03	1.32e+00	8.57e-04	1.69e-02	-1.36e-04	6.01e-02
37	Aerospace	-1.49e-01	1.07e-01	5.57e+00	-4.02e+02	-4.19e-02	-1.11e+00	6.32e-03	2.26e-01	-1.17e-03	4.25e-02
38	Ships and Boats	8.88e-02	-3.56e-03	1.90e+01	-1.02e+03	8.52e-02	2.49e+00	1.11e-02	-5.73e-01	8.44e-03	8.67e-02
39	Other Transportation Equipme	2.73e-01	-2.03e-01	1.05e+01	-2.19e+02	6.96e-02	1.89e+00	1.33e-01	-8.84e-01	2.37e-03	2.27e-02
40	Instruments	7.61e-02	-7.25e-02	1.24e+01	-3.88e+01	3.64e-03	-4.61e-01	9.09e-04	-1.56e-02	7.37e-04	1.75e-01
41	Miscellaneous Manufacturing	-1.19e-01	1.21e-01	-1.26e+02	7.69e+01	2.14e-03	4.61e-01	2.57e-05	-7.59e-03	1.45e-02	1.34e+00
42	Railroads	-9.98e-02	1.03e-01	-1.45e+01	7.29e+00	3.42e-03	2.20e-01	5.33e-05	-3.64e-03	1.54e-04	1.68e-01
43	Air Transport	-6.91e-02	1.00e-01	4.11e+01	-9.43e+01	3.12e-02	-5.74e-01	4.97e-04	-3.13e-02	4.51e-04	8.57e-02
44	Trucking and Other Transport	-6.07e-02	8.92e-02	1.50e+01	-3.66e+01	2.85e-02	-4.07e-01	3.51e-03	-1.00e-01	2.18e-04	2.08e-02
45	Communications Services	3.17e-01	-3.00e-01	-9.19e+02	-8.63e+01	1.69e-02	1.30e+01	1.81e-04	-1.39e-02	1.25e-04	6.24e-02
46	Electric Utilities	-1.69e-01	1.89e-01	-1.46e+01	4.68e+01	1.93e-02	2.18e+00	3.51e-03	-1.42e-02	1.39e-05	8.82e-03
47	Gas, Water and Sanitation	4.36e-02	-4.68e-02	2.67e-01	-2.29e+00	-3.26e-03	-1.68e-01	2.35e-03	3.19e-03	-3.03e-06	3.21e-02
48	Wholesale and Retail Trade	-5.00e-02	4.71e-02	-2.96e+00	3.18e+00	-2.87e-03	-1.83e-01	8.88e-04	1.53e-02	-5.69e-05	3.46e-02
49	Finance and Insurance	4.83e-02	-2.97e-02	2.29e+02	-4.46e+02	1.86e-02	-4.13e+00	1.16e-02	-5.45e-01	2.75e-03	4.09e-02
50	Real Estate	-7.05e-02	2.89e-01	1.65e+03	-2.48e+03	2.19e-01	-3.60e+01	-3.77e-03	1.53e-01	-1.32e-04	9.43e-03
51	Hotels and repairs Minus Aut	-2.62e-01	2.55e-01	-2.09e+00	8.06e+00	-7.13e-03	-7.21e-02	3.13e-03	2.35e-02	-7.20e-05	3.17e-02
52	Business Services	9.37e-02	-4.51e-02	-2.08e+00	-8.82e+01	4.87e-02	9.74e-01	1.11e-02	-1.71e-01	1.61e-04	9.80e-03
53	Auto repair	-1.18e-01	1.10e-01	-1.96e+00	1.11e+01	-7.89e-03	7.65e-01	6.41e-03	8.15e-03	-5.32e-06	2.83e-02
54	Movies and Amusements	7.31e-03	-1.19e-02	-2.49e+00	2.29e+00	-4.55e-03	-8.03e-01	2.97e-03	1.30e-02	-7.70e-05	5.63e-02
55	Medical and Educational Serv	-6.95e-02	7.12e-02	-2.30e+01	1.76e+01	1.72e-03	2.65e-01	9.23e-05	-8.26e-03	3.60e-04	1.71e-01

Dynamic Factor Demand Model

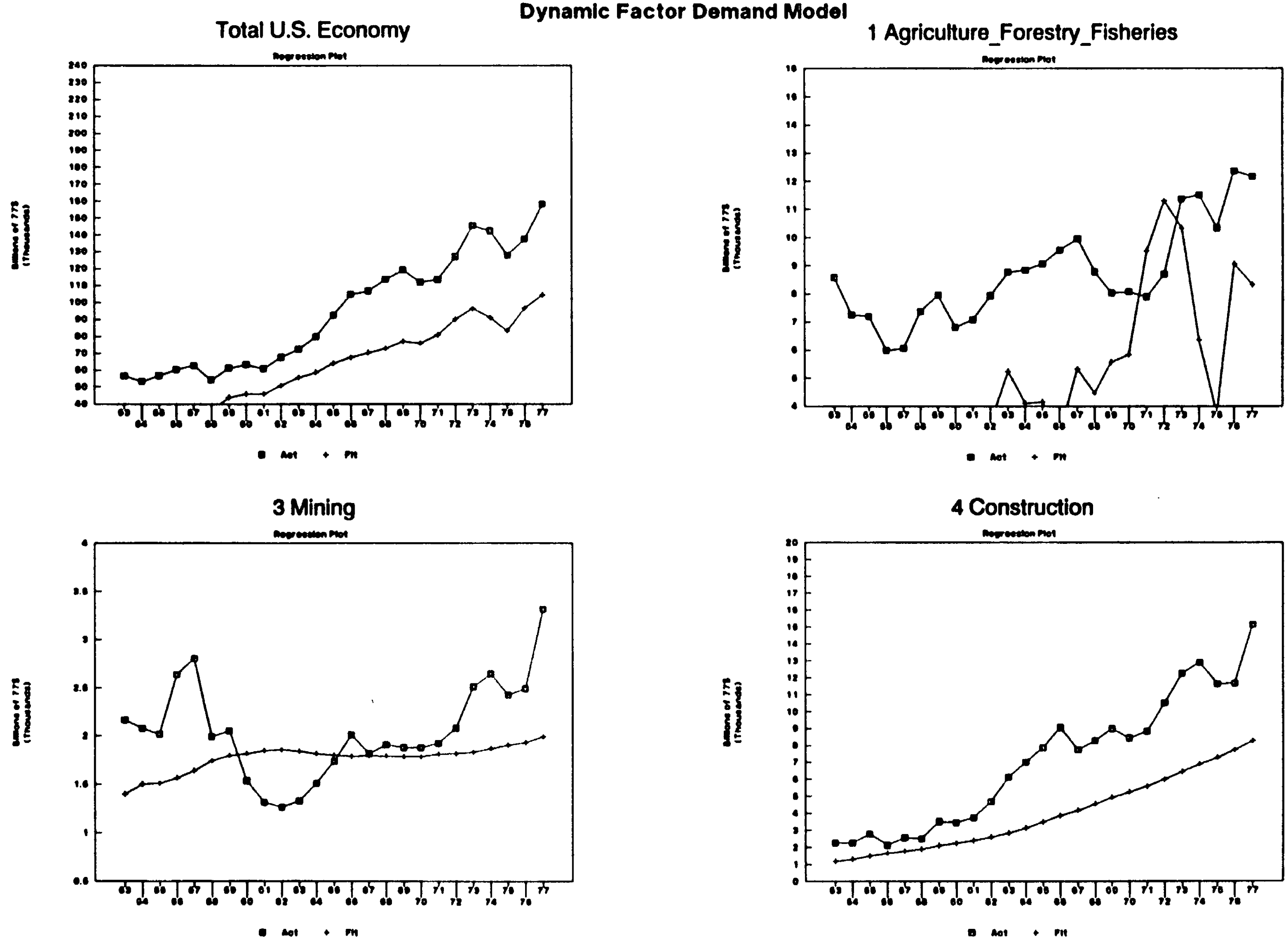


Figure 4.15.a - 1953 to 1977 Estimation

Dynamic Factor Demand Model

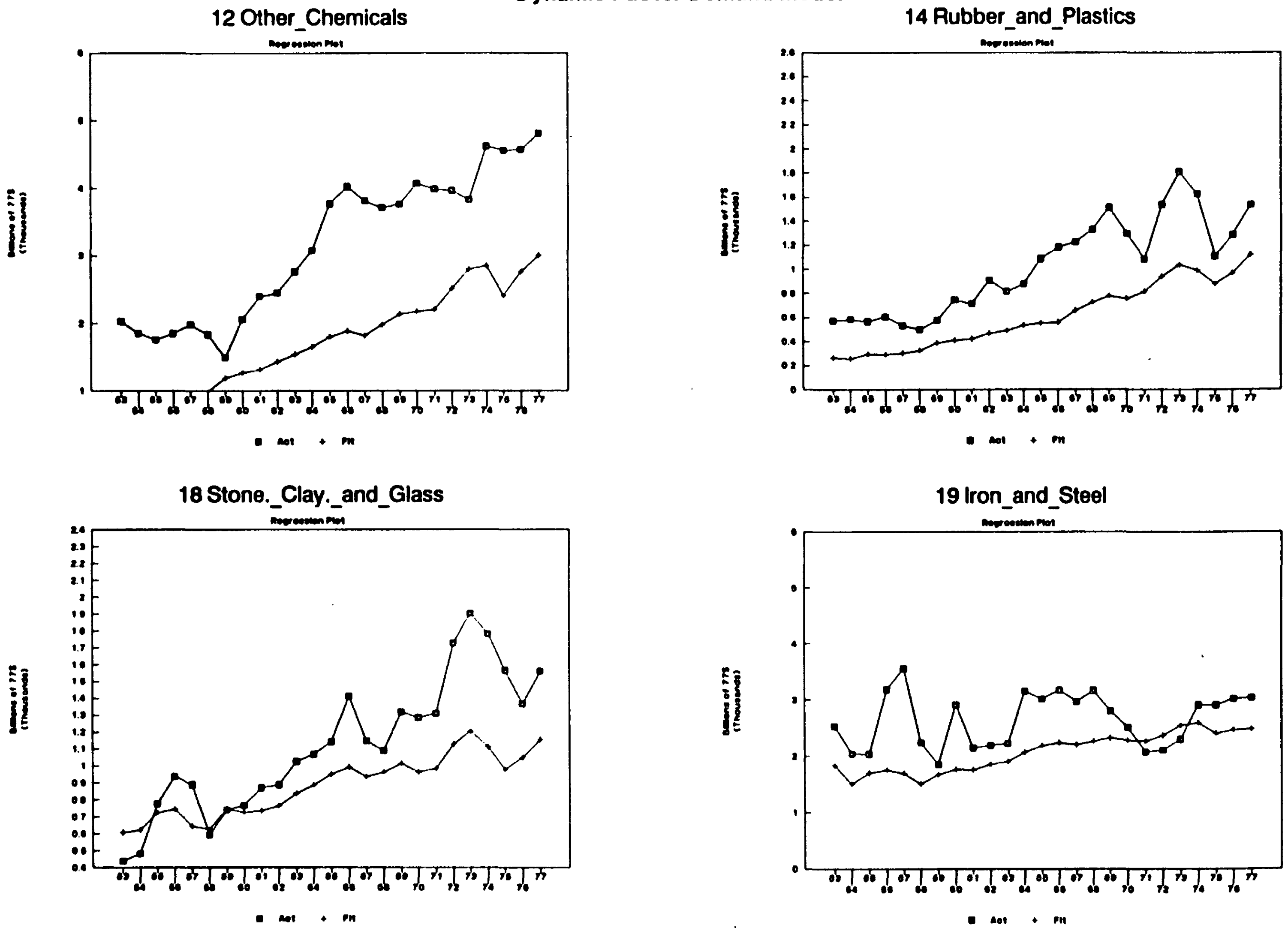


Figure 4.15.b - 1953 to 1977 Estimation

Dynamic Factor Demand Model

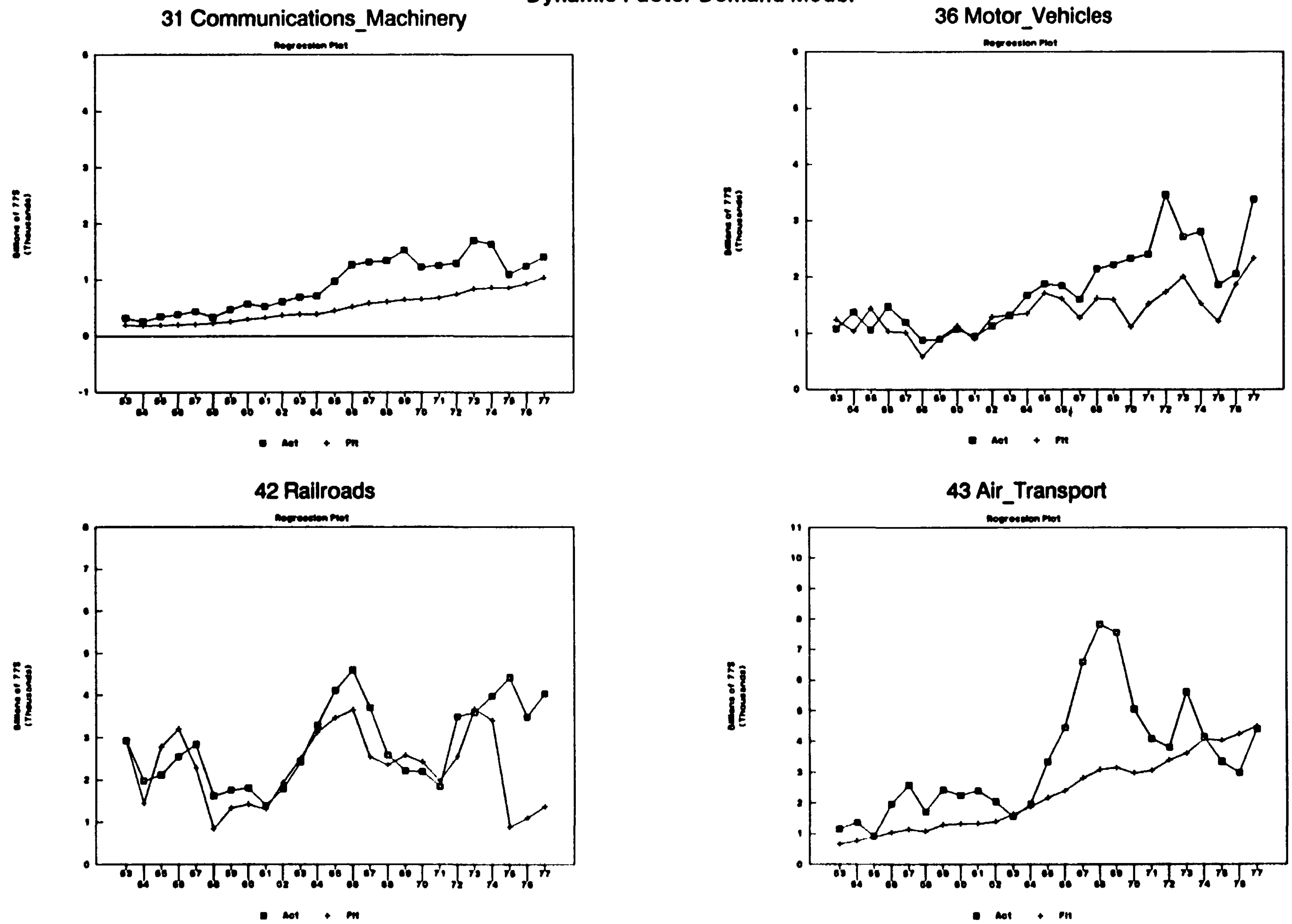


Figure 4.15.c - 1953 to 1977 Estimation

Dynamic Factor Demand Model

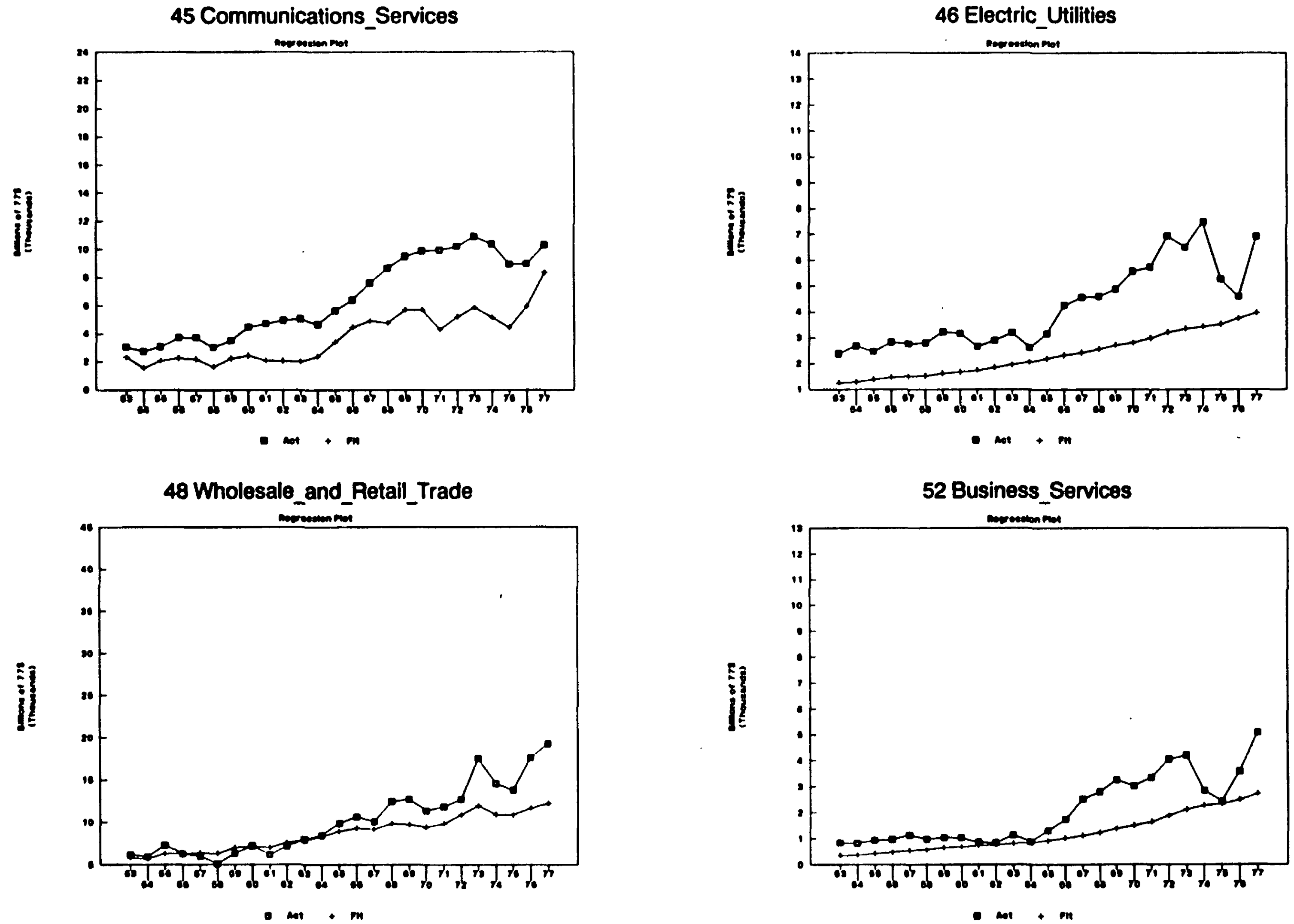


Figure 4.15.d - 1953 to 1977 Estimation

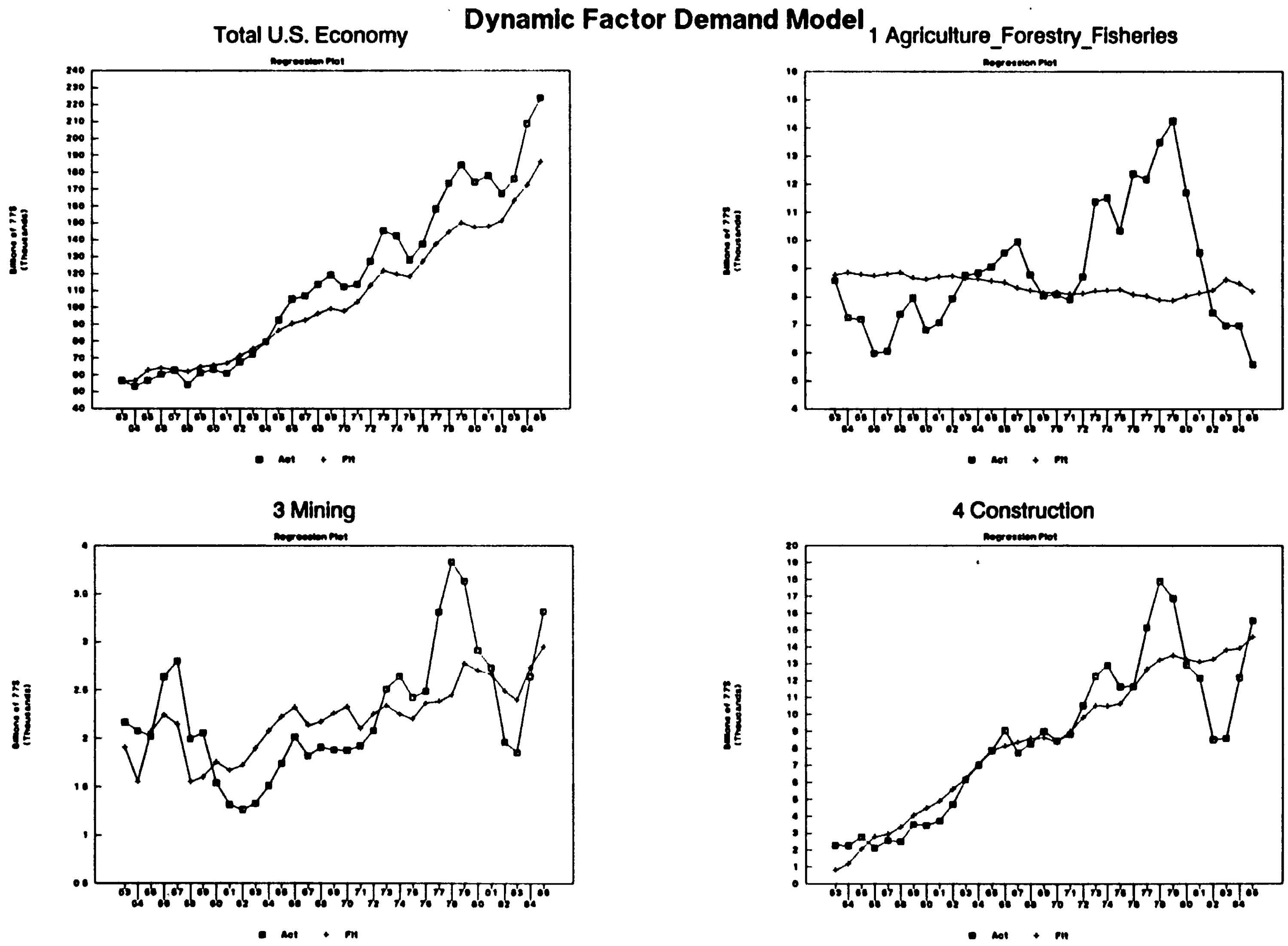


Figure 4.16.a - 1953 to 1985 Estimation

Dynamic Factor Demand Model

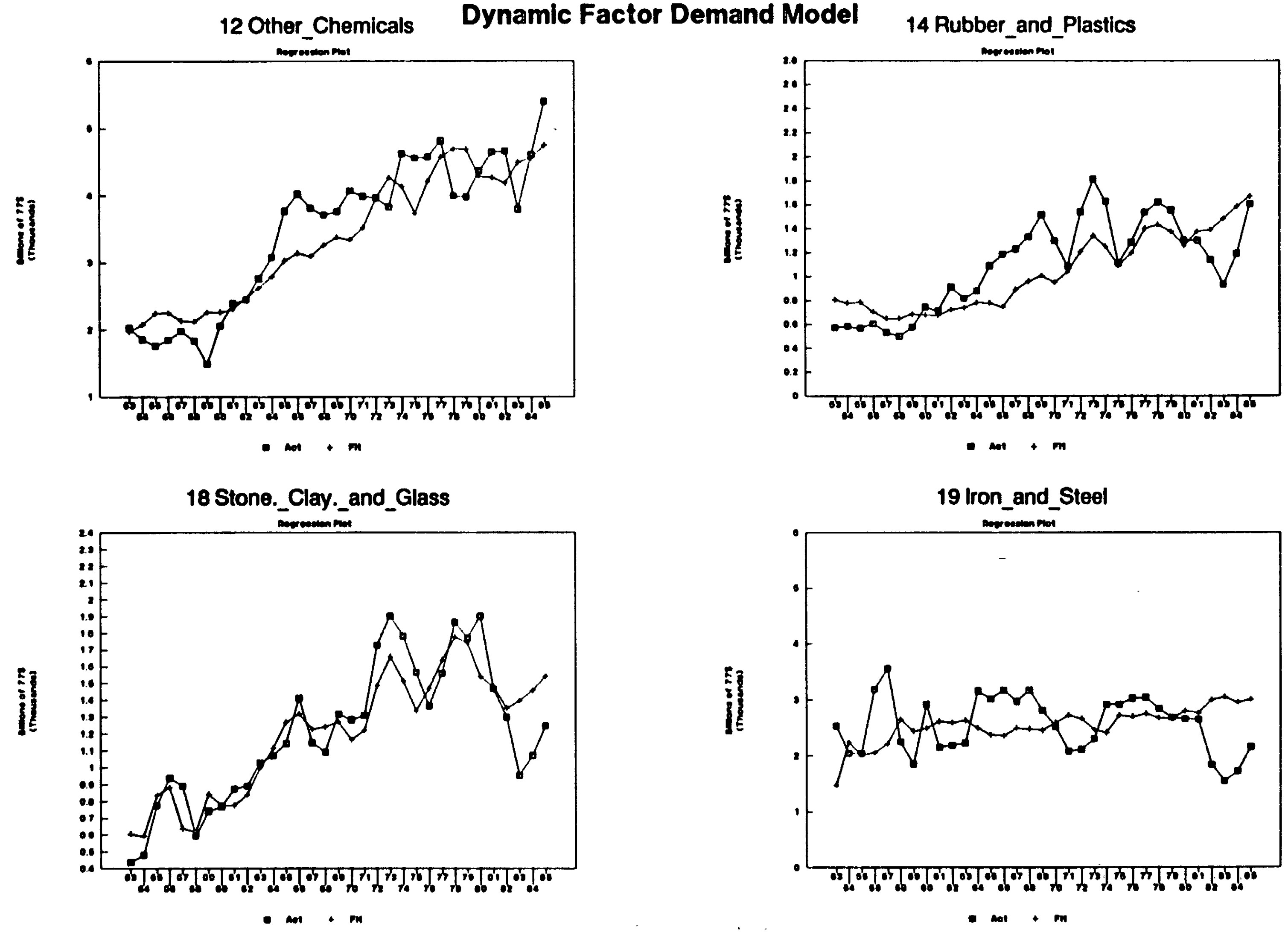


Figure 4.16.b - 1953 to 1985 Estimation

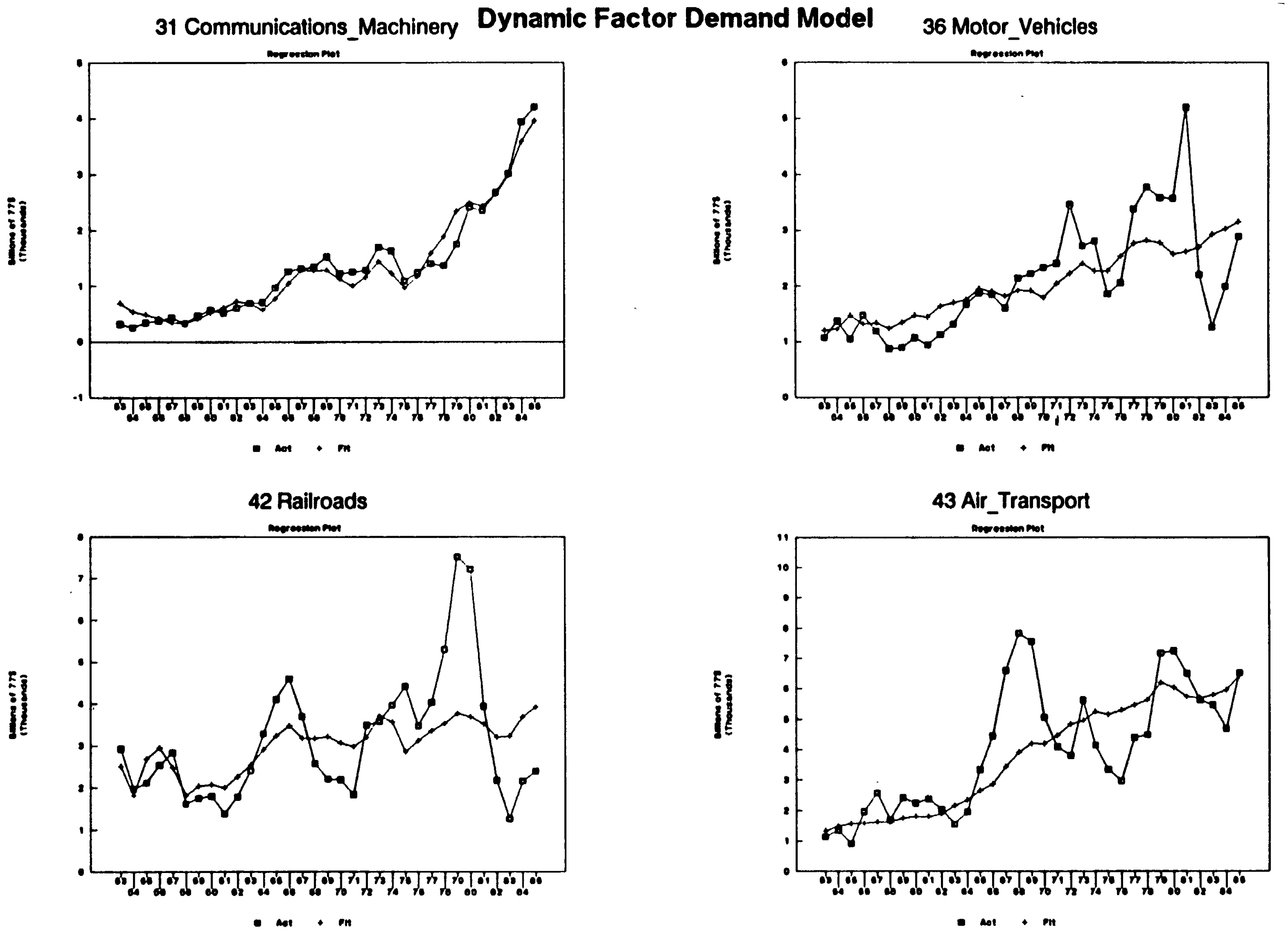


Figure 4.16.c - 1953 to 1985 Estimation

Dynamic Factor Demand Model

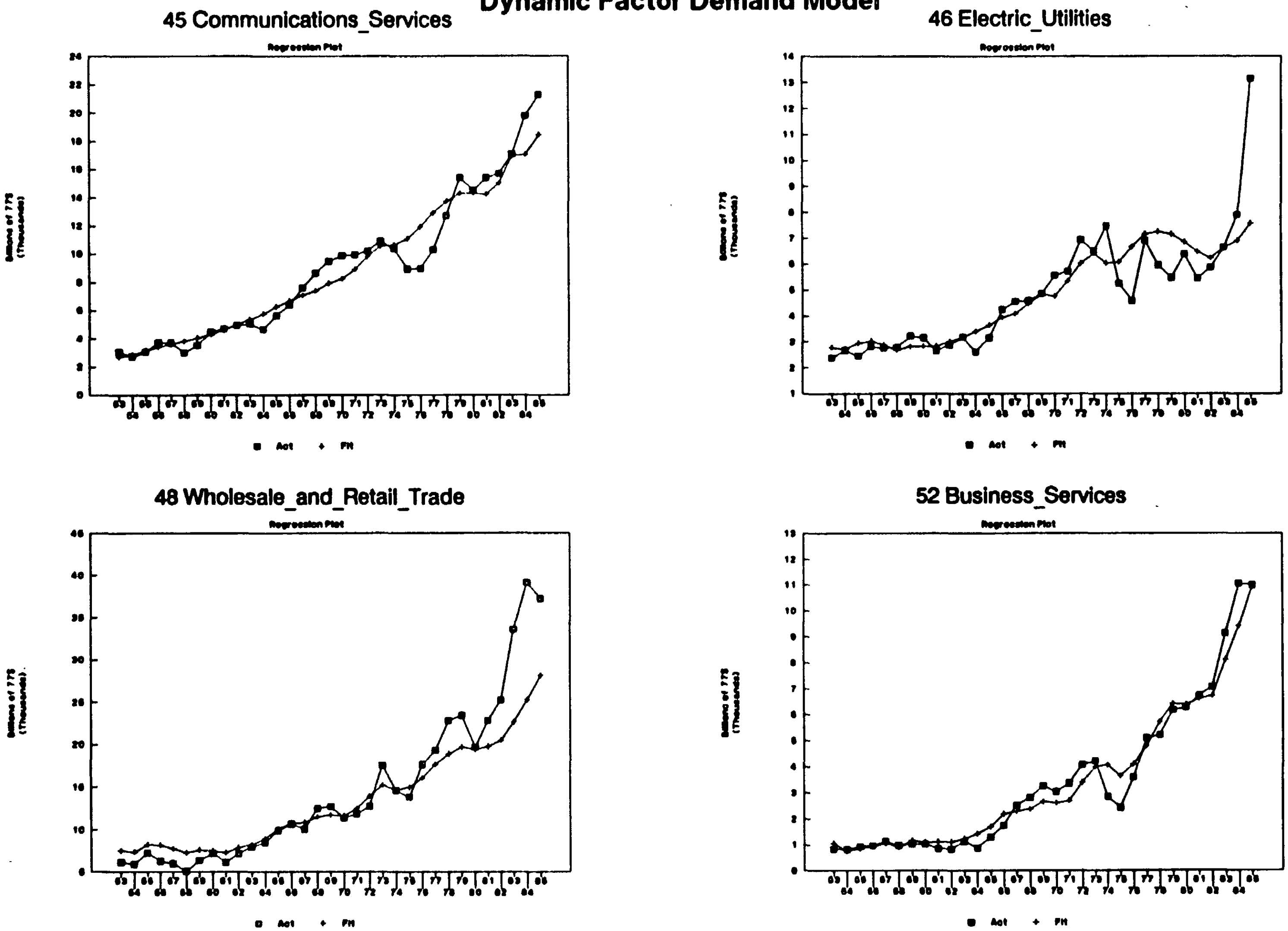


Figure 4.16.d - 1953 to 1985 Estimation

CHAPTER V

SIMULATION RESULTS

1. Background

This chapter will discuss the historical or *ex post* simulation results from the models presented in Chapter III and estimated in Chapter IV. Dealt with here is the question of which equipment investment model fits the data best in the context of a historical simulation. This reduces to the question of deciding what criteria to use to determine which fit is "best".

Related to the question of which model fits best is the issue of how the model simulations will be used, and how impact multipliers calculated from the model should be interpreted. What significance is it to have found the model with the best (defined as closest fitting) simulation performance for a certain time period? Although a given model may yield the best fitting historical simulation while using actual values of exogenous variables, that does not ensure that it will react realistically to sharp changes in exogenous variables in long-term simulations of alternative scenarios.

The six measures discussed below are statistics typically used to judge the quality of simulation performance. Most of them reduce to measures of the squared error or the general bias of the simulation. However, other criteria should be considered as well, such as success at catching turning points, accuracy of long-run trend, and the ability to respond in a sensible direction and magnitude to changes in output, and relative factor prices. Nevertheless, I will summarize the simulation results in the form of tables showing the following test statistics for each industry. A subset of industries appear in the graphs that follow each set of tables. While commenting on those graphs I will attempt to bring out the importance of some of the "non-statistical" criteria.

The test statistics presented below are highly correlated with each other. However, there is no guarantee that they will all yield the same ranking of models. It is also quite possible that a model that produces the best simulation test statistics for one historical period will not do so for another period.

Simulation testing of this kind has been criticized by Howrey and Kelejian (1971) and Kelejian and Vavrichek (1981). They have noted that with linear models, simulation tests yield no additional information about the validity of the model beyond the traditional statistical tests applied to the regression estimates. Also, non-stochastic simulation of non-linear models yields results inconsistent with the reduced-form equations of the model. They derive and compare reduced-form equations with the process that generates the simulated values of the endogenous variables, and find that the simulated values can be expected to diverge systematically from the corresponding historical values. What this means is that a "correctly" specified model need not outpredict an "incorrectly" specified model. They criticize *ad hoc RMSE* comparisons such as those in this chapter because the properties of the simulation error term are unknown, even when we know the complete multivariate distribution of the reduced-form model.

This criticism is well-taken, since it throws doubt upon the significance of rankings by these statistics produced below. However, the aim of this study is to indicate the best form of equipment investment equations to use as a tool for reliable forecasting and for sensible policy analysis. The aim is not to find the "true" or "correctly specified" model, even granted that such a model exists. Viewing the complete INFORUM model as a representation of the actual U.S. economy, it seems more natural to construct equations that replicate the behavior of the actual economy as closely as possible, and this effort should be expected to require equations that can provide close fits in a simulation.

The primary importance of investment equations such as these may be their value as forecasting instruments *per se*. On the other hand, it is also important that they have structural parameters that yield sensible economic content. Given the critique above, it would seem to be wise to remain sceptical of the exactness of tests based on goodness of fit, but rather to use them as a general guide, and to emphasize qualities such as long-run accuracy, turning point sensitivity, and sensible responses as secondary criteria.

It may be useful to estimate small systems of equations with systems or maximum likelihood techniques, and to use test statistics and hypothesis tests based on classical distribution theory to evaluate the behavior of these small models. The cost of constructing such models is negligible, and they often give an adequate approximation to a real world economic system. However, classical distribution theory, with its associated estimation and evaluation techniques, breaks down when attempting to estimate and test a large time-series model with hundreds of equations. Furthermore, no appeal can be made to asymptotic results, for the economy probably does not play the same "game" long enough to achieve a large enough sample size.

Therefore, it seems advisable to return to the criteria of economic "reasonableness", internal consistency, and the ability to reproduce the actual behavior of economic variables closely. However, upon finding a model that fits best among a certain set of alternatives for a given sample period, one must be careful not to mine the data too deeply. The choice of the best investment model should be robust with respect to the test period.

Before presenting the simulation results, I will present the definitions of the test statistics used in the following tables to summarize the performance of the models.[69]

Perhaps the most commonly used measure of predictive accuracy for a given variable Y is the *root-mean-square simulation error*

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[69] These formulas are taken from Pindyck and Rubinfeld (1981), pp 362-363, except for Theil's *inequality coefficient*, which is Fair's (1984) version (p 261).

(RMSE), defined as

$$(1.1) \qquad RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}$$

where Y_t^s = simulated value of Y

Y_t^a = actual value of Y

T = number of periods in the simulation

The *RMSE* gives a rough measure of the average deviation of the simulated value from the actual. It is analogous to a standard error.

Another statistic for evaluating simulation errors is the *RMS percent error*, defined as:

$$(1.2) \qquad RMS\ percent\ error = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left[\frac{Y_t^s - Y_t^a}{Y_t^a}\right]^2}$$

which gives a measure of the deviation of the simulated value from the actual in percentage terms. Two other measures are the *mean simulation error*:

$$(1.3) \qquad mean\ simulation\ error = \frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)$$

and the *mean percent error:*

$$(1.4) \qquad mean\ percent\ error = \frac{1}{T}\sum_{t=1}^{T}\frac{Y_t^s - Y_t^a}{Y_t^a}$$

The latter two measures are appropriate if it is desired to see how the simulation performs *on average*. The trouble with them is that large positive and negative errors will cancel each other. For this reason, the *mean absolute simulation error* or the *average absolute percentage error (AAPE)* may be calculated. The formulas for these statistics are the same as for the *mean error* and the *mean percent error*, with the differences between simulated and actual replaced by the absolute value of the difference. *RMS* error calculations penalize large errors more heavily, and are more often used in practice. However, the *AAPE* may be better as an average measure of overall forecasting ability.

Another statistic used in assessing simulation performance is Theil's[1966] *inequality coefficient* (*U*), defined as:

$$(1.5) \qquad U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\Delta Y_t^a - \Delta Y_t^s)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(\Delta Y_t^a)^2}}$$

For a perfect forecast, the value of *U* will be zero. *U* will take on a value of unity for a no change forecast ($\Delta Y_t^a = 0$). A value of *U* greater than unity implies that the forecast is less accurate than a forecast of no change from the previous period.[2]

A well-known example of a comparison of models in terms of *ex post* forecasting accuracy is Fromm and Klein (1976), where eleven major macroeconomic models are analyzed. One problem with a comparison such as this is that the various models compared used

[2] Of course, in the context of an *ex post* full model simulation, the use of a no change forecast is not an option, since the model is not allowed to use previous period actual data in making its forecasts.

different estimation periods, and the period of simulation may be included in the sample, be outside the sample, or overlap the sample in different models. A model that includes the period of simulation in its data sample may be at a relative advantage because of data mining over this period. Another problem is that the models differ in the number and types of exogenous variables. A model that uses more exogenous information has an advantage in an *ex post* simulation exercise.

In the simulations discussed below, all models are estimated over the same historical period for each simulation exercise. Both within sample (1953 to 1985 estimations) and beyond sample (1953 to 1977) simulations are compared, to determine the sensitivity of the conclusions to the estimation sample period. Finally, since the investment equations considered all are included within the same host model, the same exogenous data is used by all of them. Any differences in the set of exogenous data actually used are due purely to the structure of the equations.

2. Simulations Within the Period of Estimation

In this exercise, the estimated equations from the 1953 to 1985 sample period were used to make historical simulations with the INFORUM model from 1978 to 1985. For each of the eight investment models, two simulations were made. The first consisted of a single-equation dynamic simulation, with equipment investment being the only endogenous variable forecast. For the Autoregressive Model, it does not matter whether the rest of the model is simulated or not, since it does not use any other variables from the model. The forecast for this model is a simple dynamic period-ahead forecast, so that the model is relying solely on its own past forecasts by 1982 (since the equation uses four lagged values of the dependent variable). For the other models this forecast should differ from the predicted values of the estimated equations only to the extent that capital stock growth in the simulation period is different from the actual. (This, in turn, is a function of how well the investment equation performed during the previous periods of the forecast interval.)

The second simulation consisted of a full simulation of the real or demand side of the INFORUM model, where the mutual interactions between investment and output are brought into play. This real-side model simulation includes forecasts for consumption, inventory and structures investment, government spending, and exports and imports. These final demands are used by the input-output solution to produce an estimated vector of industry outputs, which are in turn used to calculate further iterations of calculating equipment investment.

The results of the simulations are presented both in terms of descriptive statistics for all industries, and in graphs of the same set of industries selected in the previous chapter.

2.a. Single-Equation Simulations

Table 5.1 summarizes the simulation performance of each of the eight models in the single equation dynamic simulation, for each of 53 industries, using calculated values of the six descriptive statistics defined in the previous section. The heading at the top of each page provides a key to the simulation number corresponding to each of the model simulations. For each industry, a column of simulation performance statistics is presented, and the number of the model with the best ranking is displayed in the column labeled "best".

Three salient observations emerge from the perusal of this table. First, depending on which simulation test criterion is used, one would choose a different model to be "the best" for any given industry. For example, for Motor Vehicles (36), if we use *RMSE*, then the CES Model II is superior. If we use RMS percent error or *AAPE* however, then the Generalized Leontief Putty-Clay model is best. For other industries, such as Crude Petroleum (14), one model (in this case CES Model I) is ranked best by all criteria. Second, by turning to the last page of this table, under the heading "Ranking of Simulations by Each Statistic", it is seen that the Autoregressive Model and the Accelerator Model perform better in most industries in terms of *RMSE*, *RMS* Percent Error, and *AAPE*, while there is no clear winner if we rank by the Mean Simulation Error or Mean Percent Error. Even by these measures, however, the Autogressive and Accelerator models show favorable results. Third, if we add up the *RMSE* and Mean Simulation Error for all industries, the Autoregressive Model and Accelerator Model stand out as giving a significantly better overall forecast in terms of *RMSE*, followed by the CES Model II. In terms of Mean Simulation Error, the Autoregressive Model is the best, followed by the Cobb-Douglas Model and CES Model II. The Dynamic Factor Demand Model is by far *the worst* in terms of overall *RMSE.* This poor overall performance is due mainly to unreasonable results in the Construction (4), Trucking and Other Transport (44), Wholesale and Retail Trade (48), and Real Estate (50) industries.

Figures 5.1.a through 5.1.h show simulation plots for the same set of industries plotted in Chapter IV. Figures 5.1.a through 5.1.d show the simulation comparisons of the first four models (*AUT* = Autoregressive, *ACC* = Accelerator, *COB* = Cobb-Douglas, *CES1* = CES I) with actual data. Figures 5.1.e through 5.1.h show the comparisons for the other four models (*CES2* = CES II, *DPC* = Generalized Leontief Putty-Clay, *DPP* = Generalized Leontief Putty-Putty, *BFW* = Dynamic Factor Demand). Note the erratic performance of the CES I model in Other Chemicals (12); Stone, Clay, and Glass (18); and Railroads (42). Even the simple Accelerator Model manages to forecast negative investment in the Air Tranport (43) industry. The Dynamic Factor Demand Model produces an unstable forecast in Construction (4), Iron and Steel (19), Motor Vehicles (36), and numerous other industries. In fact, a cursory glance at these charts suggests the same conclusion as the total *RMSE* comparison at the end of Table 5.1;

i.e., that the CES Model I and the Dynamic Factor Demand model are clear losers in terms of goodness of fit.

Comparing simulation behavior across models, it is notable that the two versions of the Generalized Leontief model produce similar forecasts for most industries. The distinction between the putty-putty formulation and the putty-clay does not seem to make much difference in most cases. However, in industries such as Iron and Steel (19) and Air Transport (43) the two versions are significantly different. At the level of the total U.S. economy, these two models are extremely close. Although the Autoregressive Model performs well in terms of fit, it appears to drift through the middle of most of the charts, producing a conservative, unimaginative forecast. All of the other models pick up turning points better, even though they may be poor at predicting the level of investment. It is curious that in an industry such as Agriculture (1), none of the equations is able to pick up the drop in investment that continued through 1985. Also remarkable is the Railroad (42) industry, in which five of the models yield a close consensus, but it is a consensus which does not include the actual data.

The summary for the total U.S. economy in Figures 5.1.a and 5.1.e shows some provocative results. Although the two closest fitting models in terms of aggregate *RMSE* were the Accelerator, followed by the Autoregressive, the *CES* and *GL* models, and even the Dynamic Factor Demand model follow the overall turning points and directions more faithfully.

Table 5.1

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 1
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

1 Agriculture

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	2000.9	2307.8	3343.4	3955.2	3933.0	3183.9	2974.9	4238.2
RMS Percent Error	10	0.2274	0.2996	0.4123	0.5844	0.5678	0.4797	0.4658	0.6388
Mean Simulation Error	12	-184.58	516.54	118.75	1975.04	2105.72	2718.34	2391.54	1100.29
Mean Percent Error	10	0.0494	0.1379	0.1313	0.3534	0.3426	0.3676	0.3314	0.2534
AAPE	10	0.1988	0.2601	0.3498	0.4683	0.4200	0.3676	0.3314	0.4792
Theil's Inequality Coef	10	0.9084	0.9829	1.3686	1.1671	2.0582	1.0933	1.2132	2.4804

2 Crude Petroleum

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	1217.7	1299.8	1279.2	1327.8	672.1	1407.7	1388.2	1281.5
RMS Percent Error	14	0.2852	0.3210	0.3339	0.4208	0.2165	0.3451	0.3468	0.3037
Mean Simulation Error	14	-854.85	-805.33	-956.48	-563.03	-179.10	-970.07	-990.62	-825.29
Mean Percent Error	14	-0.2218	-0.1818	-0.2548	-0.0790	0.0002	-0.2408	-0.2533	-0.1987
AAPE	14	0.2218	0.2860	0.2876	0.4000	0.1958	0.3088	0.2952	0.2514
Theil's Inequality Coef	14	0.9547	1.0614	1.0134	1.1430	0.6520	1.0754	0.9838	1.0132

3 Mining

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	486.0	692.6	990.9	1041.6	650.4	521.9	490.9	560.8
RMS Percent Error	16	0.1983	0.1988	0.2949	0.3062	0.2312	0.1583	0.1557	0.1592
Mean Simulation Error	16	-89.88	-387.92	-674.42	-795.37	-155.84	-82.77	-8.59	-301.07
Mean Percent Error	14	0.0087	-0.0948	-0.1826	-0.2321	-0.0017	-0.0040	0.0249	-0.0893
AAPE	39	0.1562	0.1681	0.2754	0.2746	0.1817	0.1301	0.1320	0.1240
Theil's Inequality Coef	10	0.8693	1.1845	1.4806	1.4519	1.2235	1.0881	1.0384	1.2842

4 Construction

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	3512.9	1873.2	4130.5	5411.9	2089.4	1887.6	2045.0	14344.8
RMS Percent Error	11	0.3854	0.1395	0.3894	0.5593	0.1509	0.1811	0.1764	0.9795
Mean Simulation Error	14	2352.31	-114.83	797.52	3405.43	11.80	465.22	102.67	12435.75
Mean Percent Error	11	0.2496	0.0120	0.1459	0.3628	0.0223	0.0710	0.0445	0.9177
AAPE	11	0.2676	0.1135	0.2963	0.4326	0.1445	0.1441	0.1499	0.9177
Theil's Inequality Coef	15	0.8387	0.7287	1.2214	1.1877	0.8795	0.5967	0.6554	4.1679

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

5 Food, Tobacco

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	618.5	323.7	281.9	1313.3	828.0	315.5	420.5	1018.7
RMS Percent Error	12	0.1748	0.0921	0.0756	0.3377	0.2297	0.0872	0.1189	0.2761
Mean Simulation Error	12	554.51	209.54	20.19	-1179.34	712.21	158.92	318.85	-901.59
Mean Percent Error	12	0.1554	0.0603	0.0094	-0.3098	0.1959	0.0482	0.0912	-0.2427
AAPE	12	0.1557	0.0762	0.0656	0.3098	0.1959	0.0691	0.1024	0.2427
Theil's Inequality Coef	11	0.9595	0.7857	1.0012	1.8088	1.3136	0.8190	0.8145	2.0221

6 Textiles

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	127.0	160.7	113.5	123.3	318.9	261.7	380.3	212.3
RMS Percent Error	13	0.1550	0.1904	0.1390	0.1262	0.3728	0.3110	0.4506	0.2561
Mean Simulation Error	39	87.06	149.70	84.47	-92.80	309.23	77.85	297.99	38.63
Mean Percent Error	39	0.1092	0.1750	0.1039	-0.0992	0.3573	0.0947	0.3479	0.0476
AAPE	13	0.1360	0.1750	0.1140	0.0992	0.3573	0.2374	0.3479	0.2163
Theil's Inequality Coef	13	0.9458	0.9080	0.9001	0.8027	1.2689	2.2582	2.6778	2.7777

7 Knitting, Hosiery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	36.5	44.1	60.9	162.3	29.7	75.2	45.2	44.9
RMS Percent Error	14	0.1841	0.2943	0.3988	1.1124	0.1837	0.4120	0.2551	0.2751
Mean Simulation Error	14	-17.66	-8.53	15.55	141.99	-2.41	-61.91	-26.16	-9.88
Mean Percent Error	14	-0.0665	-0.0178	0.1613	0.9336	0.0149	-0.3288	-0.1212	-0.0483
AAPE	14	0.1589	0.2269	0.3437	0.9408	0.1499	0.3954	0.2322	0.2353
Theil's Inequality Coef	14	0.9958	1.5512	1.3233	1.2250	0.9191	1.6757	1.3058	1.6816

8 Apparel

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	39	121.4	192.4	176.0	933.0	288.0	170.9	271.1	106.2
RMS Percent Error	39	0.3876	0.6024	0.5469	2.7911	0.8812	0.5467	0.8446	0.3220
Mean Simulation Error	39	107.36	170.00	173.49	925.06	268.37	149.94	261.51	60.33
Mean Percent Error	39	0.3380	0.5211	0.5292	2.7610	0.8097	0.4657	0.7975	0.1775
AAPE	39	0.3380	0.5211	0.5292	2.7610	0.8097	0.4657	0.7975	0.2535
Theil's Inequality Coef	10	0.7797	1.5636	0.7833	2.5161	1.8610	1.4893	1.7328	0.9257

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

9 Paper

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	15	432.1	364.6	492.5	687.9	340.9	319.4	370.0	926.4
RMS Percent Error	15	0.1398	0.0966	0.1293	0.2320	0.1066	0.0865	0.1012	0.2674
Mean Simulation Error	14	148.76	-140.26	-298.86	469.68	106.00	-109.27	-150.67	-745.10
Mean Percent Error	15	0.0603	-0.0318	-0.0785	0.1571	0.0415	-0.0258	-0.0389	-0.2189
AAPE	15	0.1107	0.0796	0.1100	0.1937	0.0879	0.0697	0.0833	0.2298
Theil's Inequality Coef	14	0.9300	0.8558	0.8805	1.3773	0.8451	0.8886	1.0014	1.6658

10 Printing

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	172.3	201.1	327.8	1526.6	186.9	286.7	211.0	238.2
RMS Percent Error	11	0.0807	0.0749	0.1358	0.7500	0.0781	0.1502	0.1002	0.1214
Mean Simulation Error	14	63.23	-68.23	-260.37	1435.67	2.72	223.89	69.04	144.06
Mean Percent Error	14	0.0363	-0.0232	-0.1195	0.7049	0.0112	0.1223	0.0466	0.0793
AAPE	11	0.0661	0.0487	0.1195	0.7049	0.0560	0.1404	0.0825	0.1009
Theil's Inequality Coef	10	0.7387	0.8132	0.8969	1.7075	0.8946	0.9855	0.9272	1.1186

11 Agri. Fertilizers

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	16	221.6	208.2	309.4	762.6	469.5	229.9	197.7	302.0
RMS Percent Error	11	0.8209	0.5119	1.2998	2.9985	1.8310	0.8801	0.6206	0.8609
Mean Simulation Error	16	176.83	25.50	214.23	619.36	269.55	149.32	19.77	-46.98
Mean Percent Error	39	0.6258	0.2182	0.8849	2.2423	1.1423	0.5966	0.2019	0.1892
AAPE	11	0.6735	0.4403	0.9538	2.3544	1.2804	0.6821	0.4620	0.7241
Theil's Inequality Coef	10	0.8315	1.3310	0.8523	1.3517	1.3341	0.9595	1.2418	1.3759

12 Other Chemicals

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	744.3	530.1	398.8	1796.6	835.1	1505.0	1155.0	1166.0
RMS Percent Error	12	0.1858	0.1264	0.0993	0.4250	0.1985	0.3247	0.2614	0.2476
Mean Simulation Error	16	617.00	212.73	138.45	1664.72	388.90	-905.08	-35.73	-662.20
Mean Percent Error	16	0.1506	0.0578	0.0396	0.3837	0.1016	-0.1885	0.0113	-0.1331
AAPE	12	0.1576	0.1012	0.0700	0.3837	0.1725	0.2754	0.2130	0.2062
Theil's Inequality Coef	12	1.0003	1.0416	0.8313	1.5392	1.6214	1.6652	1.9343	2.1958

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 4
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

13 Petroleum Refining

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	454.2	350.8	307.5	611.3	331.3	1043.6	1001.5	1130.9
RMS Percent Error	14	0.2035	0.1513	0.1581	0.2574	0.1490	0.4772	0.5009	0.5098
Mean Simulation Error	12	-291.01	-304.47	-110.17	-533.99	-183.73	-658.26	-569.45	-1072.29
Mean Percent Error	12	-0.1037	-0.1366	-0.0249	-0.2383	-0.0748	-0.2337	-0.1878	-0.5048
AAPE	12	0.1782	0.1366	0.1109	0.2383	0.1341	0.4400	0.4782	0.5048
Theil's Inequality Coef	11	0.9578	0.3866	0.9473	0.8525	0.8072	1.2983	1.4293	0.9633

14 Rubber & Plastics

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	254.9	310.9	301.8	1640.4	745.6	689.0	707.3	618.7
RMS Percent Error	10	0.2402	0.2856	0.2755	1.4053	0.6487	0.6087	0.6323	0.5004
Mean Simulation Error	39	85.64	136.65	99.64	1518.35	523.54	442.92	370.02	61.06
Mean Percent Error	10	0.1002	0.1390	0.1162	1.2456	0.4481	0.3786	0.3241	0.1059
AAPE	10	0.1778	0.2063	0.2147	1.2456	0.4481	0.4183	0.4203	0.4509
Theil's Inequality Coef	10	1.0331	1.0871	1.1986	1.8638	2.8457	1.7865	2.6676	2.1790

15 Footwear & Leather

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	15	35.7	29.7	42.4	62.1	52.2	20.5	33.2	28.9
RMS Percent Error	15	0.5240	0.4334	0.6055	0.8731	0.7626	0.2624	0.4435	0.3663
Mean Simulation Error	15	32.53	19.09	40.60	60.38	37.07	4.34	24.93	-18.92
Mean Percent Error	15	0.4528	0.2751	0.5533	0.8140	0.5320	0.0732	0.3367	-0.2286
AAPE	15	0.4528	0.3460	0.5533	0.8140	0.6023	0.2251	0.3733	0.3195
Theil's Inequality Coef	10	1.0583	1.8807	1.1861	1.4171	3.2665	1.3796	1.7348	1.7977

16 Lumber

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	267.0	222.7	408.3	1785.8	375.4	271.0	306.8	379.5
RMS Percent Error	11	0.3512	0.2821	0.5271	2.2041	0.4561	0.3511	0.3907	0.4469
Mean Simulation Error	39	115.30	81.60	130.44	1625.95	253.09	169.58	226.20	18.50
Mean Percent Error	39	0.1892	0.1290	0.2460	1.8805	0.3030	0.2228	0.2780	0.1159
AAPE	11	0.2773	0.2006	0.4170	1.8805	0.3380	0.2374	0.2849	0.3628
Theil's Inequality Coef	15	0.9833	1.0366	1.6049	2.1889	1.6004	0.6828	0.7162	1.5754

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 5
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

17 Furniture

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	64.5	40.7	51.9	290.6	58.6	62.2	65.7	63.5
RMS Percent Error	11	0.2299	0.1377	0.1661	0.9931	0.2020	0.1990	0.2134	0.2077
Mean Simulation Error	12	42.64	32.20	3.05	274.31	50.01	49.08	52.22	44.89
Mean Percent Error	12	0.1587	0.1113	0.0343	0.9116	0.1705	0.1543	0.1660	0.1451
AAPE	11	0.1943	0.1212	0.1367	0.9116	0.1705	0.1722	0.1739	0.1593
Theil's Inequality Coef	11	1.0067	0.7685	1.1733	1.7324	0.8081	1.2183	1.2922	1.5111

18 Stone,Clay & Glass

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	16	304.2	273.5	459.5	721.8	399.9	256.6	211.2	495.7
RMS Percent Error	16	0.2687	0.2177	0.2803	0.6369	0.2682	0.1729	0.1641	0.3444
Mean Simulation Error	11	85.61	53.28	-218.98	454.76	-232.27	-178.65	75.66	-106.54
Mean Percent Error	39	0.1145	0.0629	-0.0897	0.4234	-0.1511	-0.1171	0.0613	-0.0586
AAPE	16	0.2094	0.1783	0.2476	0.5133	0.2111	0.1421	0.1378	0.2905
Theil's Inequality Coef	15	0.9543	1.2466	1.4336	1.7709	1.8917	0.8229	0.8382	2.1267

19 Iron & Steel

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	547.6	301.3	623.9	775.2	750.9	505.4	666.6	1553.7
RMS Percent Error	11	0.3258	0.1579	0.3667	0.4416	0.4051	0.1923	0.3820	0.6534
Mean Simulation Error	11	341.41	116.26	393.99	454.87	515.36	-369.23	366.24	-1355.77
Mean Percent Error	11	0.2036	0.0771	0.2333	0.2735	0.2608	-0.1440	0.2231	-0.5829
AAPE	11	0.2238	0.1349	0.2586	0.3359	0.2742	0.1512	0.2636	0.5829
Theil's Inequality Coef	11	0.9392	0.8352	1.1324	1.3281	2.3109	1.4874	1.6289	3.3645

20 Non-Ferrous Metals

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	128.7	141.6	203.6	548.4	214.5	298.1	218.1	180.1
RMS Percent Error	10	0.1210	0.1294	0.2011	0.5057	0.1953	0.2531	0.1919	0.1474
Mean Simulation Error	10	17.56	69.91	127.58	471.20	159.67	-260.68	-112.86	-155.81
Mean Percent Error	10	0.0270	0.0674	0.1248	0.4227	0.1452	-0.2222	-0.1004	-0.1296
AAPE	10	0.1065	0.1108	0.1457	0.4579	0.1486	0.2289	0.1739	0.1296
Theil's Inequality Coef	39	0.9390	0.8867	0.9251	1.3913	1.0590	0.9880	0.9327	0.6124

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 6
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

21 Metal Products

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	323.3	357.6	378.3	997.0	379.9	484.8	495.2	535.2
RMS Percent Error	11	0.2014	0.1933	0.2320	0.5796	0.2009	0.2426	0.2425	0.2780
Mean Simulation Error	16	128.98	181.79	141.94	833.65	201.88	193.01	15.28	85.86
Mean Percent Error	16	0.0909	0.1100	0.1020	0.4616	0.1115	0.1079	0.0108	0.0660
AAPE	10	0.1397	0.1638	0.1768	0.4898	0.1713	0.2186	0.1994	0.2569
Theil's Inequality Coef	10	0.9968	1.1464	1.0602	1.6581	1.2801	1.3777	1.6061	1.5397

22 Engines & Turbines

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	13	55.6	63.1	57.0	52.5	62.0	162.0	118.6	71.1
RMS Percent Error	13	0.1721	0.2029	0.2056	0.1403	0.2165	0.4365	0.3284	0.1944
Mean Simulation Error	11	-13.56	-5.75	30.86	-29.39	8.38	-126.63	-71.35	-41.00
Mean Percent Error	10	-0.0105	0.0152	0.1205	-0.0726	0.0612	-0.3394	-0.1695	-0.0991
AAPE	13	0.1492	0.1719	0.1665	0.1243	0.1823	0.3849	0.2920	0.1647
Theil's Inequality Coef	13	1.0228	0.9551	1.0266	0.8890	1.0027	1.0913	1.1400	1.1022

23 Agri. Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	58.7	33.5	86.1	76.0	32.1	66.0	57.4	73.1
RMS Percent Error	11	0.4191	0.1549	0.6642	0.5183	0.2076	0.3250	0.2617	0.3169
Mean Simulation Error	14	18.36	-8.09	39.07	5.57	-1.17	-50.33	-33.68	-29.09
Mean Percent Error	11	0.2003	0.0048	0.3587	0.1735	0.0489	-0.2613	-0.1642	-0.1222
AAPE	11	0.3052	0.1384	0.4507	0.4109	0.1630	0.2840	0.1849	0.2874
Theil's Inequality Coef	14	0.9790	0.6937	0.9914	1.0845	0.6753	0.9548	1.1060	1.4474

25 Metalworking Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	70.8	36.8	69.6	107.4	54.1	127.4	127.2	72.9
RMS Percent Error	11	0.2163	0.0967	0.1996	0.2447	0.1316	0.3416	0.3207	0.2162
Mean Simulation Error	12	11.95	-19.58	7.25	-78.67	41.58	-43.12	42.45	27.42
Mean Percent Error	12	0.0617	-0.0525	0.0503	-0.1781	0.1046	-0.1370	0.0931	0.1011
AAPE	11	0.1654	0.0786	0.1648	0.2258	0.1136	0.3099	0.2260	0.1840
Theil's Inequality Coef	11	0.9824	0.6948	1.1038	1.1485	0.7471	1.2073	1.7498	1.0114

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

27 Special Industry Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	39.5	27.3	40.7	26.7	26.1	181.5	140.4	38.9
RMS Percent Error	13	0.2425	0.1611	0.2492	0.1484	0.1527	0.9037	0.6600	0.2317
Mean Simulation Error	13	26.78	12.22	30.66	-4.65	17.66	-178.20	-119.34	26.69
Mean Percent Error	13	0.1577	0.0788	0.1741	-0.0027	0.1017	-0.8872	-0.5793	0.1552
AAPE	11	0.1762	0.1187	0.1751	0.1198	0.1239	0.8872	0.5793	0.1803
Theil's Inequality Coef	14	0.9358	0.8647	1.1023	0.9888	0.8414	3.6151	4.2608	0.9440

28 Misc.nonelec. Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	209.2	119.2	254.3	397.9	216.9	480.2	301.6	817.6
RMS Percent Error	11	0.1518	0.0730	0.1837	0.2383	0.1395	0.3166	0.1950	0.5534
Mean Simulation Error	10	-6.48	-80.47	-11.45	-325.96	-149.67	-382.68	-149.12	250.94
Mean Percent Error	12	0.0144	-0.0515	0.0133	-0.1974	-0.0991	-0.2533	-0.0965	0.1540
AAPE	11	0.1166	0.0583	0.1597	0.2023	0.1143	0.2581	0.1609	0.4060
Theil's Inequality Coef	11	1.0293	0.4977	1.0198	1.1142	0.7305	1.0427	1.0233	3.5351

29 Computers & Other

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	39	341.5	319.7	564.9	663.3	341.4	974.9	677.8	308.1
RMS Percent Error	11	0.1749	0.1418	0.2634	0.3141	0.1509	0.6806	0.5115	0.1423
Mean Simulation Error	39	-296.75	-205.65	-456.66	-540.53	-200.48	959.46	664.57	-6.36
Mean Percent Error	39	-0.1689	-0.0920	-0.2413	-0.2875	-0.0957	0.6488	0.4717	0.0328
AAPE	14	0.1689	0.1228	0.2413	0.2875	0.1074	0.6488	0.4717	0.1089
Theil's Inequality Coef	10	0.4376	0.5710	0.6355	0.7723	0.8615	0.9269	0.9893	1.3426

30 Service Industry Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	29.0	49.4	33.9	75.3	48.6	115.5	118.6	51.9
RMS Percent Error	10	0.1256	0.2085	0.1636	0.2996	0.2089	0.4848	0.5065	0.2324
Mean Simulation Error	10	4.12	21.97	15.61	-63.47	32.20	-35.68	-30.16	-4.33
Mean Percent Error	39	0.0282	0.0971	0.0780	-0.2548	0.1415	-0.1501	-0.1319	-0.0078
AAPE	10	0.1057	0.1570	0.1134	0.2548	0.1817	0.4010	0.4091	0.1951
Theil's Inequality Coef	12	1.2357	2.0009	0.9969	1.7168	1.5391	3.4752	3.9957	1.5936

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 8
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

31 Communications Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	692.9	564.2	626.1	1312.5	632.5	1138.3	973.7	755.6
RMS Percent Error	12	0.2025	0.2110	0.1958	0.3844	0.2747	0.6087	0.5316	0.2083
Mean Simulation Error	11	-533.65	-100.30	-353.44	-1037.45	243.75	916.57	642.21	-532.62
Mean Percent Error	11	-0.1596	0.0301	-0.0736	-0.3173	0.1511	0.4561	0.3535	-0.1587
AAPE	12	0.1856	0.1753	0.1728	0.3424	0.2250	0.4567	0.3895	0.1816
Theil's Inequality Coef	10	0.6955	0.8741	0.7693	0.9701	1.7246	1.4530	1.3552	0.7155

32 Heavy Electrical Machinery

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	96.2	92.6	85.2	212.6	117.0	218.3	169.8	187.6
RMS Percent Error	12	0.1455	0.1616	0.1422	0.3085	0.2065	0.3331	0.2979	0.3069
Mean Simulation Error	12	-39.68	-15.53	-12.95	-173.19	-13.65	-134.06	-42.27	-87.77
Mean Percent Error	11	-0.0387	-0.0002	0.0048	-0.2563	0.0145	-0.1775	-0.0228	-0.1040
AAPE	12	0.1295	0.1421	0.1253	0.2705	0.1747	0.2997	0.2668	0.2746
Theil's Inequality Coef	11	0.8947	0.7832	0.9713	1.1700	1.0824	1.1470	1.2995	1.5619

33 Household Appliances

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	24.5	44.7	29.4	36.4	50.3	102.3	78.6	39.9
RMS Percent Error	10	0.1458	0.2983	0.1887	0.2265	0.3388	0.6125	0.4706	0.2423
Mean Simulation Error	39	7.64	17.80	20.00	14.25	35.60	-51.87	-33.18	4.79
Mean Percent Error	39	0.0628	0.1273	0.1342	0.1035	0.2330	-0.2770	-0.2169	0.0395
AAPE	10	0.1325	0.2101	0.1667	0.1826	0.2351	0.5210	0.3636	0.1985
Theil's Inequality Coef	10	1.0164	1.9458	1.0843	2.1944	1.8464	3.6398	4.4379	2.4713

34 Elec. Lighting & Wiring Equip

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	55.0	61.9	73.4	121.0	78.9	114.4	116.1	112.9
RMS Percent Error	10	0.1188	0.1213	0.1631	0.2370	0.1651	0.2245	0.2273	0.2312
Mean Simulation Error	10	22.43	35.58	55.48	-91.42	58.01	42.81	47.22	-25.61
Mean Percent Error	10	0.0542	0.0703	0.1194	-0.1734	0.1194	0.0770	0.0860	-0.0555
AAPE	10	0.0906	0.1063	0.1201	0.2261	0.1426	0.2085	0.2110	0.2010
Theil's Inequality Coef	10	1.0752	1.1999	1.1475	1.9164	1.3561	1.9007	1.9548	2.1783

Table 5.1 (continued)

Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

35 Radio,T.V. Receiving, Phono

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	25.9	15.8	19.5	42.8	49.3	53.4	53.6	21.9
RMS Percent Error	11	0.1604	0.1160	0.1606	0.2616	0.3507	0.3689	0.3742	0.1514
Mean Simulation Error	12	-15.93	7.54	5.14	-31.36	42.48	34.66	29.66	-10.49
Mean Percent Error	11	-0.0899	0.0512	0.0522	-0.1986	0.2967	0.2232	0.1865	-0.0589
AAPE	11	0.1403	0.0820	0.1015	0.1986	0.2967	0.3026	0.3120	0.1389
Theil's Inequality Coef	11	1.0093	0.8082	0.9500	1.7583	1.5159	2.2536	2.3122	0.9476

36 Motor Vehicles

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	1198.1	1083.7	1229.4	2189.9	1031.5	1437.9	1444.6	2516.9
RMS Percent Error	15	0.4573	0.3883	0.5375	1.1681	0.3898	0.3485	0.3754	0.7443
Mean Simulation Error	11	-413.82	-181.29	-195.28	1446.75	-444.37	-404.90	-311.11	-1172.33
Mean Percent Error	16	0.0205	0.0782	0.1190	0.7810	-0.1683	-0.0422	-0.0007	-0.2092
AAPE	15	0.3643	0.3079	0.4104	0.8870	0.3214	0.2937	0.3284	0.6517
Theil's Inequality Coef	10	0.9969	1.0379	1.0781	1.7997	1.1307	1.1248	1.1263	1.4431

37 Aerospace

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	380.3	242.3	223.7	556.1	190.2	295.4	289.8	429.5
RMS Percent Error	15	0.3422	0.3449	0.3069	0.5020	0.3510	0.2752	0.3025	0.4291
Mean Simulation Error	11	-305.81	-46.26	-106.67	-432.72	134.15	-148.20	-108.68	-340.11
Mean Percent Error	12	-0.2468	0.0484	-0.0295	-0.3469	0.2068	-0.0906	-0.0371	-0.2650
AAPE	14	0.3280	0.2557	0.2424	0.4672	0.2280	0.2501	0.2755	0.4161
Theil's Inequality Coef	10	0.9120	1.2064	1.1068	1.6536	1.2406	1.2348	1.2557	1.2860

38 Ships & Boats

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	41.8	30.6	93.8	57.9	115.6	34.9	36.6	61.3
RMS Percent Error	11	0.2471	0.1697	0.4967	0.2892	0.5915	0.1846	0.1698	0.2904
Mean Simulation Error	16	23.15	21.86	81.84	37.15	83.61	10.22	-8.26	-27.90
Mean Percent Error	16	0.1487	0.1267	0.4220	0.1918	0.4338	0.0795	-0.0166	-0.1268
AAPE	16	0.1911	0.1495	0.4220	0.2162	0.4338	0.1512	0.1330	0.2162
Theil's Inequality Coef	11	1.0643	0.6775	0.6924	1.7721	2.2086	0.8473	0.8932	1.6861

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS **PAGE 10**
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

39 Other Trans. Equip.

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	68.0	22.3	46.4	81.1	67.6	57.2	49.3	87.4
RMS Percent Error	11	0.4543	0.1115	0.3073	0.3813	0.3960	0.2612	0.2155	0.4508
Mean Simulation Error	11	56.82	-12.57	26.56	-60.72	39.14	-38.85	-31.30	-44.76
Mean Percent Error	11	0.3586	-0.0567	0.1767	-0.3169	0.2347	-0.1884	-0.1479	-0.1962
AAPE	11	0.3586	0.0910	0.2386	0.3169	0.3291	0.2078	0.1479	0.3395
Theil's Inequality Coef	11	0.9590	0.7349	0.9781	1.8624	1.4192	1.0316	0.9900	2.6312

40 Instruments

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	136.8	150.3	180.3	193.5	182.0	283.3	219.5	215.8
RMS Percent Error	10	0.1628	0.1875	0.2142	0.2810	0.2585	0.4224	0.3056	0.1942
Mean Simulation Error	10	5.41	14.98	-16.84	37.19	80.50	54.28	-33.97	-153.83
Mean Percent Error	16	0.0442	0.0606	0.0309	0.1005	0.1404	0.1502	0.0214	-0.1426
AAPE	10	0.1359	0.1467	0.1887	0.1775	0.1950	0.2939	0.2068	0.1697
Theil's Inequality Coef	39	0.8907	0.8144	1.0412	1.3057	1.2390	1.5927	1.6435	0.7893

41 Miscellaneous Manufacturing

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	83.1	63.8	77.5	69.3	98.7	128.6	124.4	87.9
RMS Percent Error	13	0.2711	0.1958	0.2586	0.1915	0.2985	0.3515	0.3474	0.2319
Mean Simulation Error	39	69.69	46.04	63.93	-8.44	79.55	-41.75	47.52	-1.54
Mean Percent Error	39	0.2202	0.1469	0.2043	-0.0058	0.2456	-0.1236	0.1426	0.0041
AAPE	39	0.2319	0.1796	0.2043	0.1724	0.2784	0.3183	0.2622	0.1615
Theil's Inequality Coef	12	0.8215	1.0898	0.8212	1.6103	1.5277	2.1132	2.5509	1.9055

42 Railroads

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	2105.7	1307.3	2439.7	3480.8	1298.6	1358.2	1316.4	1538.1
RMS Percent Error	11	0.6212	0.2931	0.7432	0.8040	0.3744	0.3102	0.3628	0.5394
Mean Simulation Error	14	-637.28	-340.92	-687.55	-2732.19	-172.98	-369.36	-216.75	-670.96
Mean Percent Error	11	0.1421	0.0556	0.1891	-0.6308	0.1211	0.0593	0.1116	-0.1319
AAPE	11	0.5038	0.2791	0.6078	0.7926	0.3249	0.2899	0.3181	0.4164
Theil's Inequality Coef	16	0.9657	0.7106	1.0663	1.4072	0.7451	0.6821	0.6239	1.0280

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

43 Air Transport

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	1339.4	1070.9	1357.5	1231.6	1217.9	2675.6	3369.6	2152.4
RMS Percent Error	11	0.2015	0.1918	0.1944	0.1974	0.2078	0.4880	0.6269	0.3505
Mean Simulation Eryor	11	-966.87	77.92	-870.13	-353.74	-672.26	1659.65	449.41	-1475.12
Mean Percent Error	11	-0.1391	0.0185	-0.1219	-0.0277	-0.1021	0.2956	0.1165	-0.2309
AAPE	12	0.1865	0.1751	0.1540	0.1681	0.1824	0.4078	0.4975	0.2940
Theil's Inequality Coef	14	0.9091	0.9904	0.9543	1.0653	0.7981	1.7304	2.5267	1.0380

44 Trucking & Other Transport

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	1241.9	1064.8	1465.9	2918.1	1204.9	1398.0	1675.5	5877.2
RMS Percent Error	11	0.1425	0.1323	0.1833	0.3591	0.1508	0.1758	0.2185	0.7021
Mean Simulation Error	12	-759.75	-709.71	130.23	-2341.51	432.54	-1170.85	-1402.03	-5600.16
Mean Percent Error	12	-0.0824	-0.0876	0.0276	-0.2853	0.0567	-0.1459	-0.1786	-0.6796
AAPE	14	0.1204	0.1248	0.1606	0.3154	0.1176	0.1572	0.1879	0.6796
Theil's Inequality Coef	16	1.0340	0.9217	0.9820	1.6266	0.9938	0.8343	0.6769	2.6291

45 Communications Services

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	14	2162.2	2286.6	3235.7	2950.2	1402.6	3392.4	3023.6	3548.0
RMS Percent Error	14	0.1214	0.1277	0.1829	0.1534	0.0751	0.2319	0.2061	0.2420
Mean Simulation Error	14	-1963.11	-2024.94	-2987.37	-2289.40	-444.13	2494.10	1609.58	2878.62
Mean Percent Error	14	-0.1149	-0.1169	-0.1759	-0.1270	-0.0195	0.1712	0.1196	0.1946
AAPE	14	0.1149	0.1169	0.1759	0.1270	0.0633	0.1761	0.1700	0.2049
Theil's Inequality Coef	10	0.5811	0.6859	0.7625	0.9580	0.8039	1.1569	1.1765	1.1542

46 Electric Utilities

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	11	3193.5	1300.7	2226.8	2029.0	1389.0	2560.7	2061.8	2565.0
RMS Percent Error	11	0.4942	0.1464	0.1844	0.2347	0.1838	0.2733	0.2275	0.2240
Mean Simulation Error	11	2787.61	-48.61	-797.09	446.73	441.09	-1467.85	-599.22	-1509.60
Mean Percent Error	16	0.4287	0.0321	-0.0555	0.1277	0.1005	-0.1599	-0.0320	-0.1633
AAPE	11	0.4287	0.1152	0.1247	0.2172	0.1666	0.2341	0.1986	0.1666
Theil's Inequality Coef	11	0.7406	0.6540	0.9502	1.0018	0.8921	0.8288	0.8521	0.9600

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 12
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

47 Gas,water & Sanitation

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	1120.3	1309.6	1641.7	2638.1	1176.2	1850.9	1780.0	2346.2
RMS Percent Error	10	0.2510	0.2961	0.3869	0.6439	0.2891	0.4595	0.4362	0.5739
Mean Simulation Error	14	-803.09	-940.27	-1386.19	-2454.67	-702.25	-1775.70	-1692.28	-2242.47
Mean Percent Error	14	-0.1760	-0.2147	-0.3282	-0.6152	-0.1450	-0.4536	-0.4301	-0.5670
AAPE	10	0.2267	0.2342	0.3614	0.6152	0.2531	0.4536	0.4301	0.5670
Theil's Inequality Coef	10	0.9792	1.2802	1.3107	1.9009	1.4893	1.1950	1.2053	1.4076

48 Wholesale & Retail trade

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	3496.4	5785.9	4404.7	8410.4	5807.4	7766.5	6344.7	13778.2
RMS Percent Error	10	0.1235	0.1740	0.1866	0.2887	0.1807	0.2438	0.2039	0.4498
Mean Simulation Error	10	-916.80	-4929.60	3491.46	-7831.48	-5096.10	-6350.58	-5460.32	-12840.76
Mean Percent Error	10	-0.0145	-0.1612	0.1404	-0.2764	-0.1708	-0.2081	-0.1845	-0.4437
AAPE	10	0.1173	0.1612	0.1404	0.2764	0.1708	0.2128	0.1845	0.4437
Theil's Inequality Coef	16	0.8996	0.5518	0.6916	0.6408	0.6298	0.5591	0.5037	1.1458

49 Finance, Insurance & Services

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	829.1	1903.0	1081.6	2461.3	1338.6	1900.4	2202.8	7495.9
RMS Percent Error	10	0.1123	0.1648	0.1183	0.2372	0.1169	0.1912	0.2224	0.9644
Mean Simulation Error	12	456.97	-1091.00	110.35	-1810.35	-615.91	-505.08	-964.00	-7204.19
Mean Percent Error	15	0.0526	-0.1014	0.0473	-0.2000	-0.0505	-0.0046	-0.0632	-0.9633
AAPE	14	0.0934	0.1227	0.1128	0.2000	0.0798	0.1651	0.1836	0.9633
Theil's Inequality Coef	10	0.3871	0.7026	0.6059	0.7590	0.6688	0.7547	0.7623	1.4980

50 Real Estate

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	1165.9	1601.6	1528.5	2814.8	2502.8	2472.0	2757.2	8099.9
RMS Percent Error	10	0.1355	0.1996	0.1823	0.3369	0.3006	0.3135	0.3503	1.0000
Mean Simulation Error	13	-994.42	-1480.43	-1116.92	768.40	-2033.74	-2396.00	-2698.27	-8039.88
Mean Percent Error	13	-0.1200	-0.1855	-0.1361	0.0776	-0.2482	-0.3020	-0.3405	-1.0000
AAPE	10	0.1200	0.1855	0.1446	0.2711	0.2482	0.3020	0.3405	1.0000
Theil's Inequality Coef	15	0.7897	0.8080	1.2099	2.1897	1.3266	0.7147	0.7652	2.2507

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

51 Hotels & Repairs Minus Auto

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	39	443.6	372.5	462.8	706.1	948.3	451.5	588.3	284.9
RMS Percent Error	39	0.1383	0.1435	0.1706	0.2129	0.3730	0.1541	0.2234	0.0921
Mean Simulation Error	15	-129.25	156.32	158.75	-567.47	742.20	-25.32	168.12	-132.66
Mean Percent Error	15	-0.0224	0.0737	0.0791	-0.1840	0.2924	0.0115	0.0763	-0.0372
AAPE	39	0.1233	0.1216	0.1440	0.1840	0.3101	0.1414	0.1834	0.0727
Theil's Inequality Coef	11	0.9207	0.7420	0.9214	1.3629	1.5732	0.8895	1.2661	0.8651

52 Business Services

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	1290.8	1595.7	795.7	1464.8	1355.3	2018.2	2514.3	2182.1
RMS Percent Error	12	0.1381	0.1672	0.0844	0.1837	0.1354	0.2123	0.2667	0.2331
Mean Simulation Error	12	-926.29	-1249.68	-233.21	-1149.53	-665.03	-1364.26	-1914.60	-1827.94
Mean Percent Error	12	-0.1019	-0.1382	-0.0129	-0.1407	-0.0643	-0.1379	-0.2086	-0.2133
AAPE	12	0.1237	0.1475	0.0744	0.1489	0.0945	0.1795	0.2410	0.2133
Theil's Inequality Coef	11	0.8541	0.4959	0.7074	1.2048	1.1736	0.7709	0.9510	0.7460

53 Auto Repair

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	16	979.6	956.4	842.3	1044.1	1039.6	827.1	813.6	1378.5
RMS Percent Error	11	0.1854	0.1537	0.2090	0.1919	0.1740	0.2047	0.2001	0.2219
Mean Simulation Error	10	-138.77	-645.54	353.71	-850.38	-756.22	389.68	-336.95	-1018.89
Mean Percent Error	10	0.0209	-0.1178	0.1257	-0.1731	-0.1434	0.1078	-0.0776	-0.1897
AAPE	11	0.1564	0.1201	0.1807	0.1731	0.1465	0.1566	0.1789	0.1897
Theil's Inequality Coef	13	0.9225	0.7299	0.7923	0.6183	0.7105	0.9028	0.7620	0.8286

54 Movies & Amusements

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	10	199.3	218.3	231.6	290.6	259.4	554.2	428.5	651.3
RMS Percent Error	10	0.1247	0.1253	0.1335	0.1780	0.1623	0.3486	0.2560	0.3781
Mean Simulation Error	12	75.09	-17.29	-8.87	59.80	161.08	508.19	367.55	-345.97
Mean Percent Error	11	0.0574	0.0054	0.0109	0.0530	0.1007	0.3085	0.2137	-0.1929
AAPE	10	0.1047	0.1129	0.1165	0.1443	0.1342	0.3085	0.2137	0.2628
Theil's Inequality Coef	14	0.7438	0.9128	0.9900	1.2989	0.7187	0.9438	1.5490	2.7367

Table 5.1 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 14
Single Equation Simulations - Estimated to 1985

Simulation 10: Autoregressive Model
Simulation 11: Accelerator Model
Simulation 12: Cobb-Douglas Model
Simulation 13: CES Model I
Simulation 14: CES Model II
Simulation 15: Generalized Leontief Putty-Clay Model
Simulation 16: Generalized Leontief Putty-Putty Model
Simulation 39: Dynamic Factor Demand Model

55 Medical & Ed. Services

Simulation :1978 to 1985	Best	10	11	12	13	14	15	16	39
Root Mean Square Error	12	1439.2	1624.6	1170.7	1507.5	1414.0	1744.5	2223.8	1971.1
RMS Percent Error	14	0.1647	0.1565	0.1471	0.1461	0.1401	0.1823	0.2199	0.1848
Mean Simulation Error	10	-208.13	-763.15	303.80	-480.98	-564.86	-578.97	-1381.18	-986.44
Mean Percent Error	10	0.0144	-0.0456	0.0596	-0.0197	-0.0283	-0.0197	-0.1107	-0.0629
AAPE	12	0.1462	0.1465	0.1233	0.1274	0.1245	0.1695	0.2049	0.1737
Theil's Inequality Coef	11	0.9432	0.7793	0.9095	1.2310	0.8014	0.9673	1.2611	0.9778

Ranking of Simulations by Each Statistic

Simulation :	10	11	12	13	14	15	16	39
Root Mean Square Error	15	14	7	1	8	2	3	3
RMS Percent Error	12	19	5	4	5	4	2	2
Mean Simulation Error	8	9	11	2	9	2	5	7
Mean Percent Error	8	10	8	2	6	4	6	9
AAPE	12	15	8	2	7	3	2	4
Theil's Inequality Coef	17	14	3	3	7	4	3	2

Total RMSE and MSE Across all Industries

Simulation :	10	11	12	13	14	15	16	39
Root Mean Square Error	36685.0	35646.0	41358.5	66693.8	39699.8	50738.2	49852.9	89244.8
Mean Simulation Error	-2984.68	-14359.17	-4335.30	-9757.98	-4697.49	-9364.14	-10871.91	-35396.41

Single Equation Simulations
Estimated to 1985

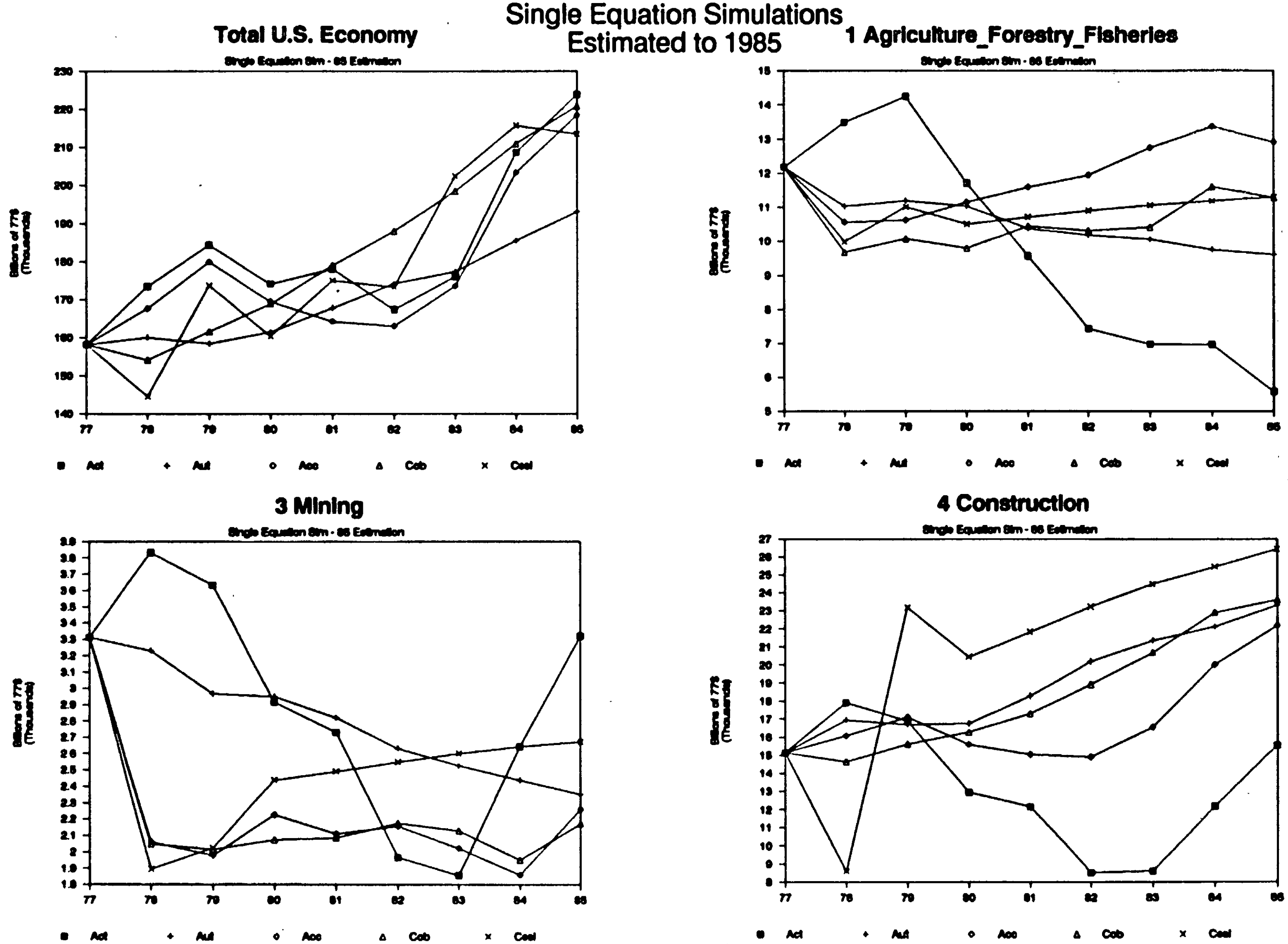


Figure 5.1.a

Single Equation Simulations Estimated to 1985

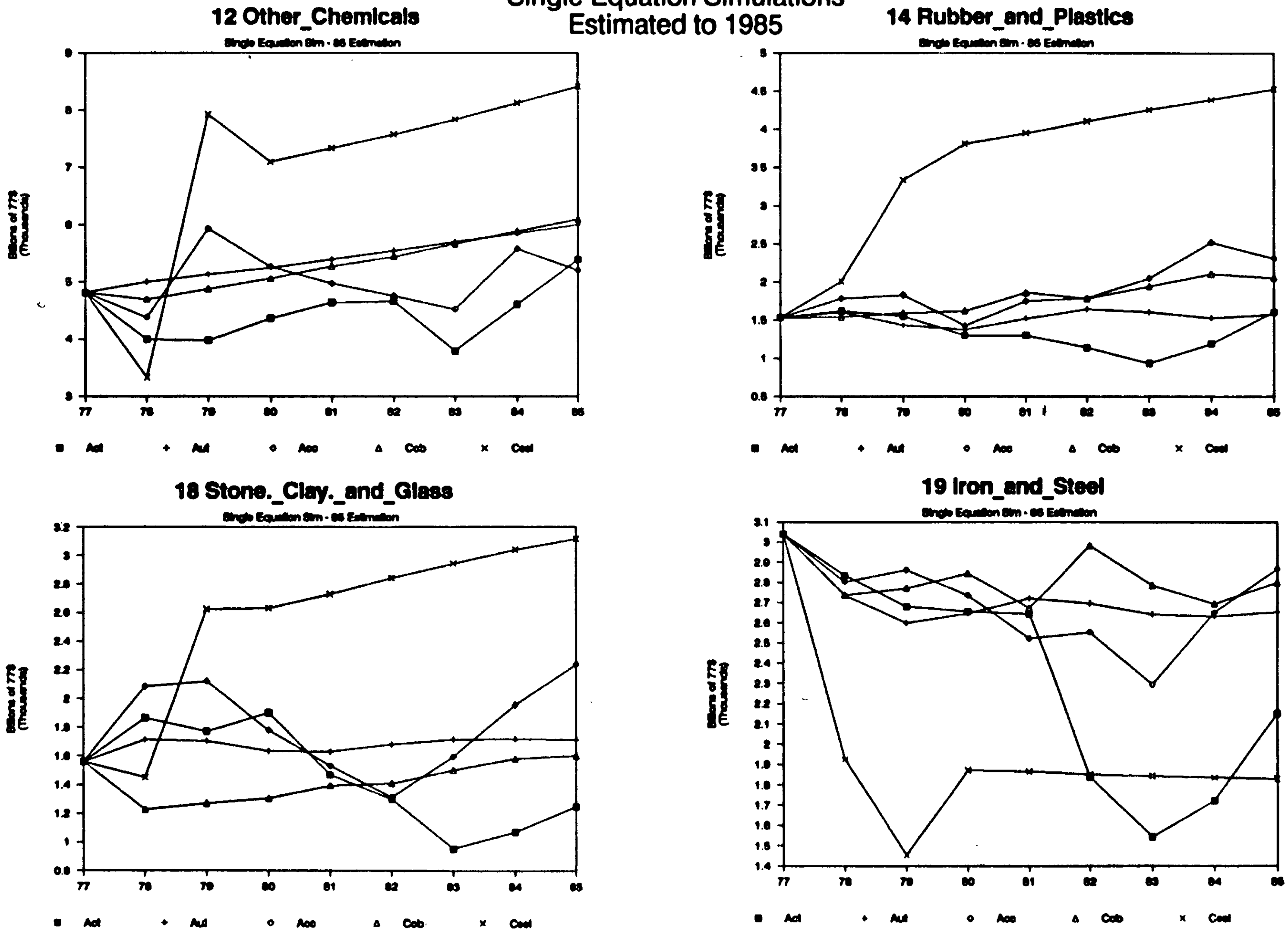


Figure 5.1.b

Single Equation Simulations
Estimated to 1985

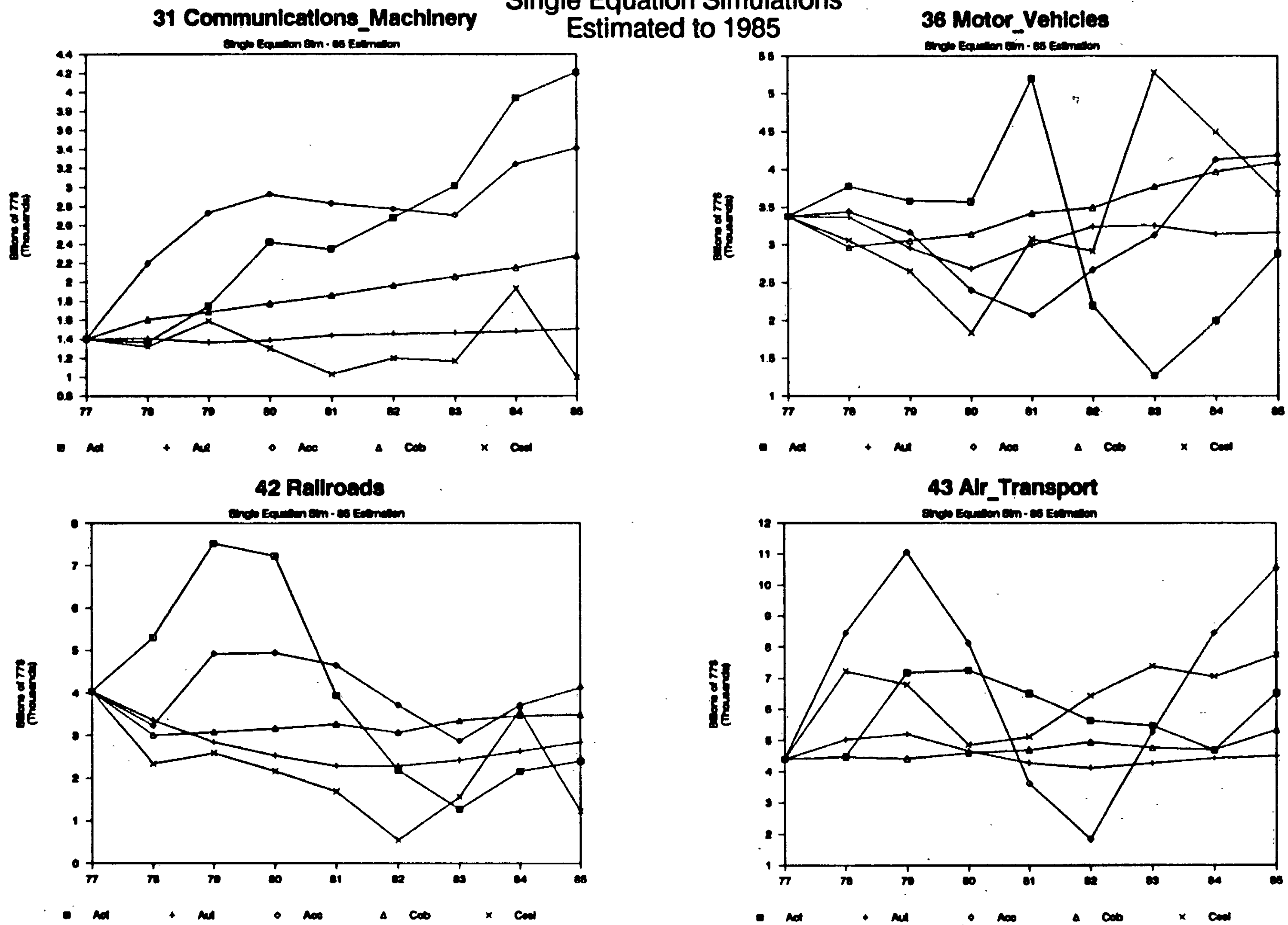


Figure 5.1.c

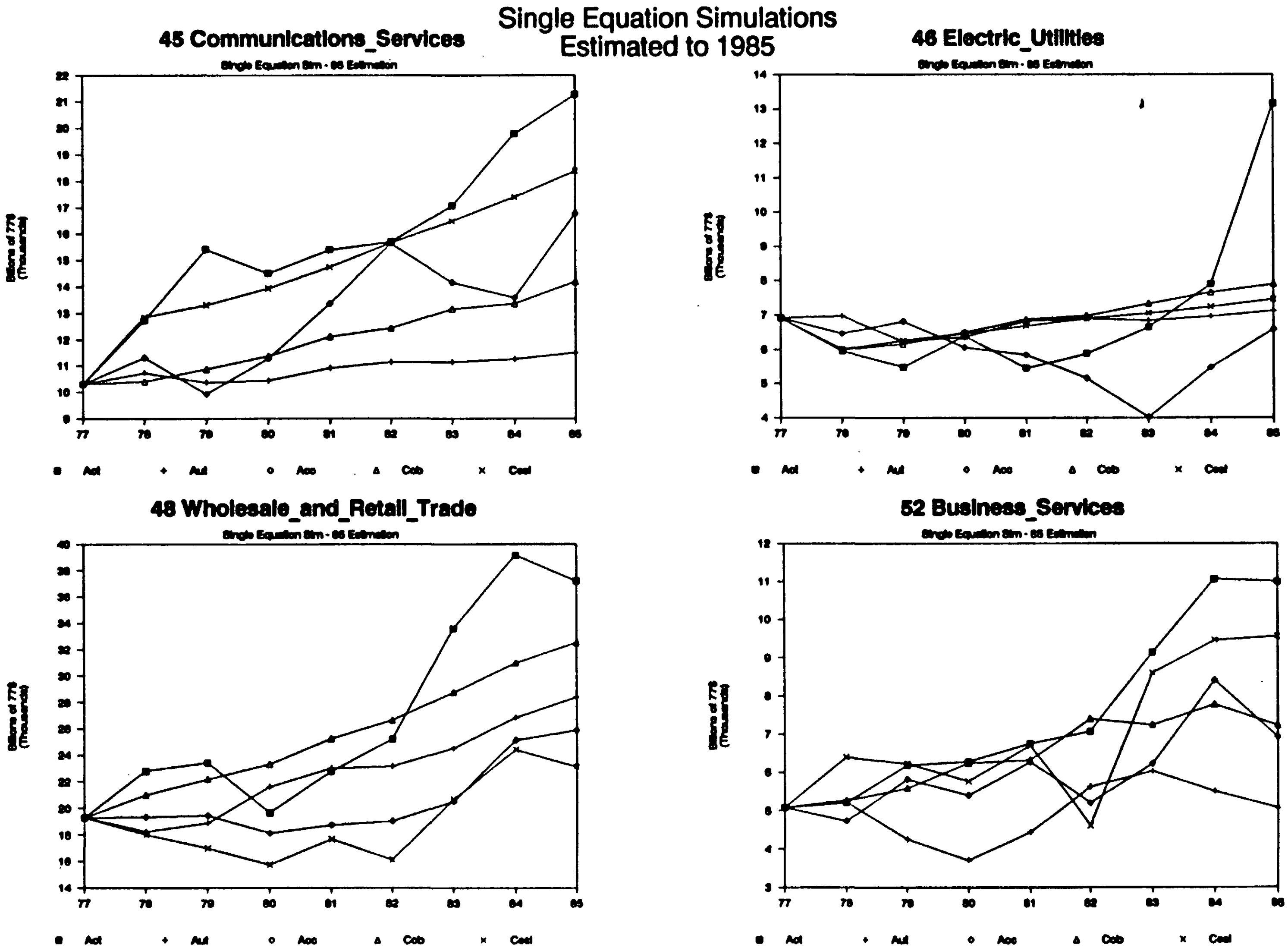

Single Equation Simulations
Estimated to 1985
45 Communications_Services
46 Electric_Utilities
48 Wholesale_and_Retail_Trade
52 Business_Services
Single Equation Sim - 85 Estimation
Billions of 77$ (Thousands)
Act
Aut
Acc
Cob
77 78 79 80 81 82 83 84 85

Figure 5.1.d

Single Equation Simulations
Estimated to 1985

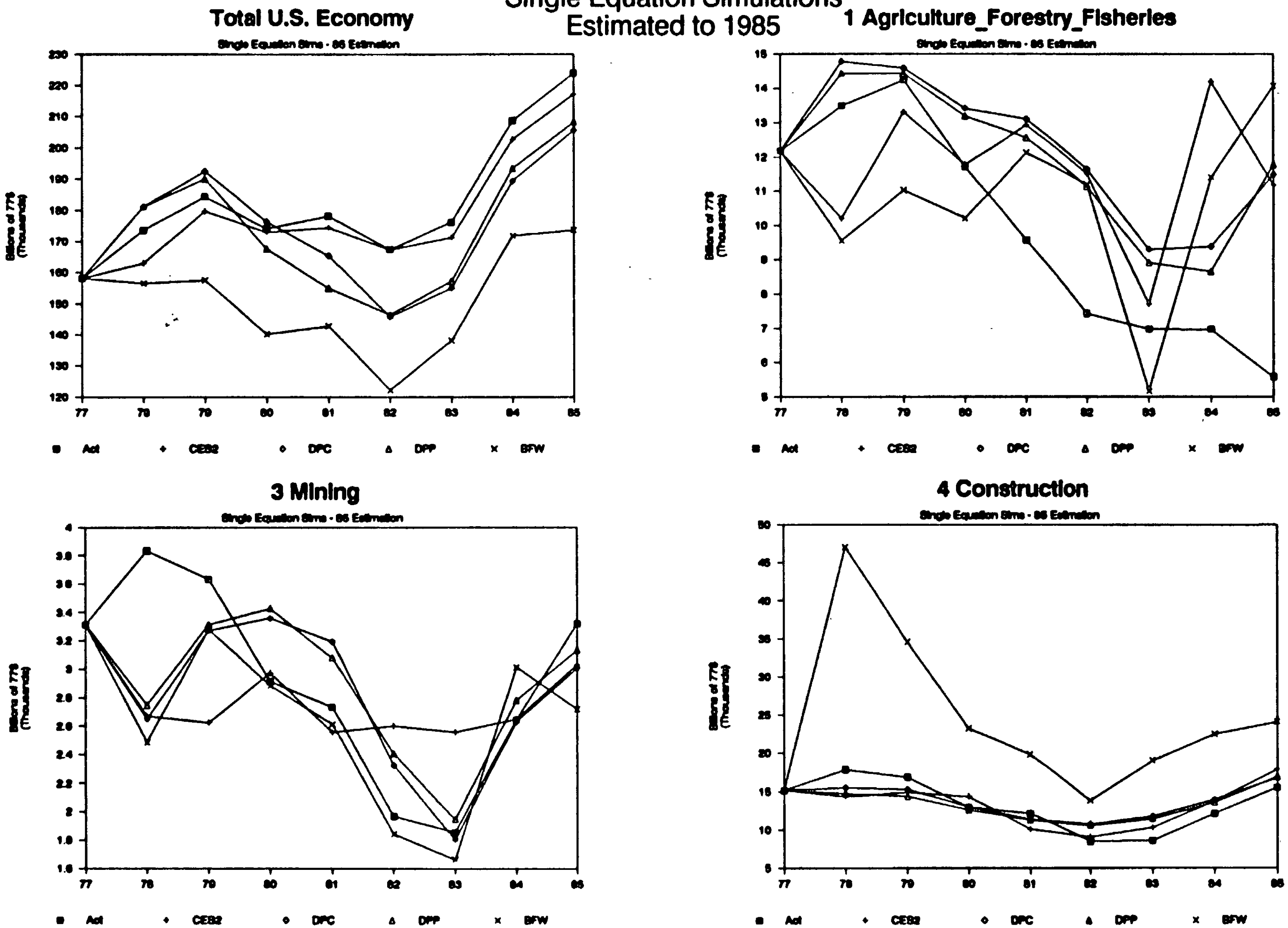


Figure 5.1.e

Single Equation Simulations
Estimated to 1985

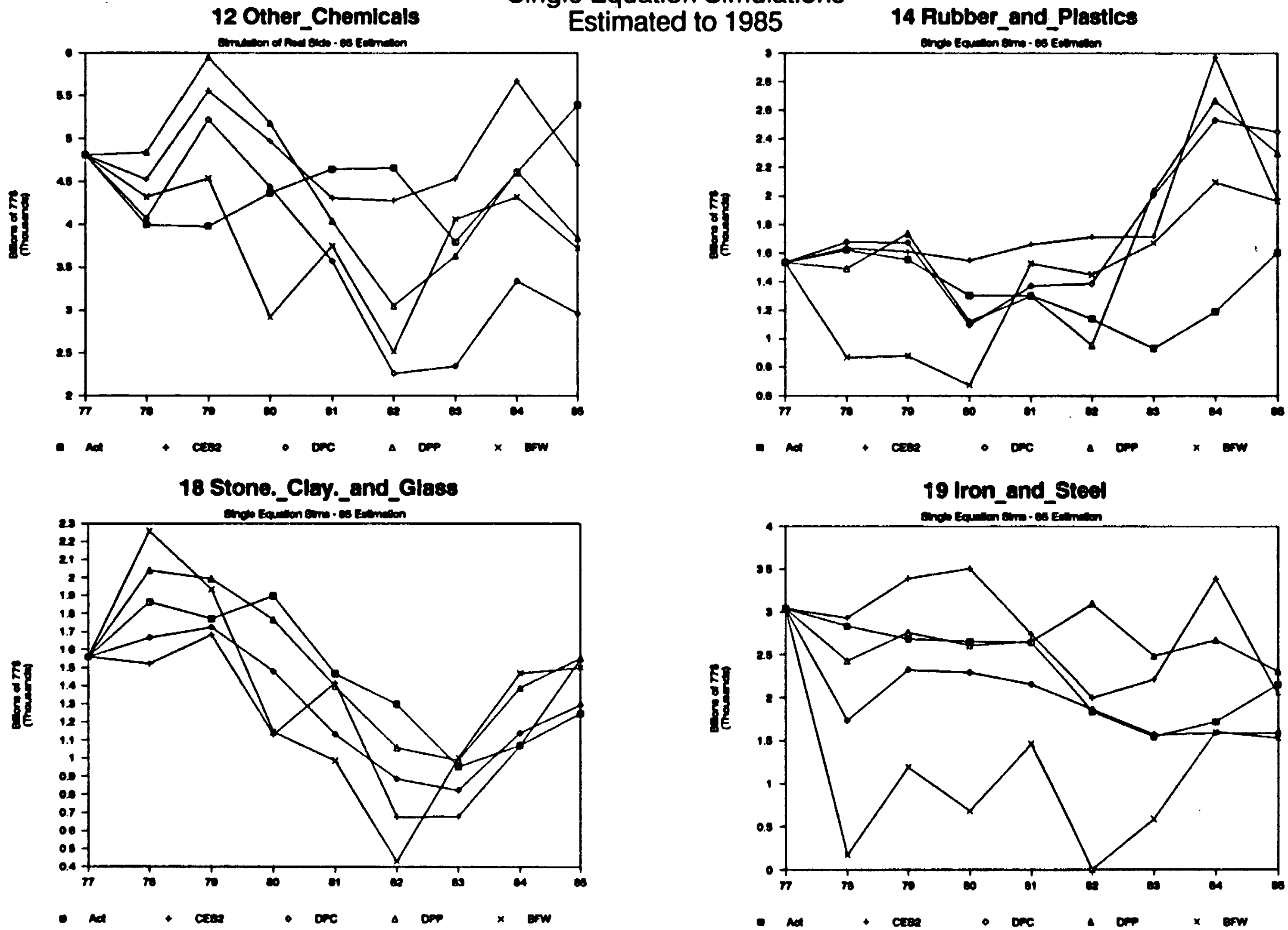


Figure 5.1.f

Single Equation Simulations
Estimated to 1985

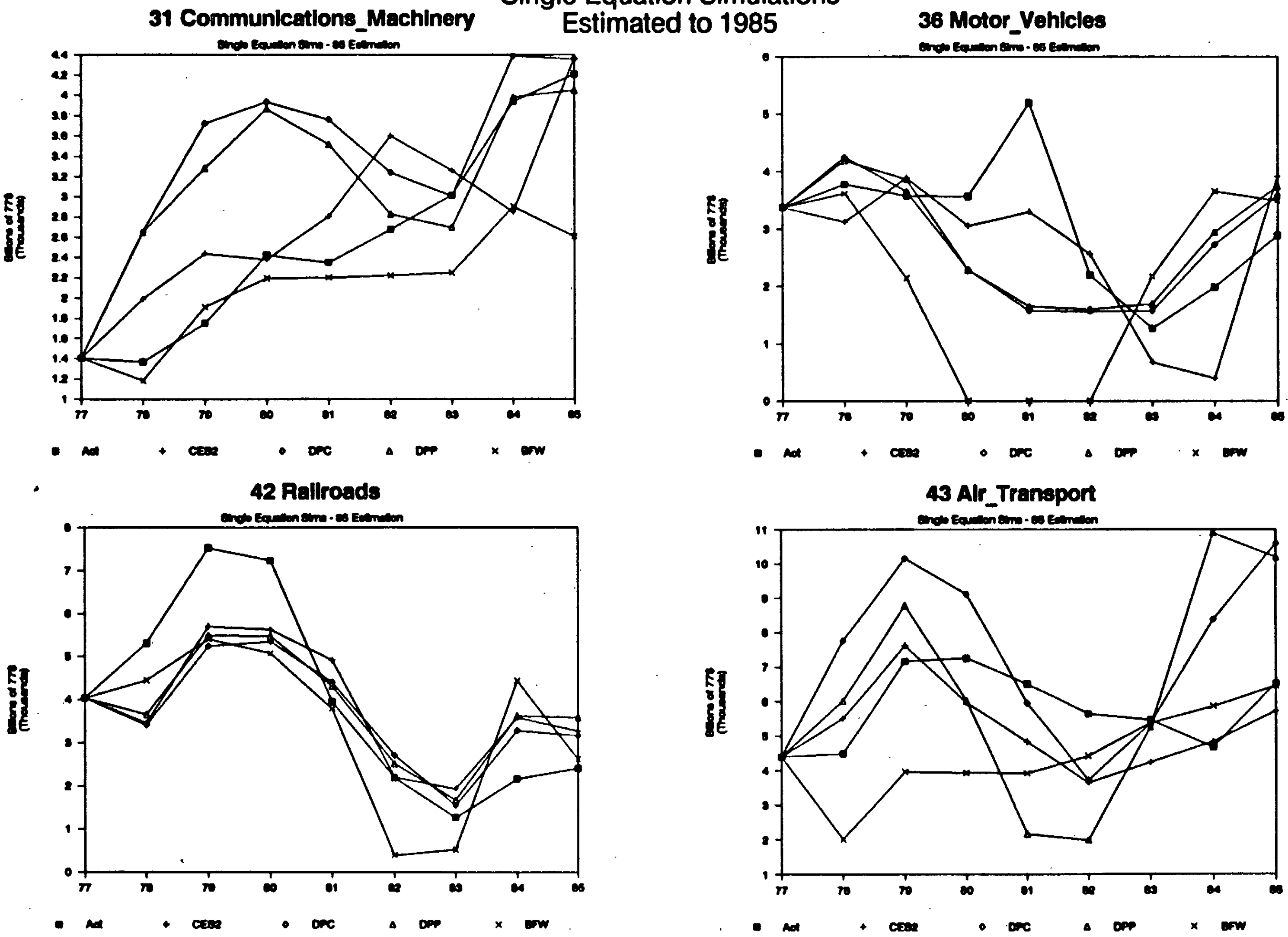


Figure 5.1.8

Single Equation Simulations
Estimated to 1985

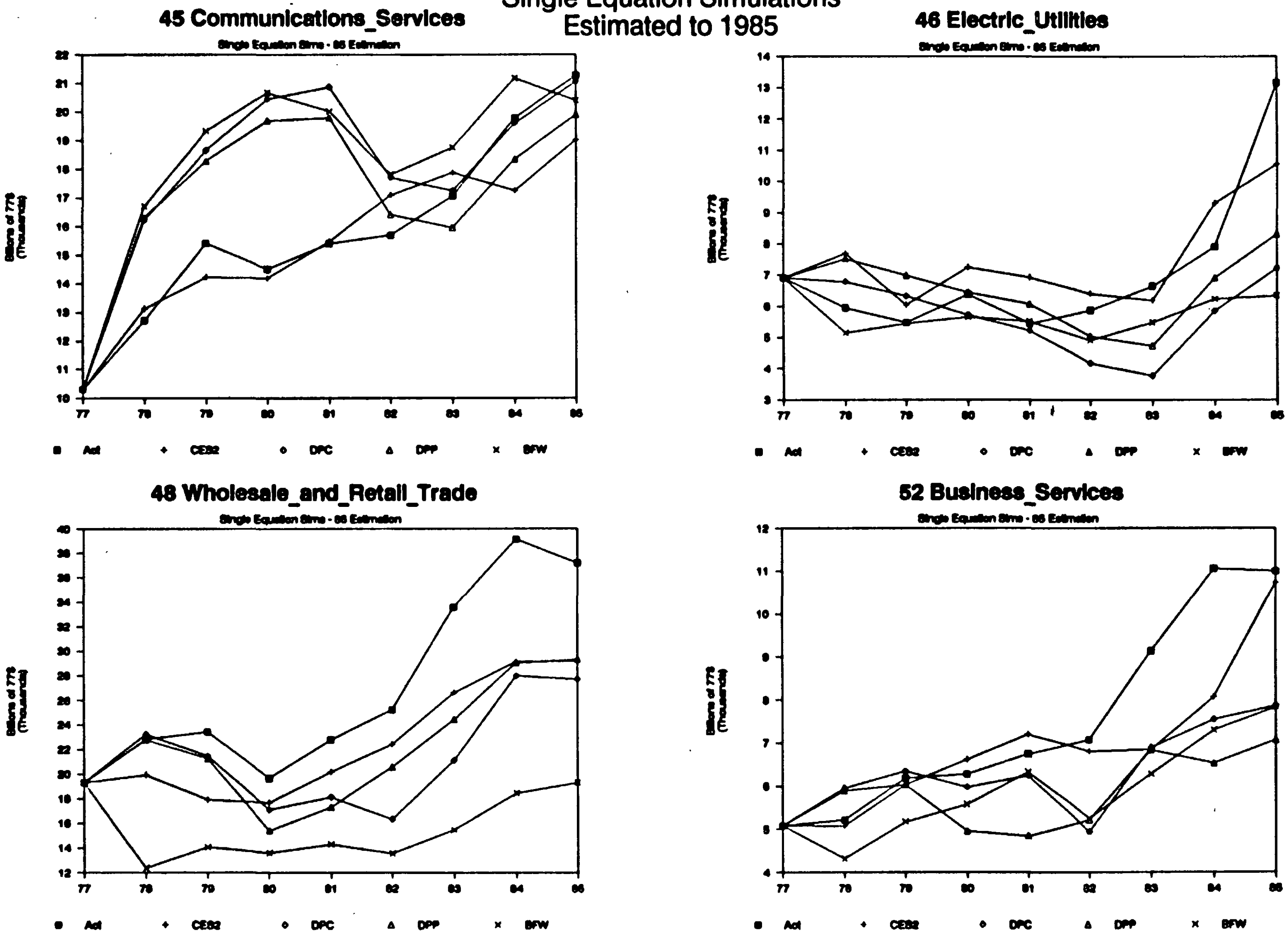


Figure 5.1.h

2.b. Real-Side Simulations

Table 5.2 shows results corresponding to Table 5.1 for the full real-side versions of the within-sample-period simulations (estimated 1953 to 1985, simulated 1978 to 1985). Turning to the last page of this table, it is remarkable how much the results differ from the single-equation forecast. In this set of simulations the Autoregressive Model is a clear winner by wide margin if judged by *RMSE*, *RMS* Percent Error, or *AAPE*. If judged by *MSE* or *MPE*, the Accelerator and the Cobb-Douglas models are also strong contenders, although only the Cobb-Douglas Model comes close to the Autoregressive if judged by total *RMSE*. In this set of simulations, the Dynamic Factor Demand Model does much worse than in the single-equation simulations, and is still the absolute worst in terms of overall fit. Both of the Generalized Leontief Models also suffer from much higher levels of total *RMSE* than in the single-equation simulation. The CES Model I ranks closely to the Generalized Leontief models.

Figures 5.2.a through 5.2.h contain the simulation plots. A quick glance at these plots bears out the same findings as the summary information at the end of Table 5.2: (1) the simulation performance of the full real-side simulation is generally worse than the single-equation simulation, just as one would suspect (since the variables exogenous to the investment equation are no longer equal to their actual values); (2) the Dynamic Factor Demand and the CES Model

I continue to show poor performance and have now been joined by the Generalized Leontief models (see how the performance of these models has deteriorated in Air Transport (43)); and (3) the Autoregressive Model usually provides a safe forecast and is sometimes uncanny in its ability to track the actual series. Of course, the Autoregressive Model does not depend on output, so the forecasts in this section should be the same as in the single equation simulation. The other models are at a disadvantage in this respect, since they all depend on output, which is not equal to its actual historical values in this set of simulations. For some reason, the two Generalized Leontief models seem to differ more in their forecasts in the real-side simulations than in the single-equation simulations.

The summary graphs of the total U.S. economy in Figures 5.2.a and 5.2.e show that in the aggregate, the fits have deteriorated considerably with respect to the single equation simulations, and this fact agrees with the higher totals of *RMSE* shown in Table 5.2 with respect to those in Table 5.1. The Autoregressive model picks up none of the cyclical movement in total investment, but manages to forecast the correct trend, whereas the *GL* and the *CES* models underpredict for most of the period, yet follow the overall pattern of rises and falls faithfully.

2.c. Summary of Within-Sample Simulations

The findings of this section are rather disappointing. Of the eight models tested, the Autoregressive Model emerges as the superior model as judged by the counting comparisons above, in the within-sample simulations, both in the single-equation and the real-side simulations. The models which required the most effort in theoretical specification and estimation (i.e., the Generalized Leontief models and the Dynamic Factor Demand Model) fared the worst. The distinction between the Putty-Putty and the Putty-Clay versions of the Generalized Leontief model appears to be academic, since the forecasts from the two models are very similar for the most part. The Accelerator Model in the single-equation simulation and also the Cobb-Douglas Model in the full real-side simulation were close contenders to the Autoregressive Model in terms of overall closeness of the simulation fits.

Perhaps the strength of the Autoregressive Model can be attributed to the fact that these are within-sample simulations. This model was the closest fitting of all the models, and the within-sample simulations should be close to the fitted values, except to the extent that errors in investment have accumulated over time. Models such as the two CES models, the Generalized Leontief models, and the Dynamic Factor Demand Model are at a disadvantage in this sort of simulation, since they had significantly worse regression fits. However, to the extent that these models contain sensible output and price coefficients, they should perform better in an out-of-sample simulation, where reacting sensibly to the economic environment is more important. The next section examines this hypothesis.

Table 5.2

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 1
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

1 Agriculture

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	2000.9	4206.3	3541.8	3510.4	4425.2	4407.4	4498.5	6039.7
RMS Percent Error	25	0.2274	0.6144	0.4501	0.5328	0.6862	0.6902	0.7029	0.8953
Mean Simulation Error	37	-184.58	1332.04	77.07	786.07	1941.86	1755.90	1728.23	716.90
Mean Percent Error	25	0.0494	0.3006	0.1352	0.2148	0.3651	0.3374	0.3388	0.2918
AAPE	25	0.1988	0.4770	0.3632	0.4013	0.4792	0.5069	0.5154	0.6119
Theil's Inequality Coef	25	0.9084	1.5769	1.5841	1.3151	1.6636	2.2007	2.2617	3.2632

2 Crude Petroleum

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	1217.7	1191.3	767.5	1424.5	1157.1	1683.7	1638.0	1456.8
RMS Percent Error	37	0.2852	0.3413	0.2293	0.3991	0.3852	0.4244	0.4222	0.3522
Mean Simulation Error	29	-854.85	-511.20	-429.11	-1241.11	-422.06	-1180.52	-1145.32	-967.81
Mean Percent Error	29	-0.2218	-0.0704	-0.0920	-0.3743	-0.0397	-0.2965	-0.2869	-0.2387
AAPE	37	0.2218	0.3127	0.2144	0.3743	0.3204	0.3803	0.3745	0.2910
Theil's Inequality Coef	37	0.9547	1.0328	0.6696	1.0562	0.9276	1.1817	1.0924	1.0867

3 Mining

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	486.0	735.5	776.5	867.4	651.1	490.0	499.9	698.0
RMS Percent Error	30	0.1983	0.2264	0.2300	0.2558	0.2329	0.1543	0.1647	0.2219
Mean Simulation Error	25	-89.88	-413.88	-531.86	-651.77	-163.38	-292.27	-131.23	-422.01
Mean Percent Error	29	0.0087	-0.0999	-0.1464	-0.1959	-0.0050	-0.0965	-0.0295	-0.1221
AAPE	30	0.1562	0.1992	0.2120	0.2087	0.1833	0.1341	0.1504	0.1801
Theil's Inequality Coef	30	0.8693	1.1783	1.2541	1.2555	1.2232	0.7524	0.8046	0.9995

4 Construction

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	3512.9	4853.6	3078.0	6119.4	6924.7	3868.2	3486.6	23245.0
RMS Percent Error	31	0.3854	0.3534	0.2575	0.4261	0.5184	0.2783	0.2484	1.5632
Mean Simulation Error	28	2352.31	2962.30	2343.00	1716.99	3921.77	2882.52	2170.22	19548.87
Mean Percent Error	28	0.2496	0.1996	0.1995	0.0699	0.2775	0.2151	0.1581	1.4370
AAPE	37	0.2676	0.3404	0.2317	0.3696	0.4402	0.2449	0.2372	1.4370
Theil's Inequality Coef	25	0.8387	1.7888	0.8788	2.4836	3.3368	1.2714	1.2823	7.2570

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 2
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

5 Food, Tobacco

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	618.5	328.3	325.6	427.9	829.1	354.0	459.7	1023.0
RMS Percent Error	37	0.1748	0.0929	0.0883	0.1213	0.2303	0.0969	0.1297	0.2763
Mean Simulation Error	37	554.51	201.59	83.98	254.68	701.95	142.19	314.95	-910.33
Mean Percent Error	37	0.1554	0.0584	0.0263	0.0730	0.1935	0.0441	0.0906	-0.2445
AAPE	37	0.1557	0.0755	0.0723	0.1060	0.1935	0.0813	0.1072	0.2445
Theil's Inequality Coef	26	0.9595	0.7880	1.1379	1.4870	1.4229	1.0679	1.1242	1.8813

6 Textiles

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	28	127.0	172.4	128.1	106.4	331.6	224.1	375.7	207.6
RMS Percent Error	28	0.1550	0.2069	0.1563	0.1194	0.3902	0.2596	0.4341	0.2445
Mean Simulation Error	35	87.06	156.62	110.01	34.31	317.02	92.78	318.31	19.13
Mean Percent Error	35	0.1092	0.1847	0.1314	0.0484	0.3676	0.1065	0.3655	0.0228
AAPE	28	0.1360	0.1847	0.1314	0.1082	0.3676	0.2166	0.3655	0.1966
Theil's Inequality Coef	37	0.9458	1.0839	0.8834	1.0370	1.3946	2.4500	2.8917	2.4949

7 Knitting, Hosiery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	29	36.5	46.7	60.3	57.1	33.4	59.6	46.4	42.5
RMS Percent Error	25	0.1841	0.3298	0.3903	0.3227	0.2172	0.3189	0.3033	0.2825
Mean Simulation Error	31	-17.66	6.42	11.50	-38.64	5.79	-42.89	1.68	2.00
Mean Percent Error	35	-0.0665	0.0801	0.1377	-0.2007	0.0695	-0.2102	0.0522	0.0298
AAPE	25	0.1589	0.2416	0.3382	0.2831	0.1740	0.2961	0.2417	0.2178
Theil's Inequality Coef	25	0.9958	1.8979	1.2088	1.8777	1.0118	1.6262	1.4304	1.8587

8 Apparel

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	121.4	233.6	184.2	335.3	346.7	212.4	326.6	172.7
RMS Percent Error	25	0.3876	0.7307	0.5676	1.0280	1.0627	0.6799	1.0215	0.5451
Mean Simulation Error	25	107.36	218.29	181.98	319.95	335.28	193.84	317.62	108.99
Mean Percent Error	25	0.3380	0.6734	0.5523	0.9728	1.0157	0.6040	0.9729	0.3386
AAPE	25	0.3380	0.6734	0.5523	0.9728	1.0157	0.6040	0.9729	0.4038
Theil's Inequality Coef	25	0.7797	1.7024	0.8622	2.2557	1.8698	1.6368	1.8118	1.7419

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 3
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

9 Paper

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	29	432.1	354.9	300.9	721.9	280.5	396.1	478.4	1032.3
RMS Percent Error	37	0.1398	0.0924	0.0872	0.2283	0.0880	0.1200	0.1484	0.3059
Mean Simulation Error	29	148.76	-170.27	-114.17	-385.20	69.96	-244.27	-255.23	-855.24
Mean Percent Error	29	0.0603	-0.0428	-0.0284	-0.1215	0.0261	-0.0736	-0.0782	-0.2557
AAPE	26	0.1107	0.0676	0.0797	0.1898	0.0748	0.1032	0.1306	0.2668
Theil's Inequality Coef	37	0.9300	0.8644	0.6734	1.7598	0.7599	0.9636	1.1526	1.5721

10 Printing

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	172.3	213.6	217.7	231.8	184.5	225.9	239.3	302.7
RMS Percent Error	29	0.0807	0.0825	0.0881	0.1211	0.0784	0.1172	0.1138	0.1541
Mean Simulation Error	29	63.23	-106.02	-135.44	-106.21	-18.67	110.75	-27.49	-47.87
Mean Percent Error	29	0.0363	-0.0427	-0.0600	-0.0524	-0.0003	0.0636	-0.0044	-0.0185
AAPE	26	0.0661	0.0622	0.0718	0.0897	0.0626	0.1016	0.1022	0.1302
Theil's Inequality Coef	25	0.7387	0.8229	0.8450	1.4232	0.8828	1.0799	1.2135	1.5565

11 Agri. Fertilizers

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	221.6	359.2	445.9	632.3	646.8	331.3	290.7	311.4
RMS Percent Error	25	0.8209	1.2246	1.8191	2.3631	2.5388	1.2507	0.9786	0.9152
Mean Simulation Error	35	176.83	66.67	232.69	179.42	313.35	164.82	46.91	-39.90
Mean Percent Error	35	0.6258	0.5471	1.0804	1.1186	1.4651	0.7447	0.3916	0.2226
AAPE	31	0.6735	0.9671	1.2177	1.6868	1.7004	0.8773	0.6688	0.7686
Theil's Inequality Coef	25	0.8315	1.5916	1.1141	2.0283	1.7757	1.0832	1.1970	1.3815

12 Other Chemicals

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	26	744.3	518.6	559.1	1136.3	808.3	1555.0	1223.3	1146.7
RMS Percent Error	26	0.1858	0.1267	0.1360	0.2554	0.1943	0.3428	0.2784	0.2556
Mean Simulation Error	31	617.00	221.27	337.38	-463.16	433.44	-948.79	-20.69	-662.15
Mean Percent Error	31	0.1506	0.0591	0.0842	-0.0925	0.1088	-0.2030	0.0099	-0.1401
AAPE	26	0.1576	0.1044	0.1072	0.2077	0.1651	0.2855	0.2182	0.2036
Theil's Inequality Coef	25	1.0003	1.0504	1.0195	1.9320	1.4611	1.8506	2.1552	1.8523

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 4
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

13 Petroleum Refining

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	29	454.2	349.0	358.9	955.5	298.1	1107.9	1058.1	1148.0
RMS Percent Error	29	0.2035	0.1508	0.2188	0.4245	0.1324	0.5036	0.5248	0.5187
Mean Simulation Error	29	-291.01	-306.31	206.05	-740.94	-166.47	-732.70	-640.80	-1090.19
Mean Percent Error	29	-0.1037	-0.1395	0.1265	-0.3231	-0.0674	-0.2670	-0.2196	-0.5134
AAPE	29	0.1782	0.1395	0.1495	0.3752	0.1184	0.4622	0.4992	0.5134
Theil's Inequality Coef	26	0.9578	0.3422	1.0995	1.5476	0.7386	1.4030	1.5248	0.9648

14 Rubber & Plastics

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	254.9	316.5	397.9	456.2	670.7	588.9	667.1	628.9
RMS Percent Error	25	0.2402	0.3012	0.3759	0.4217	0.5935	0.5107	0.5863	0.5024
Mean Simulation Error	35	85.64	106.84	261.05	201.47	478.88	315.06	268.55	-21.42
Mean Percent Error	35	0.1002	0.1203	0.2364	0.1967	0.4139	0.2659	0.2359	0.0450
AAPE	25	0.1778	0.2205	0.2483	0.3170	0.4251	0.4031	0.4459	0.4453
Theil's Inequality Coef	25	1.0331	1.1743	1.0442	1.4866	1.9081	1.9424	2.5680	2.0160

15 Footwear & Leather

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	35.7	81.3	41.5	67.1	86.1	69.8	89.5	68.7
RMS Percent Error	25	0.5240	1.0596	0.5812	0.8574	0.9892	0.8644	1.0996	0.8827
Mean Simulation Error	26	32.53	10.76	39.59	20.83	43.41	43.82	60.61	-12.55
Mean Percent Error	26	0.4528	0.0709	0.5350	0.2094	0.4790	0.5392	0.7489	-0.1942
AAPE	25	0.4528	0.9574	0.5350	0.7539	0.8062	0.5941	0.7569	0.7943
Theil's Inequality Coef	25	1.0583	3.3123	1.3848	2.8375	3.5556	3.2702	4.3337	3.4914

16 Lumber

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	267.0	653.4	495.3	1192.5	839.2	526.8	600.8	968.2
RMS Percent Error	25	0.3512	0.7029	0.5786	1.2549	0.9283	0.5658	0.6580	0.9840
Mean Simulation Error	35	115.30	87.96	237.53	124.36	289.73	153.17	255.45	79.97
Mean Percent Error	26	0.1892	0.1635	0.3157	0.1981	0.3840	0.2031	0.3154	0.2200
AAPE	25	0.2773	0.5482	0.3980	0.8803	0.6460	0.3784	0.4002	0.7233
Theil's Inequality Coef	25	0.9833	2.8567	1.4935	5.9232	3.0164	2.3099	2.4465	4.4882

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 5
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

17 Furniture

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	30	64.5	51.4	52.8	51.6	60.9	44.5	62.3	94.3
RMS Percent Error	30	0.2299	0.1815	0.1891	0.1846	0.2208	0.1552	0.2224	0.2930
Mean Simulation Error	28	42.64	21.26	22.31	2.60	43.65	15.49	25.74	-39.34
Mean Percent Error	28	0.1587	0.0889	0.0923	0.0253	0.1591	0.0504	0.0850	-0.0993
AAPE	30	0.1943	0.1356	0.1448	0.1348	0.1782	0.1081	0.1678	0.2437
Theil's Inequality Coef	29	1.0067	1.0341	1.0592	1.3746	0.8933	1.3714	1.7196	2.0756

18 Stone,Clay & Glass

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	31	304.2	345.3	316.8	609.2	498.3	353.1	282.6	579.3
RMS Percent Error	31	0.2687	0.2725	0.2750	0.4267	0.3173	0.2318	0.2222	0.3673
Mean Simulation Error	26	85.61	16.08	89.99	-434.82	-277.12	-250.25	80.13	-204.23
Mean Percent Error	26	0.1145	0.0513	0.1090	-0.2969	-0.1638	-0.1624	0.0793	-0.1077
AAPE	31	0.2094	0.2422	0.2111	0.3654	0.2674	0.1961	0.1879	0.3265
Theil's Inequality Coef	37	0.9543	1.1946	0.7870	1.8042	1.8105	0.8884	0.9141	1.9930

19 Iron & Steel

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	26	547.6	402.2	510.8	474.4	820.8	426.4	594.3	1536.3
RMS Percent Error	30	0.3258	0.2167	0.2953	0.2582	0.4481	0.1685	0.3492	0.6082
Mean Simulation Error	28	341.41	173.62	275.19	108.87	640.51	-352.52	347.72	-1209.62
Mean Percent Error	28	0.2036	0.1124	0.1706	0.0927	0.3248	-0.1418	0.2093	-0.4915
AAPE	30	0.2238	0.1818	0.2246	0.2027	0.3248	0.1486	0.2378	0.5169
Theil's Inequality Coef	25	0.9392	0.9614	1.2935	1.6291	1.9689	1.0374	1.3810	2.7356

20 Non-Ferrous Metals

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	128.7	166.5	213.3	290.1	298.4	306.9	189.0	250.5
RMS Percent Error	25	0.1210	0.1488	0.2039	0.2449	0.2702	0.2677	0.1678	0.2042
Mean Simulation Error	25	17.56	95.28	137.13	-157.54	214.08	-245.81	36.45	-129.12
Mean Percent Error	25	0.0270	0.0889	0.1309	-0.1385	0.1955	-0.2133	0.0280	-0.0951
AAPE	25	0.1065	0.1355	0.1699	0.2087	0.2265	0.2179	0.1297	0.1916
Theil's Inequality Coef	25	0.9390	1.0043	1.0712	1.5166	1.5195	1.2198	1.2010	1.1592

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 6
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

21 Metal Products

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	323.3	423.2	392.8	578.4	458.6	624.0	654.7	753.1
RMS Percent Error	25	0.2014	0.2299	0.2287	0.2677	0.2457	0.3008	0.3374	0.3607
Mean Simulation Error	30	128.98	136.59	134.15	-74.04	158.48	52.01	184.90	-133.94
Mean Percent Error	28	0.0909	0.0957	0.0978	-0.0107	0.1030	0.0483	0.1201	-0.0229
AAPE	25	0.1397	0.1900	0.1792	0.2458	0.2054	0.2713	0.2854	0.3076
Theil's Inequality Coef	25	0.9968	1.3283	1.2010	1.9721	1.4765	1.8228	1.7729	1.9671

22 Engines & Turbines

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	55.6	61.0	69.5	131.5	66.3	140.7	112.3	76.2
RMS Percent Error	25	0.1721	0.2010	0.2470	0.3590	0.2359	0.3906	0.3386	0.2071
Mean Simulation Error	25	-13.56	14.12	43.20	-111.59	30.68	-93.28	-36.74	-46.78
Mean Percent Error	25	-0.0105	0.0720	0.1609	-0.3170	0.1261	-0.2383	-0.0628	-0.1150
AAPE	25	0.1492	0.1759	0.2125	0.3170	0.2040	0.3335	0.2700	0.1753
Theil's Inequality Coef	26	1.0228	0.9518	1.1200	0.9609	1.0569	1.3055	1.4299	1.1176

23 Agri. Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	58.7	85.3	106.2	76.0	73.8	100.1	97.2	131.2
RMS Percent Error	28	0.4191	0.5902	0.7554	0.3475	0.5259	0.4200	0.6012	0.7957
Mean Simulation Error	31	18.36	17.94	34.13	-30.84	27.91	-38.42	-0.80	15.06
Mean Percent Error	28	0.2003	0.2512	0.3667	-0.0481	0.2701	-0.0607	0.1747	0.2255
AAPE	25	0.3052	0.4608	0.5674	0.3320	0.4035	0.3670	0.4874	0.6003
Theil's Inequality Coef	29	0.9790	1.2139	1.5190	1.0044	0.9233	1.5374	1.4417	2.1091

25 Metalworking Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	26	70.8	61.4	77.4	109.1	76.1	235.3	256.7	84.8
RMS Percent Error	26	0.2163	0.1482	0.2295	0.2332	0.1945	0.5866	0.6314	0.2498
Mean Simulation Error	30	11.95	-9.71	23.74	-74.44	61.74	8.13	87.37	27.19
Mean Percent Error	26	0.0617	-0.0118	0.0926	-0.1657	0.1603	-0.0233	0.1955	0.1065
AAPE	26	0.1654	0.1099	0.1765	0.1793	0.1716	0.5591	0.4800	0.2160
Theil's Inequality Coef	25	0.9824	1.5352	1.4413	1.4503	1.0804	2.8382	3.5606	1.2322

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 7
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

27 Special Industry Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	28	39.5	33.9	43.3	29.3	44.5	109.8	96.8	61.2
RMS Percent Error	28	0.2425	0.2088	0.2596	0.1705	0.2594	0.5306	0.5434	0.3717
Mean Simulation Error	28	26.78	19.56	33.22	-0.80	36.14	-85.23	-5.04	34.36
Mean Percent Error	28	0.1577	0.1187	0.1875	0.0180	0.1991	-0.4069	0.0280	0.2091
AAPE	28	0.1762	0.1497	0.1948	0.1304	0.2076	0.4069	0.4498	0.2699
Theil's Inequality Coef	25	0.9358	1.1970	1.1207	1.1668	1.1773	3.4298	4.6321	1.7803

28 Misc.nonelec. Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	209.2	221.5	259.2	405.3	249.1	554.7	374.4	1402.5
RMS Percent Error	26	0.1518	0.1345	0.1823	0.2418	0.1513	0.3676	0.2400	0.9554
Mean Simulation Error	25	-6.48	-82.32	55.86	-320.06	-82.59	-434.10	-199.60	410.38
Mean Percent Error	25	0.0144	-0.0415	0.0553	-0.1919	-0.0445	-0.2882	-0.1291	0.3028
AAPE	26	0.1166	0.1013	0.1392	0.2139	0.1230	0.3061	0.2129	0.5885
Theil's Inequality Coef	25	1.0293	1.2036	1.2061	1.1684	1.4650	1.1421	1.2626	7.8191

29 Computers & Other

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	341.5	850.8	217.6	713.4	549.1	826.3	963.2	1207.7
RMS Percent Error	37	0.1749	0.3714	0.1320	0.3568	0.2509	0.5328	0.5844	0.6303
Mean Simulation Error	37	-296.75	-622.39	65.56	-581.37	-427.05	-233.91	-336.97	-1034.47
Mean Percent Error	30	-0.1689	-0.3102	0.0477	-0.3260	-0.2231	0.0056	-0.0803	-0.6020
AAPE	37	0.1689	0.3102	0.1121	0.3260	0.2231	0.4507	0.4932	0.6020
Theil's Inequality Coef	25	0.4376	1.4528	0.8874	1.5819	0.7413	2.5876	3.5351	2.0922

30 Service Industry Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	29.0	44.4	44.9	74.3	45.4	147.0	106.9	56.5
RMS Percent Error	25	0.1256	0.1817	0.1999	0.2991	0.1915	0.6311	0.4610	0.2485
Mean Simulation Error	25	4.12	7.78	28.25	-66.71	21.53	-85.79	-35.15	-14.00
Mean Percent Error	25	0.0282	0.0409	0.1303	-0.2737	0.0979	-0.3670	-0.1589	-0.0496
AAPE	25	0.1057	0.1572	0.1700	0.2737	0.1696	0.5492	0.4067	0.2131
Theil's Inequality Coef	37	1.2357	1.8232	1.1215	1.2456	1.5989	3.3034	3.2913	1.6878

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 8
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

31 Communications Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	692.9	1024.4	363.9	1384.1	478.5	1547.7	1377.3	1363.7
RMS Percent Error	37	0.2025	0.2872	0.1998	0.4094	0.2337	0.6844	0.6080	0.3810
Mean Simulation Error	29	-533.65	-479.12	162.20	-1080.25	133.82	-290.77	-393.94	-1061.05
Mean Percent Error	31	-0.1596	-0.0912	0.1099	-0.3475	0.1077	0.0930	0.0220	-0.3385
AAPE	37	0.1856	0.2217	0.1515	0.3519	0.1757	0.5840	0.5186	0.3385
Theil's Inequality Coef	25	0.6955	1.8881	0.7846	2.0113	1.2857	2.0248	2.0953	1.4634

32 Heavy Electrical Machinery

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	96.2	111.5	81.1	207.8	125.0	313.1	226.4	248.8
RMS Percent Error	37	0.1455	0.1741	0.1402	0.3077	0.2128	0.4656	0.3769	0.3615
Mean Simulation Error	37	-39.68	-34.38	2.90	-173.49	-18.71	-216.78	-94.54	-193.49
Mean Percent Error	29	-0.0387	-0.0268	0.0269	-0.2633	0.0079	-0.2979	-0.0942	-0.2850
AAPE	37	0.1295	0.1463	0.1198	0.2633	0.1851	0.4250	0.3437	0.3125
Theil's Inequality Coef	25	0.8947	0.9775	1.0873	1.4031	1.3228	1.5319	1.7929	1.8905

33 Household Appliances

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	28	24.5	30.9	28.6	23.6	44.1	97.6	89.0	28.7
RMS Percent Error	25	0.1458	0.2078	0.1835	0.1503	0.2958	0.5683	0.5832	0.1755
Mean Simulation Error	25	7.64	15.54	23.97	14.31	32.86	-83.26	-56.71	-21.03
Mean Percent Error	25	0.0628	0.1096	0.1512	0.0975	0.2137	-0.4806	-0.3680	-0.1241
AAPE	28	0.1325	0.1523	0.1513	0.1307	0.2172	0.4806	0.4214	0.1485
Theil's Inequality Coef	37	1.0164	1.4082	1.0137	1.0698	1.6971	2.3592	3.7135	1.6085

34 Elec. Lighting & Wiring Equip

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	55.0	63.8	95.2	121.1	80.5	113.4	114.5	103.3
RMS Percent Error	25	0.1188	0.1299	0.2010	0.2354	0.1702	0.2275	0.2283	0.2118
Mean Simulation Error	30	22.43	28.27	82.07	-100.15	51.33	16.71	27.64	-49.40
Mean Percent Error	30	0.0542	0.0590	0.1688	-0.1910	0.1084	0.0292	0.0512	-0.0973
AAPE	25	0.0906	0.1109	0.1743	0.2193	0.1427	0.1880	0.2106	0.1702
Theil's Inequality Coef	25	1.0752	1.3752	1.3898	1.6318	1.5861	2.0694	2.1139	1.5950

Table 5.2 (continued)

Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

35 Radio,T.V. Receiving, Phono

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	25.9	66.4	33.9	65.0	43.8	53.7	53.9	35.2
RMS Percent Error	25	0.1604	0.3701	0.2496	0.3852	0.3346	0.3595	0.3563	0.2187
Mean Simulation Error	37	-15.93	-19.55	10.83	-40.50	34.80	17.74	17.05	-19.33
Mean Percent Error	26	-0.0899	-0.0837	0.1012	-0.2532	0.2568	0.1579	0.1498	-0.1062
AAPE	25	0.1403	0.2457	0.1784	0.2532	0.2618	0.3177	0.3098	0.1978
Theil's Inequality Coef	25	1.0093	2.1099	1.7771	3.5732	1.8119	2.0313	1.9660	1.4597

36 Motor Vehicles

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	29	1198.1	1099.6	1225.8	2204.2	880.7	1571.4	1633.4	2631.9
RMS Percent Error	29	0.4573	0.4371	0.5244	1.1610	0.2584	0.4728	0.5074	0.8643
Mean Simulation Error	26	-413.82	-124.44	-212.24	1467.05	-284.25	183.91	204.15	-732.71
Mean Percent Error	25	0.0205	0.1059	0.1100	0.7853	-0.0720	0.1747	0.1900	0.0242
AAPE	29	0.3643	0.3347	0.4004	0.8913	0.2134	0.4200	0.4520	0.7555
Theil's Inequality Coef	29	0.9969	0.9674	1.0707	1.7951	0.8872	1.3295	1.3573	1.6937

37 Aerospace

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	380.3	257.8	145.8	530.8	179.2	337.7	267.1	441.1
RMS Percent Error	37	0.3422	0.3148	0.2512	0.4638	0.2966	0.3050	0.2576	0.4921
Mean Simulation Error	37	-305.81	-105.92	-16.43	-427.13	99.45	-230.93	-155.87	-314.09
Mean Percent Error	26	-0.2468	-0.0260	0.0363	-0.3671	0.1509	-0.1806	-0.1094	-0.2095
AAPE	37	0.3280	0.2670	0.1637	0.4129	0.1853	0.2734	0.2287	0.4451
Theil's Inequality Coef	25	0.9120	1.2884	0.9902	1.6927	1.1357	1.2692	1.2697	1.5183

38 Ships & Boats

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	30	41.8	77.5	130.5	152.7	125.8	34.8	43.2	91.3
RMS Percent Error	30	0.2471	0.4086	0.6576	0.7802	0.6051	0.1962	0.2376	0.4903
Mean Simulation Error	31	23.15	13.66	89.41	65.05	75.63	11.95	-5.57	-31.22
Mean Percent Error	31	0.1487	0.0834	0.4532	0.3204	0.3783	0.0714	-0.0193	-0.1588
AAPE	30	0.1911	0.3133	0.4985	0.6697	0.4654	0.1516	0.2104	0.3564
Theil's Inequality Coef	30	1.0643	2.3441	1.6654	4.0630	1.8958	0.9070	1.0872	2.2527

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 10
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

39 Other Trans. Equip.

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	26	68.0	37.3	52.7	67.9	86.2	61.7	52.3	87.2
RMS Percent Error	26	0.4543	0.2111	0.3409	0.3551	0.4975	0.3227	0.2853	0.4474
Mean Simulation Error	26	56.82	-10.29	26.16	-59.09	48.71	-54.14	-36.96	-49.87
Mean Percent Error	26	0.3586	-0.0320	0.1766	-0.3199	0.2835	-0.2855	-0.1844	-0.2309
AAPE	26	0.3586	0.1652	0.2802	0.3199	0.4099	0.3045	0.2736	0.3439
Theil's Inequality Coef	25	0.9590	1.1418	1.0891	1.2309	1.2873	1.3604	1.4772	2.5138

40 Instruments

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	136.8	199.5	197.7	212.8	179.1	378.1	315.0	419.7
RMS Percent Error	25	0.1628	0.2176	0.2347	0.3016	0.2584	0.5132	0.4115	0.4299
Mean Simulation Error	25	5.41	-8.95	14.64	35.81	80.81	-70.59	-104.92	-346.62
Mean Percent Error	30	0.0442	0.0414	0.0689	0.0854	0.1394	0.0255	-0.0465	-0.3661
AAPE	25	0.1359	0.1716	0.1799	0.2030	0.1967	0.4147	0.3032	0.3661
Theil's Inequality Coef	25	0.8907	1.1725	1.3202	1.9744	1.2797	2.1242	2.2634	1.8865

41 Miscellaneous Manufacturing

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	28	83.1	82.0	79.7	73.6	121.8	104.3	155.0	99.5
RMS Percent Error	28	0.2711	0.2688	0.2550	0.2345	0.3871	0.3155	0.4873	0.3311
Mean Simulation Error	28	69.69	72.31	66.66	20.87	113.76	38.07	117.55	51.18
Mean Percent Error	28	0.2202	0.2255	0.2088	0.0785	0.3474	0.1219	0.3581	0.1721
AAPE	28	0.2319	0.2255	0.2140	0.1897	0.3474	0.2576	0.3773	0.2349
Theil's Inequality Coef	37	0.8215	0.8220	0.7757	1.3442	1.1286	2.1655	2.5370	1.8333

42 Railroads

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	2105.7	2330.7	2479.7	3922.3	2287.7	2719.5	2726.2	3045.5
RMS Percent Error	26	0.6212	0.4913	0.7092	0.7792	0.5381	0.5681	0.6686	0.6975
Mean Simulation Error	25	-637.28	-1105.19	-855.35	-3001.58	-1023.67	-1461.25	-1080.84	-1915.48
Mean Percent Error	31	0.1421	-0.0675	0.1332	-0.6463	-0.0464	-0.1867	-0.0195	-0.3738
AAPE	26	0.5038	0.4503	0.5975	0.7144	0.5064	0.5322	0.6009	0.6736
Theil's Inequality Coef	29	0.9657	0.8948	1.0513	1.3031	0.8442	0.9994	0.9820	1.0771

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 11
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

43 Air Transport

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	28	1339.4	6731.7	1279.1	1253.5	4112.3	4624.5	4389.6	3762.8
RMS Percent Error	28	0.2015	1.2133	0.1896	0.1887	0.7160	0.8277	0.7362	0.6334
Mean Simulation Error	37	-966.87	-5078.78	-717.79	-718.79	-3372.69	-2729.39	-3207.85	-3701.43
Mean Percent Error	37	-0.1391	-0.8889	-0.0947	-0.0950	-0.5722	-0.4722	-0.5296	-0.6259
AAPE	37	0.1865	0.9521	0.1632	0.1655	0.6207	0.7177	0.6685	0.6259
Theil's Inequality Coef	25	0.9091	2.2232	0.9387	1.0083	1.1028	1.6581	1.9589	1.0179

44 Trucking & Other Transport

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	1241.9	3075.7	1652.2	4732.8	2124.3	2930.1	3044.0	6577.3
RMS Percent Error	25	0.1425	0.3935	0.2090	0.5727	0.2722	0.3567	0.3793	0.7896
Mean Simulation Error	37	-759.75	-2743.63	297.51	-3650.58	-1563.50	-2613.15	-2751.03	-6358.98
Mean Percent Error	37	-0.0824	-0.3448	0.0460	-0.4417	-0.1953	-0.3233	-0.3434	-0.7735
AAPE	25	0.1204	0.3448	0.1723	0.5195	0.2621	0.3233	0.3434	0.7735
Theil's Inequality Coef	25	1.0340	1.2439	1.0367	2.7365	1.2841	1.1308	1.0369	2.6796

45 Communications Services

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	29	2162.2	2137.9	2350.6	3347.0	1262.8	3620.3	3618.2	3225.8
RMS Percent Error	29	0.1214	0.1173	0.1330	0.1806	0.0645	0.2251	0.2216	0.2149
Mean Simulation Error	30	-1963.11	-1827.47	-2082.24	-2649.03	-417.83	-358.18	-891.65	612.37
Mean Percent Error	30	-0.1149	-0.1047	-0.1230	-0.1509	-0.0179	0.0097	-0.0242	0.0671
AAPE	29	0.1149	0.1047	0.1230	0.1509	0.0530	0.1882	0.1957	0.1746
Theil's Inequality Coef	25	0.5811	0.6505	0.8005	1.5616	0.6231	1.6094	1.6036	1.6776

46 Electric Utilities

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	29	3193.5	1814.2	1967.0	1727.4	1639.9	2733.8	2088.4	2465.6
RMS Percent Error	26	0.4942	0.1737	0.2210	0.2179	0.1852	0.3013	0.2142	0.2355
Mean Simulation Error	37	2787.61	-270.44	203.49	467.02	236.80	-1921.79	-972.49	-1718.00
Mean Percent Error	26	0.4287	0.0108	0.0893	0.1224	0.0784	-0.2345	-0.0946	-0.2035
AAPE	26	0.4287	0.1354	0.1820	0.1932	0.1565	0.2728	0.1959	0.2035
Theil's Inequality Coef	30	0.7406	0.9696	0.9969	0.7977	0.9790	0.7328	0.8150	0.7924

Table 5.2 (continued)

Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

47 Gas,water & Sanitation

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	1120.3	1277.4	1629.9	2622.5	1214.6	1974.9	1908.1	2404.0
RMS Percent Error	25	0.2510	0.2882	0.3908	0.6388	0.2984	0.4810	0.4553	0.5845
Mean Simulation Error	29	-803.09	-942.73	-1200.55	-2446.33	-764.82	-1872.23	-1778.41	-2285.40
Mean Percent Error	29	-0.1760	-0.2154	-0.2690	-0.6130	-0.1622	-0.4740	-0.4460	-0.5761
AAPE	25	0.2267	0.2409	0.3646	0.6130	0.2644	0.4740	0.4460	0.5761
Theil's Inequality Coef	25	0.9792	1.3187	1.7977	1.7836	1.5842	1.2426	1.2884	1.3625

48 Wholesale & Retail trade

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	3496.4	6380.3	5020.5	8839.7	6411.3	8575.1	10008.7	14423.9
RMS Percent Error	25	0.1235	0.1918	0.1947	0.3057	0.1945	0.2854	0.3733	0.4816
Mean Simulation Error	25	-916.80	-5280.54	3801.41	-8057.40	-5123.21	-7647.77	-8882.95	-13667.30
Mean Percent Error	25	-0.0145	-0.1729	0.1421	-0.2895	-0.1669	-0.2654	-0.3244	-0.4792
AAPE	25	0.1173	0.1729	0.1578	0.2895	0.1677	0.2654	0.3244	0.4792
Theil's Inequality Coef	26	0.8996	0.8446	0.8597	1.3149	0.9082	0.8585	1.3146	1.2300

49 Finance, Insurance & Services

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	829.1	1840.1	1369.9	2492.9	1427.6	1803.7	2083.4	7542.1
RMS Percent Error	25	0.1123	0.1608	0.2064	0.2468	0.1264	0.1790	0.2121	0.9690
Mean Simulation Error	25	456.97	-1023.30	1204.01	-1835.01	-628.46	-711.72	-1080.64	-7245.89
Mean Percent Error	30	0.0526	-0.0934	0.1835	-0.2059	-0.0500	-0.0430	-0.0899	-0.9681
AAPE	25	0.0934	0.1231	0.1835	0.2059	0.0956	0.1467	0.1884	0.9681
Theil's Inequality Coef	25	0.3871	0.7295	0.5942	0.9568	0.8123	0.8917	0.9079	1.4909

50 Real Estate

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	1165.9	1936.9	1308.4	2189.5	2153.8	2981.3	3210.6	8099.9
RMS Percent Error	25	0.1355	0.2390	0.1544	0.2689	0.2695	0.3643	0.3927	1.0000
Mean Simulation Error	28	-994.42	-1751.40	-954.40	354.82	-1954.28	-2889.70	-3114.70	-8039.88
Mean Percent Error	28	-0.1200	-0.2188	-0.1152	0.0452	-0.2451	-0.3578	-0.3859	-1.0000
AAPE	37	0.1200	0.2188	0.1168	0.2230	0.2451	0.3578	0.3859	1.0000
Theil's Inequality Coef	25	0.7897	1.1147	0.9987	2.1057	1.0716	1.1363	1.2202	2.2507

Table 5.2 (continued)

Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

51 Hotels & Repairs Minus Auto

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	443.6	454.8	484.5	989.1	1549.1	939.8	1044.8	958.7
RMS Percent Error	25	0.1383	0.1542	0.1889	0.3448	0.6014	0.3154	0.3830	0.3334
Mean Simulation Error	26	-129.25	61.87	403.47	-948.76	826.50	-208.16	79.33	-129.58
Mean Percent Error	25	-0.0224	0.0347	0.1554	-0.3314	0.3254	-0.0493	0.0480	-0.0317
AAPE	26	0.1233	0.1195	0.1554	0.3314	0.4264	0.3052	0.3503	0.2841
Theil's Inequality Coef	37	0.9207	1.1677	0.8916	1.5137	3.3823	1.7549	2.3562	2.5283

52 Business Services

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	1290.8	1688.2	1099.1	1563.6	1348.2	2044.8	2440.5	2560.6
RMS Percent Error	37	0.1381	0.1694	0.1091	0.1645	0.1347	0.2099	0.2765	0.2861
Mean Simulation Error	37	-926.29	-1269.69	-600.79	-1076.81	-903.13	-1421.77	-1893.25	-2253.15
Mean Percent Error	37	-0.1019	-0.1381	-0.0563	-0.1229	-0.0975	-0.1458	-0.2142	-0.2736
AAPE	37	0.1237	0.1391	0.0889	0.1382	0.1058	0.1861	0.2529	0.2736
Theil's Inequality Coef	26	0.8541	0.7477	0.8426	1.4499	0.8452	0.9572	1.3492	1.0436

53 Auto Repair

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	30	979.6	1200.7	769.1	1476.0	1312.8	732.6	884.0	1517.4
RMS Percent Error	30	0.1854	0.1849	0.1972	0.2434	0.2093	0.1698	0.1936	0.2418
Mean Simulation Error	25	-138.77	-780.01	560.56	-1048.86	-870.00	157.25	-546.06	-1117.27
Mean Percent Error	25	0.0209	-0.1374	0.1496	-0.1980	-0.1565	0.0663	-0.1115	-0.2077
AAPE	26	0.1564	0.1421	0.1675	0.2138	0.1799	0.1471	0.1584	0.2077
Theil's Inequality Coef	37	0.9225	0.8488	0.7344	1.0805	0.9464	0.8851	0.8010	0.9036

54 Movies & Amusements

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	25	199.3	240.6	245.2	275.0	217.1	438.6	333.6	724.2
RMS Percent Error	25	0.1247	0.1418	0.1497	0.1722	0.1388	0.2674	0.1866	0.4181
Mean Simulation Error	26	75.09	5.24	168.32	61.71	135.77	362.13	260.03	-435.37
Mean Percent Error	26	0.0574	0.0202	0.1011	0.0499	0.0863	0.2163	0.1447	-0.2473
AAPE	25	0.1047	0.1284	0.1210	0.1440	0.1186	0.2216	0.1558	0.2931
Theil's Inequality Coef	37	0.7438	0.9789	0.5672	1.2019	0.6171	1.0149	1.4468	2.7360

Table 5.2 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 14
Real Side Simulations - Estimated to 1985

Simulation 25: Autoregressive Model
Simulation 26: Accelerator Model
Simulation 37: Cobb-Douglas Model
Simulation 28: CES Model I
Simulation 29: CES Model II
Simulation 30: Generalized Leontief Putty-Clay Model
Simulation 31: Generalized Leontief Putty-Putty Model
Simulation 35: Dynamic Factor Demand Model

55 Medical & Ed. Services

Simulation :1978 to 1985	Best	25	26	37	28	29	30	31	35
Root Mean Square Error	37	1439.2	1671.1	1108.8	1511.2	1590.5	2261.5	2571.8	2417.1
RMS Percent Error	37	0.1647	0.1642	0.1219	0.1536	0.1551	0.2246	0.2549	0.2234
Mean Simulation Error	37	-208.13	-849.71	-179.79	-637.12	-725.82	-1073.05	-1513.46	-1452.26
Mean Percent Error	37	0.0144	-0.0572	0.0074	-0.0410	-0.0441	-0.0692	-0.1246	-0.1087
AAPE	37	0.1462	0.1515	0.1051	0.1380	0.1392	0.2031	0.2212	0.2036
Theil's Inequality Coef	37	0.9432	0.9254	0.8149	1.0307	0.9377	1.2797	1.5382	1.0978

Ranking of Simulations by Each Statistic

Simulation :	25	26	37	28	29	30	31	35
Root Mean Square Error	25	4	9	5	6	3	1	0
RMS Percent Error	22	6	9	5	4	5	2	0
Mean Simulation Error	12	6	11	6	6	4	4	4
Mean Percent Error	11	9	5	8	7	5	4	4
AAPE	19	10	11	4	3	4	2	0
Theil's Inequality Coef	30	5	11	0	4	3	0	0

Total RMSE and MSE Across all Industries

Simulation :	25	26	37	28	29	30	31	35
Root Mean Square Error	36685.0	53191.7	39182.7	63770.4	52751.0	62964.1	64447.4	110000.9
Mean Simulation Error	-2984.68	-19857.75	4152.00	-27193.93	-7250.34	-24397.16	-24446.35	-39353.43

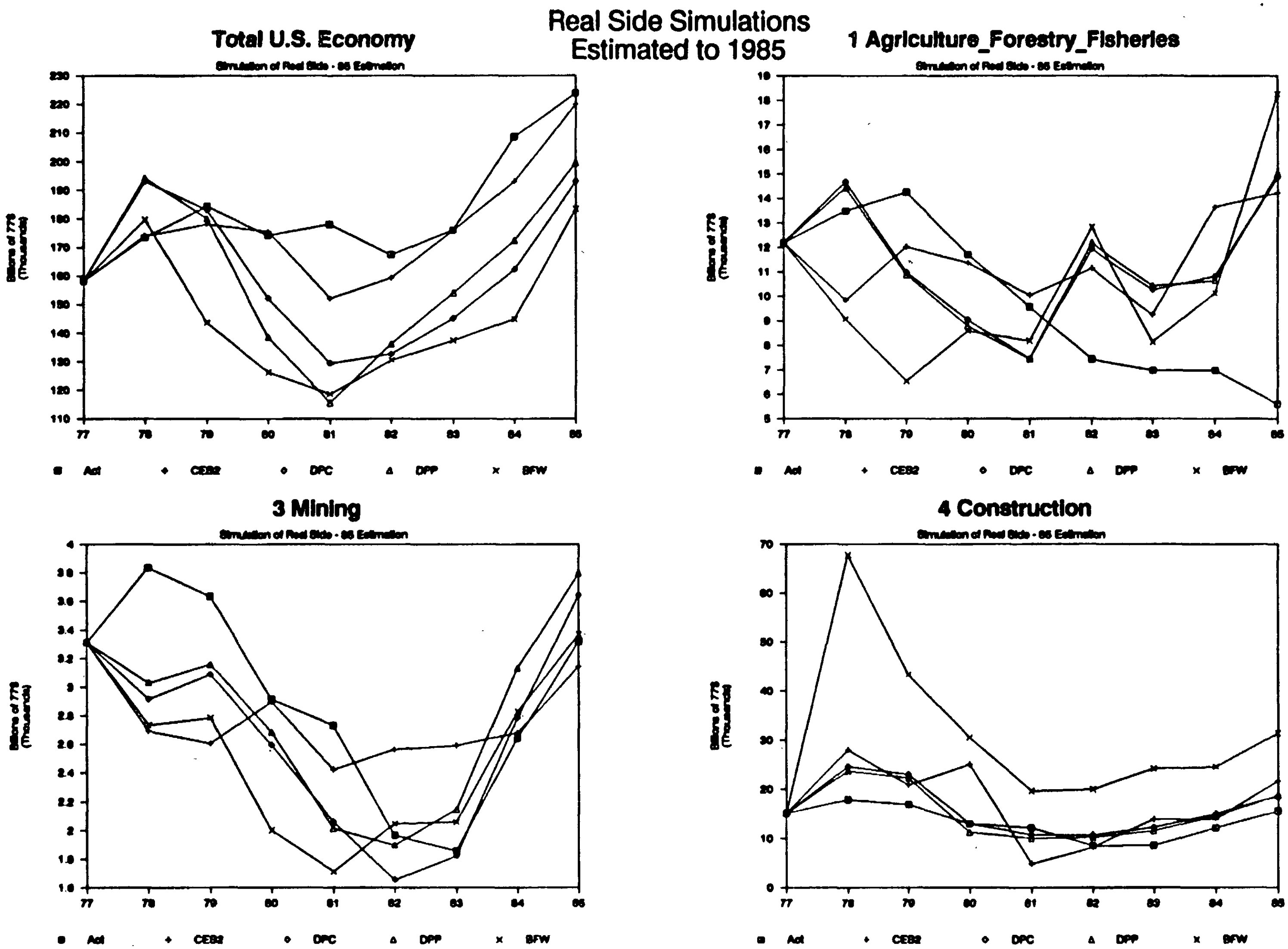

Real Side Simulations
Estimated to 1985
Total U.S. Economy
1 Agriculture_Forestry_Fisheries
3 Mining
4 Construction
Simulation of Real Side - 85 Estimation
Billions of 77$ (Thousands)
Act
CES2
DPC
DPP
SFW

Figure 5.2.a

Real Side Simulations
Estimated to 1985

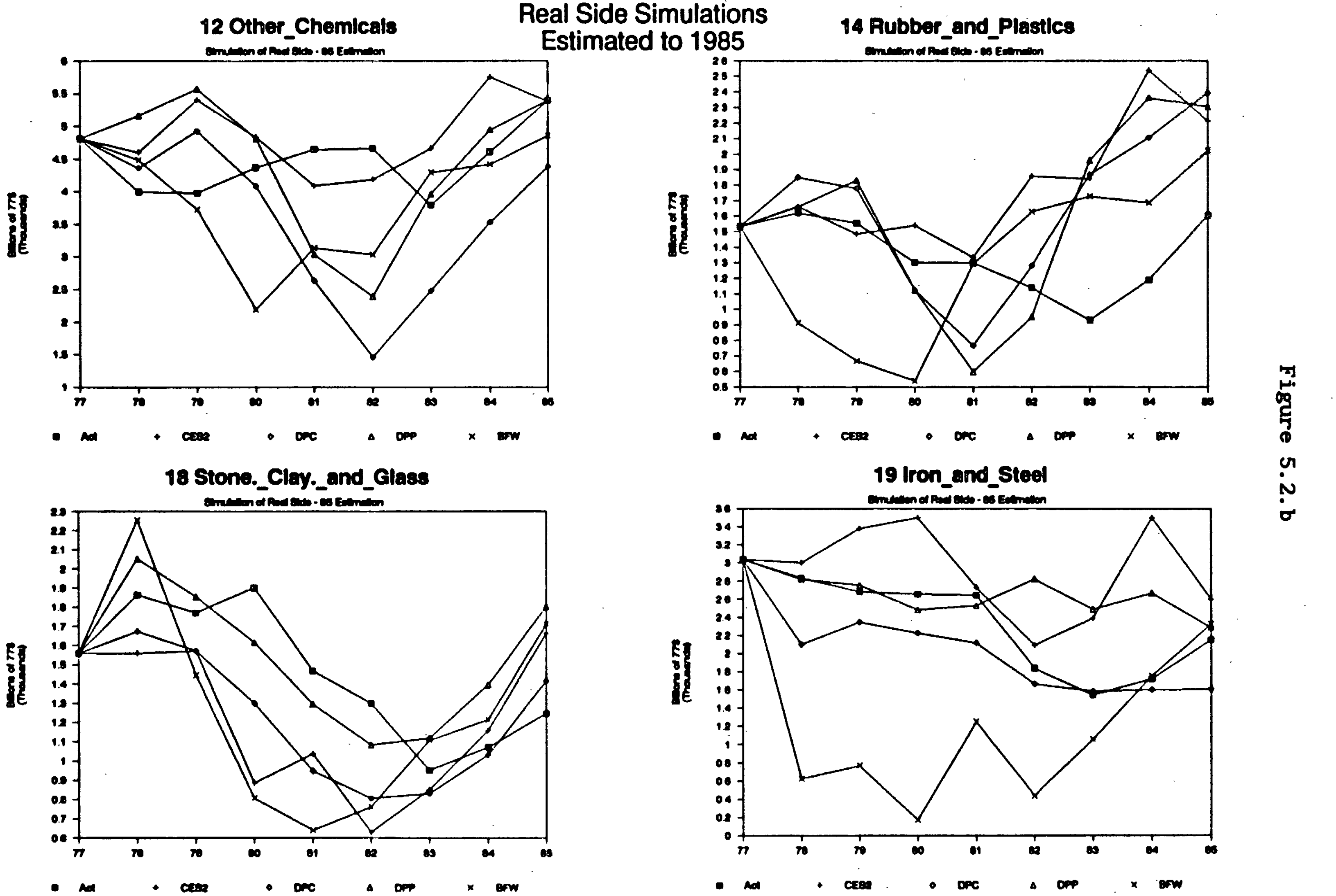
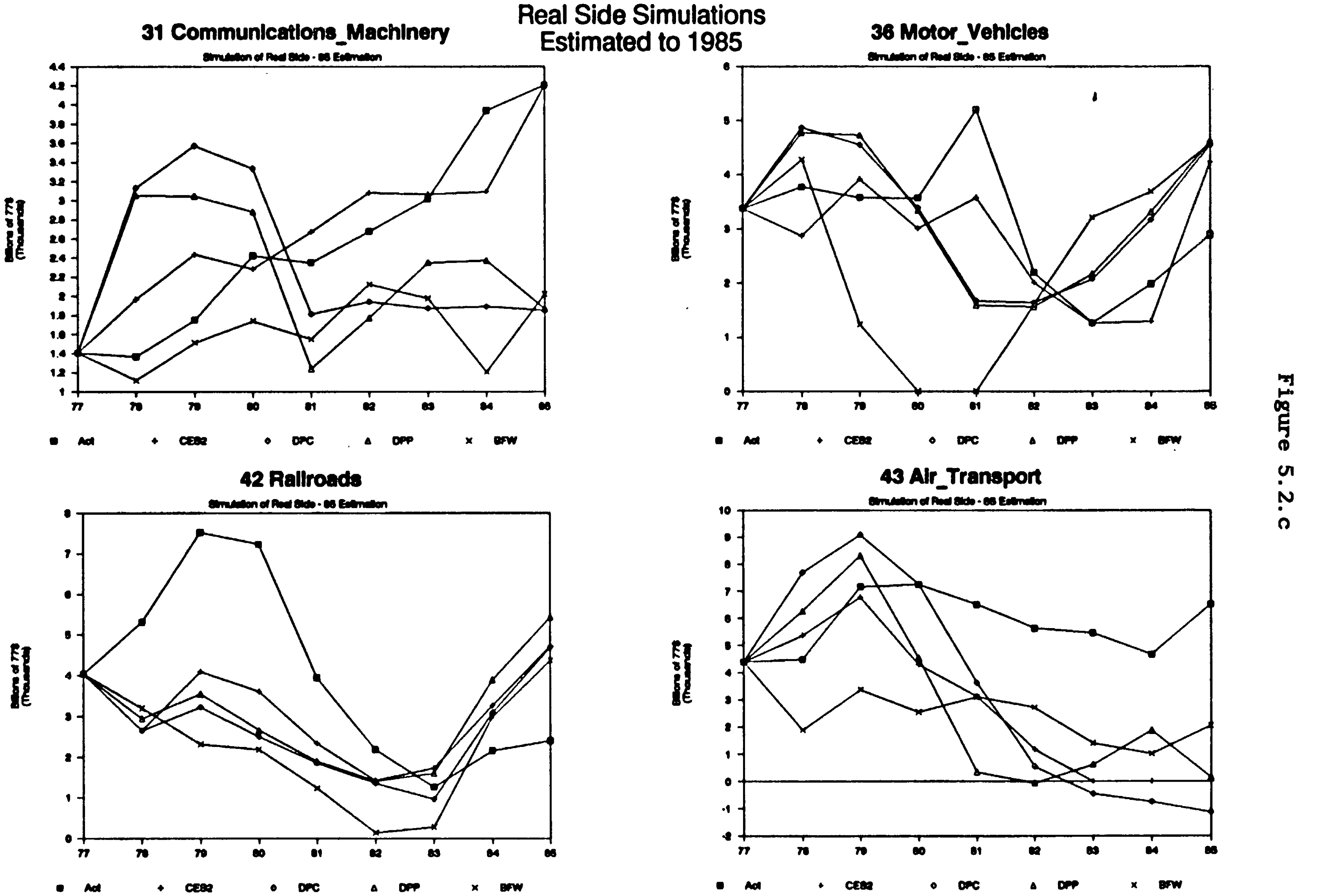


Figure 5.2.b



Real Side Simulations
Estimated to 1985
31 Communications_Machinery
Simulation of Real Side - 85 Estimation
Billions of 77$ (Thousands)
Act
CES2
DPC
DPP
BFW
36 Motor_Vehicles
Simulation of Real Side - 85 Estimation
Billions of 77$ (Thousands)
Act
CES2
DPC
DPP
BFW
42 Railroads
Simulation of Real Side - 85 Estimation
Billions of 77$ (Thousands)
Act
CES2
DPC
DPP
BFW
43 Air_Transport
Simulation of Real Side - 85 Estimation
Billions of 77$ (Thousands)
Act
CES2
DPC
DPP
BFW

Figure 5.2.c

Real Side Simulations Estimated to 1985

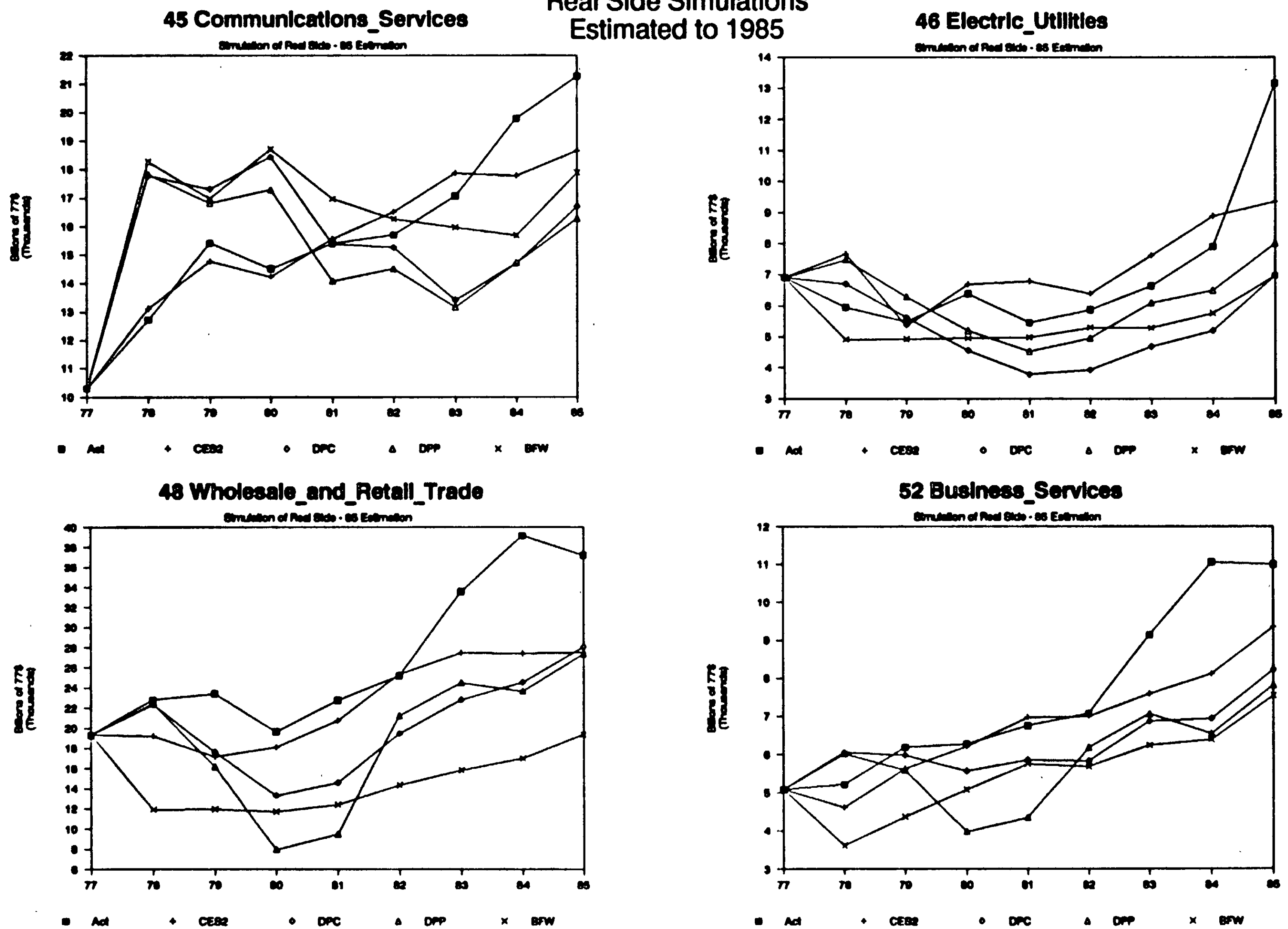
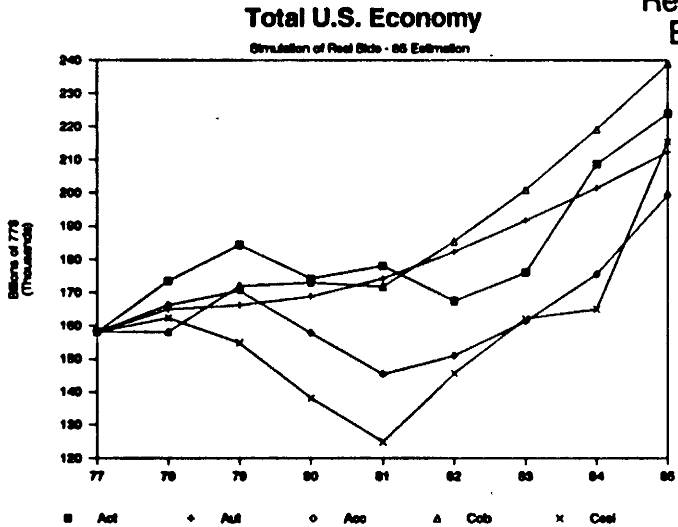
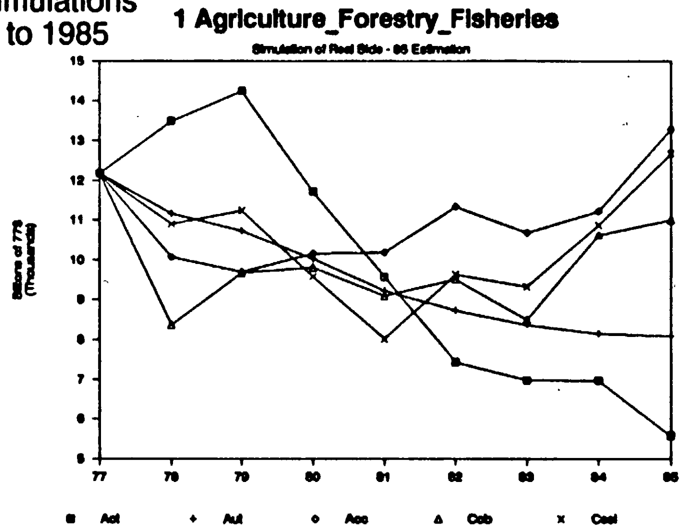
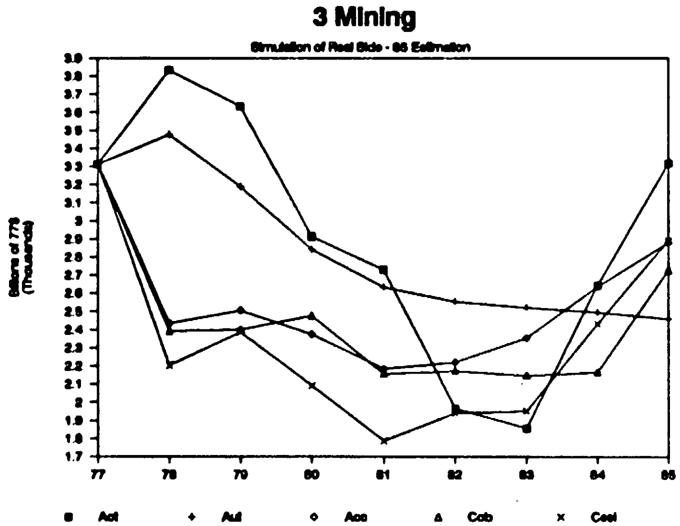


Figure 5.2.d

Real Side Simulations
Estimated to 1985







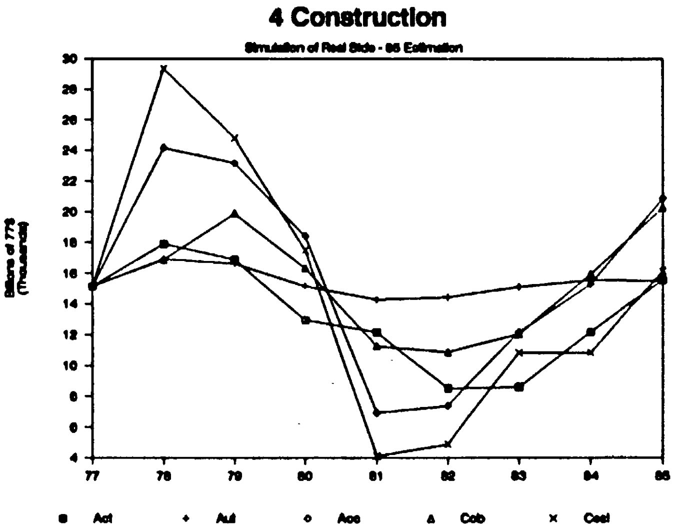
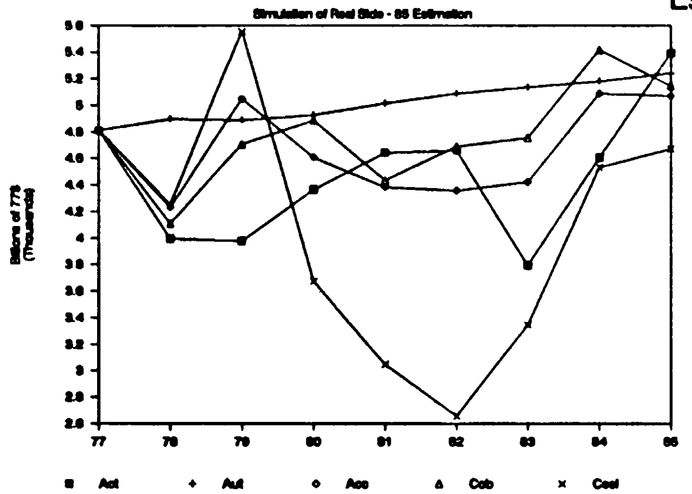


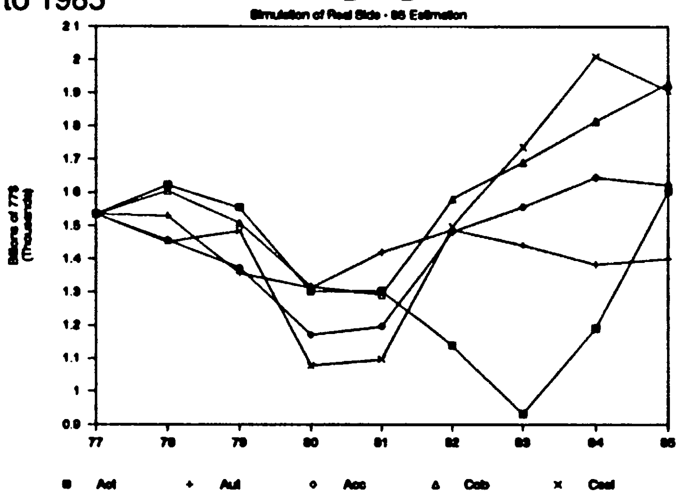
Figure 5.2.e

Real Side Simulations
Estimated to 1985

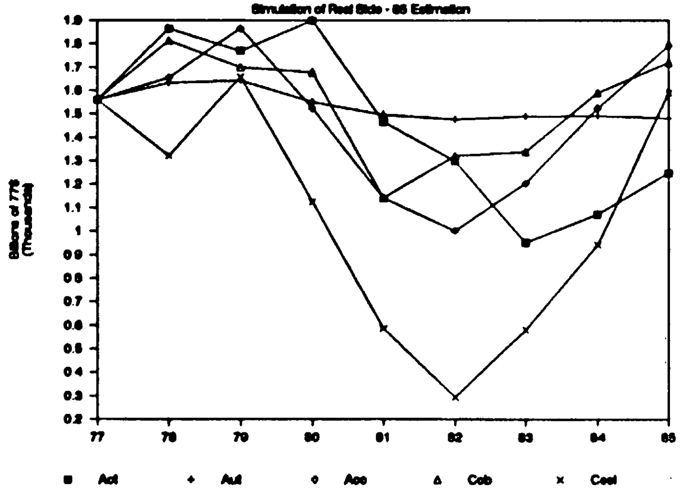
12 Other_Chemicals



14 Rubber_and_Plastics



18 Stone._Clay._and_Glass



19 Iron_and_Steel

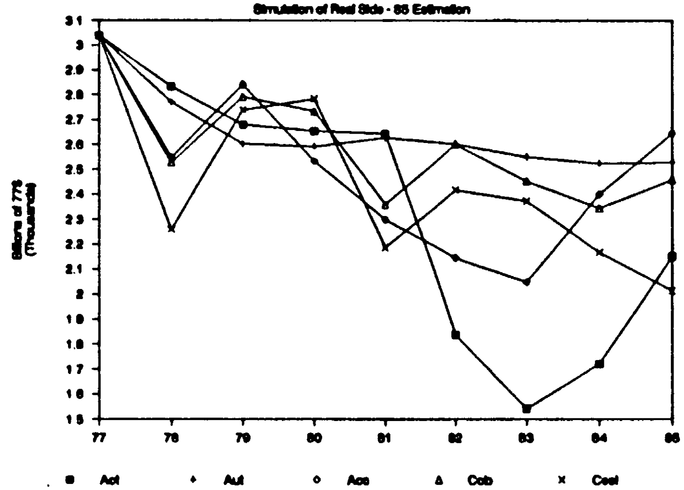


Figure 5.2.f

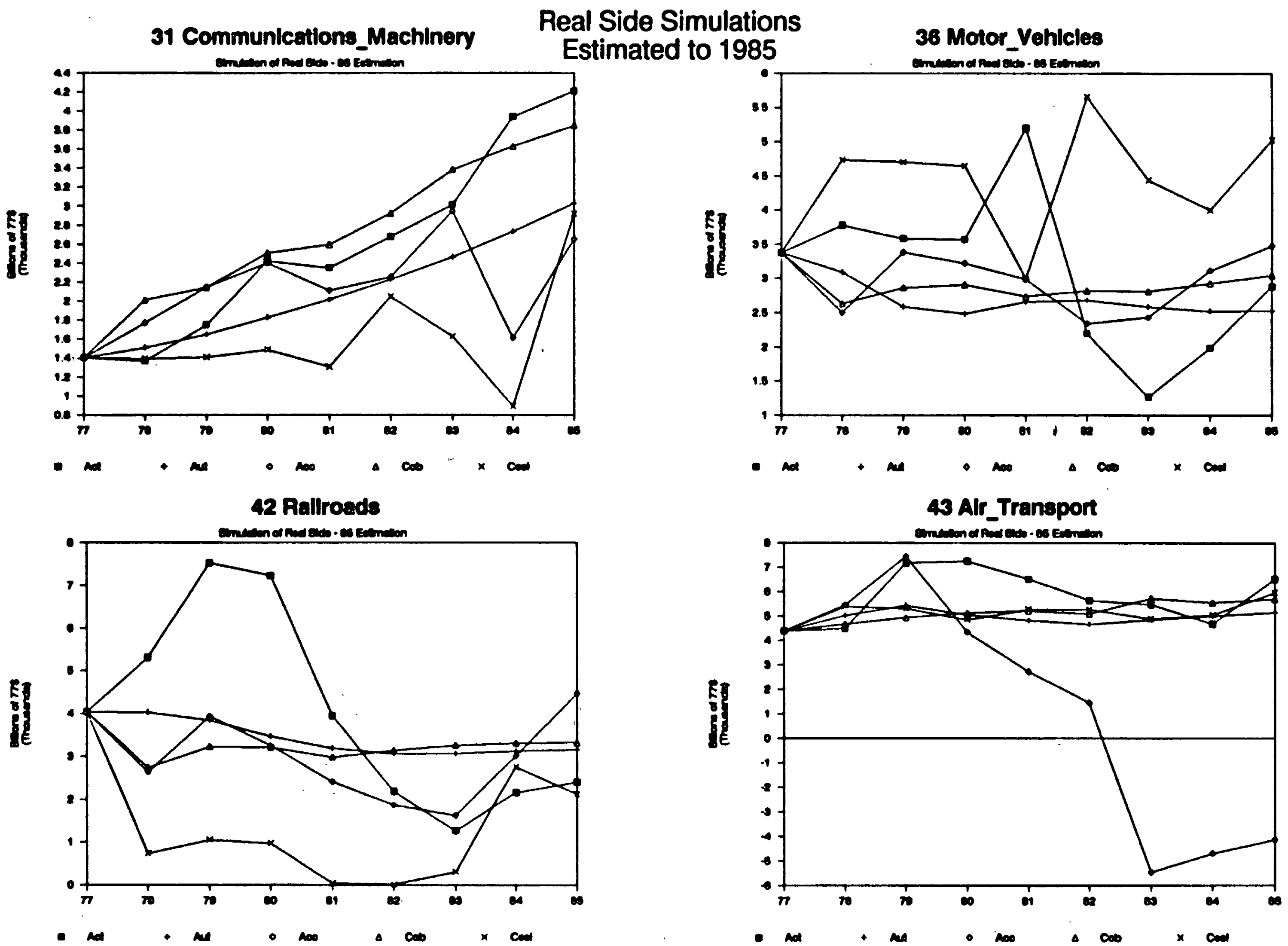

Real Side Simulations
Estimated to 1985
31 Communications_Machinery
36 Motor_Vehicles
42 Railroads
43 Air_Transport
Act
Aut
Acc
Cob

Figure 5.2.8

Real Side Simulations Estimated to 1985

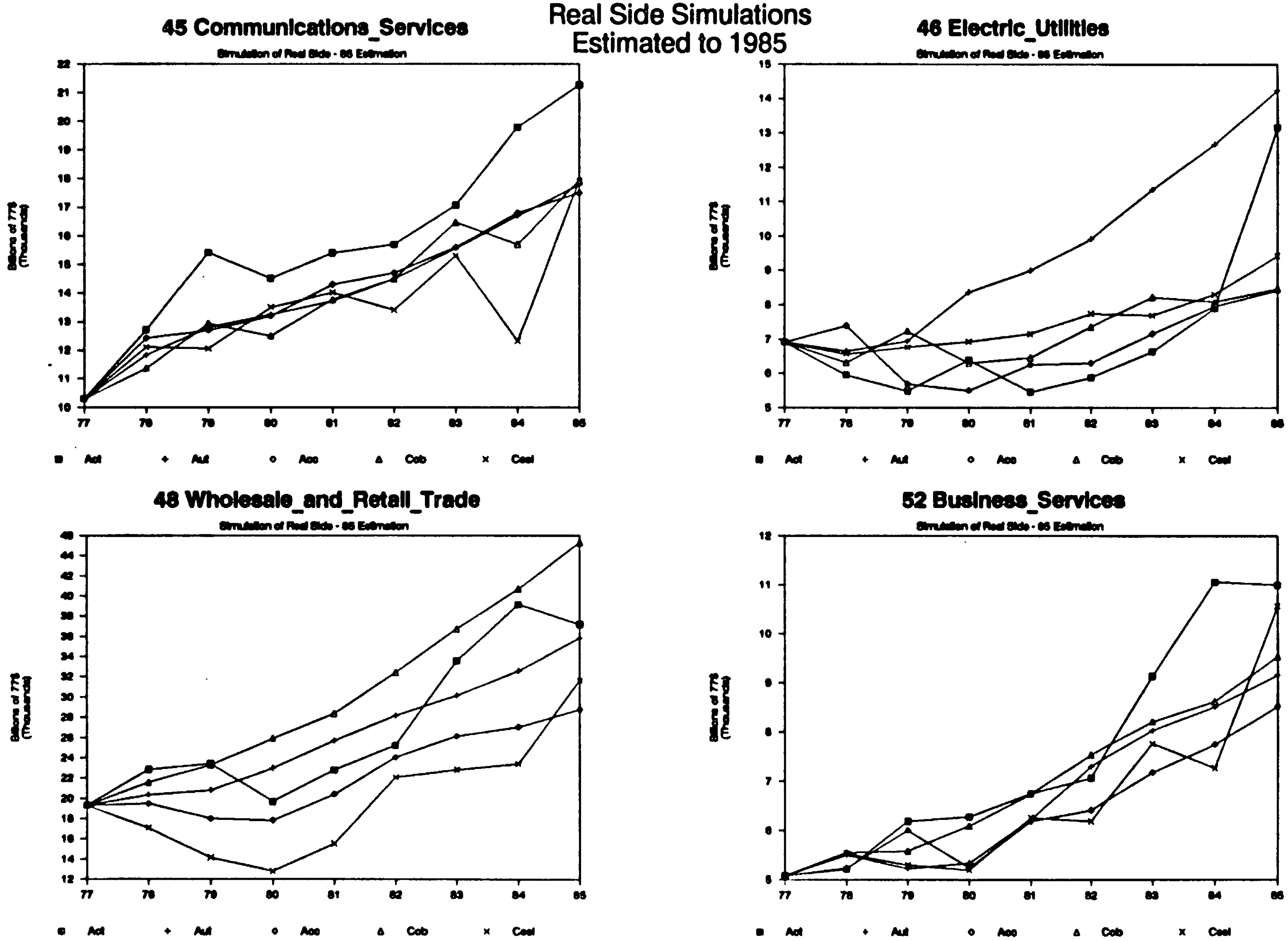


Figure 5.2.h

3. Simulations Beyond the Period of Estimation

Perhaps the most rigorous test of an econometric equation is its performance in a dynamic simulation outside of the period of estimation. In this section, the models estimated for the 1953 to 1977 period are used to make simulations with the INFORUM model for the period 1978 to 1985. One would expect the structural equations to make a better showing in this test and for the Autoregressive Model to do less well, as discussed in the previous section. Whether or not this is the case will be investigated below.

As with the 1953 to 1985 estimations, two sets of simulations were run for the 1953 to 1977 regressions: one set as a single-equation simulation, and one set with the full real side of the model operating. The latter set of simulations comprises the most difficult test of the equations.

3.a. Single-Equation Simulations

Table 5.3 contains the summary of simulation test statistics for the single equation simulations. Turning to the back of this table to the part labeled "Ranking of Simulations by Each Statistic", it can be seen that the Autoregressive Model again takes first prize in terms of an industry count, although the results are not as stark as the within-sample simulations. In terms of *RMSE*, the Autoregressive Model does the best in 14 industries, followed by the

Dynamic Factor Demand Model in 9 industries, followed in turn by the putty-putty and putty-clay *GL* models, with 7 industries and 6 industries, respectively. In terms of *MSE* and *MPE,* the *GL* Putty-Putty Model does best in nearly as many industries as the Autoregressive Model. Judged by total *RMSE* summed across all industries, however, the Cobb-Douglas Model is superior, followed by the Accelerator and then the Autoregressive Model. The Cobb-Douglas Model also performs best in terms of total *MSE* summed across all industries. The Dynamic Factor Demand Model again performs the worst in terms of overall *RMSE,* followed by the CES Model I and the *GL* putty-clay Model. All of the models have increased in total *RMSE* (summed over all industries) to lie in the 60,000 to 85,000 range, as compared to the best figure for the within-sample simulations, which was around 36,000. This represents rougly a doubling in the size of the errors.

The plots in Figures 5.3.a to 5.3.h look quite different from the corresponding plots in Figures 5.1. However, some general features are similar. Both the Dynamic Factor Demand Model and the CES Model I yield erratic, unacceptable forecasts in quite a few industries. The Autoregressive Model again does an acceptable job in most industries by forecasting a gently rolling trend. However, in industries such as Communications Machinery (31), Communications Services (45), and Business Services (52), the structural models can all do a lot better than the Autoregressive Model.

The model that yields the best fit for total equipment

Table 5.3

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 1

Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

1 Agriculture

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	2680.6	4669.7	3712.2	3614.5	4421.3	4535.5	3976.1	4227.7
RMS Percent Error	2	0.3711	0.6873	0.5092	0.5141	0.6570	0.6704	0.6075	0.6510
Mean Simulation Error	2	906.88	2365.27	953.26	1331.91	2186.84	4052.75	3385.76	1465.97
Mean Percent Error	2	0.1952	0.4197	0.2397	0.2759	0.3900	0.5362	0.4613	0.2926
AAPE	2	0.3089	0.5494	0.4242	0.4234	0.5146	0.5362	0.4613	0.4737
Theil's Inequality Coef	2	0.9922	1.3067	1.3100	1.2246	1.3868	1.2589	1.3021	2.3646

2 Crude Petroleum

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	1685.0	1710.8	1872.7	1493.3	1584.7	1742.3	1669.6	1366.6
RMS Percent Error	38	0.4281	0.4324	0.4754	0.4067	0.3999	0.4481	0.4099	0.3392
Mean Simulation Error	38	-1376.80	-1367.49	-1515.06	-997.83	-1066.33	-1431.62	-1264.47	-953.17
Mean Percent Error	38	-0.3917	-0.3806	-0.4275	-0.2409	-0.2628	-0.4075	-0.3389	-0.2371
AAPE	38	0.3917	0.3806	0.4275	0.3698	0.3463	0.4075	0.3453	0.3029
Theil's Inequality Coef	38	1.0658	1.0970	1.2615	1.1849	1.3235	1.1071	1.2115	1.0120

3 Mining

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	579.3	1033.9	1052.4	996.8	839.5	594.8	604.0	1690.6
RMS Percent Error	7	0.2221	0.3034	0.3116	0.3109	0.3027	0.1883	0.1988	0.5167
Mean Simulation Error	8	-123.70	-778.65	-782.02	-448.71	-269.41	-111.85	-62.26	-1102.96
Mean Percent Error	2	0.0040	-0.2266	-0.2241	-0.0874	-0.0275	-0.0083	0.0108	-0.2912
AAPE	7	0.1815	0.2729	0.2873	0.2617	0.2542	0.1629	0.1788	0.4859
Theil's Inequality Coef	2	1.0000	1.5033	1.5039	1.6470	1.5925	1.1893	1.2772	2.4936

4 Construction

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	7986.1	5339.2	7771.5	11400.5	5123.7	4943.4	3891.1	9436.0
RMS Percent Error	8	0.8157	0.5147	0.7733	1.0867	0.4621	0.3319	0.2749	0.5977
Mean Simulation Error	8	6363.67	4091.77	5645.21	8613.98	3900.73	-4400.55	-2743.22	-7601.85
Mean Percent Error	8	0.6124	0.3870	0.5553	0.8238	0.3560	-0.3138	-0.1670	-0.5214
AAPE	8	0.6282	0.4126	0.6196	0.9540	0.3803	0.3138	0.2661	0.5214
Theil's Inequality Coef	6	1.0388	0.6914	1.1227	2.4631	0.6752	1.1832	1.2914	2.5334

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

5 Food, Tobacco

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	7	1018.8	1262.3	873.2	1722.9	1269.8	448.2	550.2	2722.4
RMS Percent Error	7	0.2824	0.3450	0.2403	0.4469	0.3468	0.1275	0.1561	0.7448
Mean Simulation Error	8	970.23	1212.20	782.89	-1552.26	1224.74	375.08	355.27	-2604.22
Mean Percent Error	8	0.2655	0.3289	0.2130	-0.4090	0.3322	0.1061	0.1022	-0.7078
AAPE	7	0.2655	0.3289	0.2130	0.4090	0.3322	0.1110	0.1156	0.7078
Theil's Inequality Coef	7	1.0028	0.9802	0.9157	2.4690	0.9718	0.8534	1.6710	3.9079

6 Textiles

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	158.6	639.6	265.2	288.1	510.7	334.7	486.2	549.7
RMS Percent Error	2	0.1943	0.7455	0.3141	0.3151	0.6066	0.3961	0.5655	0.6474
Mean Simulation Error	2	132.22	597.92	253.49	-244.73	418.37	195.21	413.81	403.39
Mean Percent Error	2	0.1606	0.6891	0.2955	-0.2747	0.4904	0.2279	0.4770	0.4699
AAPE	2	0.1669	0.6891	0.2955	0.2996	0.4904	0.2644	0.4770	0.5318
Theil's Inequality Coef	4	0.9611	3.2090	0.9558	1.3133	3.7374	2.5683	3.1451	4.5446

7 Knitting, Hosiery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	37.5	60.5	149.3	176.4	69.4	91.7	81.8	86.7
RMS Percent Error	2	0.1862	0.4439	1.0457	1.2040	0.4788	0.5187	0.4814	0.5020
Mean Simulation Error	2	-19.75	29.00	111.38	157.67	42.57	-76.09	-60.42	-72.33
Mean Percent Error	2	-0.0790	0.2202	0.7731	1.0277	0.3083	-0.4120	-0.3134	-0.4085
AAPE	2	0.1595	0.3068	0.8211	1.0277	0.3704	0.5020	0.4680	0.4590
Theil's Inequality Coef	2	1.0054	1.7064	1.5583	1.2233	1.2956	2.1503	2.4048	1.8159

8 Apparel

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	142.5	540.7	437.4	1191.7	444.6	284.4	368.3	234.6
RMS Percent Error	2	0.4522	1.6348	1.3173	3.5620	1.3655	0.8889	1.1381	0.7231
Mean Simulation Error	2	132.98	526.79	435.03	1182.32	433.74	270.69	358.15	221.14
Mean Percent Error	2	0.4137	1.5788	1.3036	3.5277	1.3127	0.8266	1.0867	0.6706
AAPE	2	0.4137	1.5788	1.3036	3.5277	1.3127	0.8266	1.0867	0.6706
Theil's Inequality Coef	2	0.8150	2.9367	1.5064	3.2405	2.3376	1.8789	2.1559	1.6566

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 3
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

9 Paper

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	6	507.3	445.1	457.0	932.2	428.0	463.0	554.2	1178.0
RMS Percent Error	3	0.1264	0.1193	0.1226	0.3123	0.1369	0.1240	0.1485	0.3477
Mean Simulation Error	3	-223.25	-184.66	-232.23	460.91	239.83	-272.88	-290.43	-1010.32
Mean Percent Error	3	-0.0517	-0.0449	-0.0583	0.1509	0.0827	-0.0742	-0.0785	-0.3022
AAPE	3	0.0972	0.0931	0.1082	0.2679	0.1084	0.1007	0.1271	0.3022
Theil's Inequality Coef	6	0.9824	1.1498	0.9336	2.4722	0.8709	1.1339	1.3982	1.9205

10 Printing

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	6	335.6	208.5	291.3	2043.4	205.8	415.7	318.8	1124.0
RMS Percent Error	6	0.1304	0.1046	0.1203	0.9975	0.1030	0.2184	0.1649	0.6043
Mean Simulation Error	6	-235.29	126.34	-221.03	1919.81	104.64	382.23	193.47	1033.54
Mean Percent Error	6	-0.1033	0.0719	-0.1012	0.9391	0.0624	0.2001	0.1099	0.5373
AAPE	6	0.1033	0.0955	0.1012	0.9391	0.0892	0.2007	0.1388	0.5373
Theil's Inequality Coef	6	0.8752	0.8557	0.8954	2.2204	0.8533	0.9923	1.0360	3.4198

11 Agri. Fertilizers

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	7	1059.1	598.1	1442.6	1038.4	752.1	194.0	267.2	368.2
RMS Percent Error	7	4.0733	2.3197	5.6450	3.9920	2.9503	0.7212	0.8194	0.7574
Mean Simulation Error	7	985.00	504.52	1289.58	859.46	545.84	91.59	-123.18	-224.36
Mean Percent Error	8	3.3018	1.7914	4.4284	3.0410	2.0417	0.4334	-0.2923	-0.3184
AAPE	7	3.3018	1.8627	4.4284	3.1886	2.2016	0.5608	0.5753	0.7264
Theil's Inequality Coef	7	1.2126	1.3302	1.5399	1.7221	2.2462	0.9611	1.8547	1.3061

12 Other Chemicals

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	3	1118.5	894.5	1027.6	3103.5	1537.7	1636.2	1151.1	1292.5
RMS Percent Error	3	0.2711	0.2182	0.2482	0.7213	0.3546	0.3522	0.2587	0.2786
Mean Simulation Error	6	1053.84	647.28	945.89	2774.93	89.52	-1077.10	-262.99	-1074.22
Mean Percent Error	6	0.2474	0.1567	0.2209	0.6306	0.0384	-0.2273	-0.0433	-0.2335
AAPE	3	0.2474	0.1654	0.2209	0.6723	0.2719	0.2976	0.2256	0.2381
Theil's Inequality Coef	4	1.0173	1.4180	0.9222	2.9220	3.7652	1.6739	1.7334	1.9315

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 4
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

13 Petroleum Refining

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	5	1059.2	1418.7	989.5	305.9	1359.1	1289.3	1341.8	1294.2
RMS Percent Error	5	0.4511	0.6189	0.4156	0.1923	0.5973	0.5619	0.5790	0.5609
Mean Simulation Error	5	-905.95	-1185.93	-863.49	115.10	-885.05	-951.02	-1065.66	-1143.17
Mean Percent Error	5	-0.3908	-0.5144	-0.3852	0.0884	-0.3418	-0.3762	-0.4418	-0.5078
AAPE	5	0.4227	0.5461	0.3852	0.1421	0.5021	0.5154	0.5235	0.5089
Theil's Inequality Coef	5	1.0420	1.3170	1.1844	1.0051	1.5148	1.2712	1.2246	1.1282

14 Rubber & Plastics

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	335.5	729.7	603.5	2629.9	803.6	712.7	762.9	903.1
RMS Percent Error	2	0.3250	0.6496	0.5510	2.2172	0.7002	0.6279	0.6674	0.7806
Mean Simulation Error	2	207.87	602.72	483.88	2469.15	674.72	471.18	459.15	652.15
Mean Percent Error	2	0.1981	0.5063	0.4202	2.0050	0.5592	0.4043	0.4031	0.5482
AAPE	2	0.2237	0.5063	0.4326	2.0050	0.5592	0.4170	0.4758	0.6383
Theil's Inequality Coef	2	1.0580	1.4925	1.1680	2.7819	1.7720	1.9226	2.2059	2.7086

15 Footwear & Leather

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	5	53.7	43.6	50.6	20.0	79.2	24.8	33.7	26.0
RMS Percent Error	5	0.7639	0.6388	0.7157	0.2246	1.1233	0.3244	0.4551	0.3391
Mean Simulation Error	5	51.42	32.64	49.03	-4.79	61.65	8.74	23.27	-14.48
Mean Percent Error	5	0.6971	0.4616	0.6635	-0.0428	0.8631	0.1351	0.3201	-0.1798
AAPE	5	0.6971	0.5118	0.6635	0.1953	0.9642	0.2732	0.3428	0.2515
Theil's Inequality Coef	2	1.2244	2.4906	1.2701	1.3662	4.7402	1.6805	1.9622	1.7349

16 Lumber

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	7	369.9	732.3	781.9	2266.5	657.3	253.2	387.4	423.8
RMS Percent Error	7	0.4891	0.9286	1.0159	2.7666	0.8228	0.2156	0.4649	0.4519
Mean Simulation Error	38	203.37	633.78	619.95	2099.14	576.02	-169.01	-104.85	-18.45
Mean Percent Error	8	0.2998	0.7527	0.7745	2.3988	0.6772	-0.1283	-0.0799	0.0942
AAPE	7	0.3839	0.7527	0.7879	2.3988	0.6772	0.1942	0.3345	0.3746
Theil's Inequality Coef	6	1.1259	0.9377	1.2467	2.6594	0.7972	0.9309	2.9206	1.8011

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 5

Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

17 Furniture

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	82.7	151.8	112.6	395.9	92.4	67.4	84.1	63.2
RMS Percent Error	38	0.3024	0.4964	0.3998	1.3395	0.3178	0.2154	0.2686	0.2002
Mean Simulation Error	38	66.03	148.56	94.75	375.70	88.28	56.45	65.69	19.32
Mean Percent Error	38	0.2348	0.4795	0.3270	1.2412	0.2938	0.1781	0.2058	0.0510
AAPE	38	0.2452	0.4795	0.3439	1.2412	0.2938	0.1859	0.2187	0.1726
Theil's Inequality Coef	6	1.0161	1.1190	1.0159	2.2679	0.7494	1.1957	1.6372	1.8026

18 Stone,Clay & Glass

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	7	430.1	542.8	463.0	1445.8	504.7	370.0	919.0	609.9
RMS Percent Error	7	0.3977	0.4766	0.3428	1.2529	0.3999	0.2430	0.5505	0.3863
Mean Simulation Error	4	239.83	379.28	-37.22	1224.65	279.01	-305.46	352.10	-434.79
Mean Percent Error	4	0.2389	0.3240	0.0528	1.0141	0.2339	-0.2049	0.2230	-0.2637
AAPE	7	0.3043	0.3400	0.3006	1.0697	0.3296	0.2049	0.4217	0.3210
Theil's Inequality Coef	7	0.9965	1.2560	1.3870	2.1764	2.0194	0.8530	5.1823	1.7955

19 Iron & Steel

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	616.8	559.4	730.8	686.1	1649.7	619.8	467.0	1044.3
RMS Percent Error	7	0.3642	0.3156	0.4262	0.2627	0.8839	0.2416	0.2577	0.5573
Mean Simulation Error	8	406.92	402.26	527.71	-449.92	1399.00	-519.35	273.60	-671.65
Mean Percent Error	5	0.2376	0.2235	0.2971	-0.1566	0.7108	-0.2129	0.1609	-0.3615
AAPE	8	0.2546	0.2377	0.3055	0.2234	0.7269	0.2129	0.2080	0.4429
Theil's Inequality Coef	3	0.9361	0.9263	1.2179	1.4220	4.0611	1.5348	1.1103	2.6744

20 Non-Ferrous Metals

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	257.6	382.4	496.5	991.1	449.1	385.5	235.5	489.3
RMS Percent Error	8	0.2410	0.3525	0.4702	0.8870	0.4140	0.3256	0.2014	0.4171
Mean Simulation Error	8	171.55	337.35	438.90	843.69	379.41	-349.53	-127.38	-464.85
Mean Percent Error	8	0.1608	0.3017	0.3984	0.7462	0.3429	-0.2974	-0.1097	-0.3976
AAPE	8	0.1988	0.3099	0.3984	0.8425	0.3484	0.2974	0.1781	0.3976
Theil's Inequality Coef	2	1.1592	1.1639	1.2526	2.8495	1.9009	1.1781	1.2908	1.2780

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS

Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

21 Metal Products

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	7	434.8	737.4	727.6	1146.1	668.1	424.8	431.8	784.6
RMS Percent Error	8	0.2722	0.4136	0.4387	0.6565	0.3770	0.2141	0.2119	0.4002
Mean Simulation Error	8	285.20	636.83	578.90	947.20	546.05	172.06	-10.39	501.72
Mean Percent Error	8	0.1730	0.3455	0.3294	0.5220	0.2980	0.0971	0.0023	0.2635
AAPE	8	0.1935	0.3470	0.3294	0.5731	0.3080	0.1930	0.1716	0.3477
Theil's Inequality Coef	2	1.0239	1.1657	1.0434	2.0946	1.5803	1.2214	1.4455	2.2375

22 Engines & Turbines

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	64.1	113.1	92.1	290.3	86.9	210.8	226.9	170.0
RMS Percent Error	2	0.2114	0.3583	0.3113	0.8949	0.2869	0.5751	0.6867	0.4778
Mean Simulation Error	6	2.67	-28.01	74.27	276.57	1.96	-175.78	-158.54	-112.97
Mean Percent Error	3	0.0448	-0.0341	0.2491	0.8481	0.0510	-0.4847	-0.4218	-0.2916
AAPE	2	0.1817	0.2852	0.2521	0.8481	0.2396	0.5210	0.6281	0.4082
Theil's Inequality Coef	4	1.1580	1.4306	1.0726	1.2100	1.2171	1.1703	2.0571	1.5581

23 Agri. Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	129.6	76.5	158.3	82.2	62.6	78.6	57.7	104.5
RMS Percent Error	8	1.0047	0.5662	1.2088	0.6036	0.4963	0.3935	0.2476	0.4262
Mean Simulation Error	5	102.73	49.57	124.44	21.94	34.94	-65.00	-39.91	-86.16
Mean Percent Error	8	0.7096	0.3720	0.8608	0.2678	0.2873	-0.3381	-0.1823	-0.3782
AAPE	8	0.7096	0.4147	0.8608	0.4522	0.3329	0.3606	0.1981	0.3782
Theil's Inequality Coef	6	1.3317	0.8876	1.0845	1.1111	0.7837	1.0429	0.9927	1.2964

25 Metalworking Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	3	76.0	53.2	71.0	83.3	82.7	130.1	135.3	128.6
RMS Percent Error	3	0.2287	0.1490	0.2000	0.1844	0.2085	0.3511	0.3373	0.3865
Mean Simulation Error	4	8.85	-33.00	3.21	-50.71	65.82	-50.04	46.52	113.08
Mean Percent Error	4	0.0558	-0.0903	0.0401	-0.1030	0.1691	-0.1545	0.1072	0.3201
AAPE	3	0.1808	0.1162	0.1631	0.1628	0.1832	0.3167	0.2335	0.3201
Theil's Inequality Coef	3	1.0396	0.8620	1.1787	0.9511	1.2323	1.1995	1.9388	1.3217

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 7
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

27 Special Industry Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	3	46.2	38.1	44.8	46.0	50.2	224.8	191.5	63.6
RMS Percent Error	3	0.2771	0.2268	0.2716	0.2781	0.2938	1.1308	0.8976	0.3672
Mean Simulation Error	3	35.97	29.13	35.26	36.29	43.71	-223.06	-164.03	57.76
Mean Percent Error	3	0.2034	0.1640	0.1978	0.2035	0.2387	-1.1162	-0.7954	0.3117
AAPE	3	0.2193	0.1691	0.1978	0.2035	0.2387	1.1162	0.7954	0.3117
Theil's Inequality Coef	38	0.9431	0.8676	1.1355	1.1726	0.9514	3.9505	5.4709	0.8609

28 Misc.nonelec. Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	3	233.1	147.2	332.9	765.2	231.5	569.2	367.4	630.7
RMS Percent Error	3	0.1815	0.0915	0.2574	0.4871	0.1408	0.3763	0.2370	0.4280
Mean Simulation Error	2	69.46	-88.62	160.30	-639.23	-99.15	-490.65	-246.70	-516.75
Mean Percent Error	3	0.0654	-0.0568	0.1289	-0.4088	-0.0607	-0.3247	-0.1608	-0.3450
AAPE	3	0.1282	0.0690	0.1790	0.4320	0.1045	0.3247	0.1950	0.3510
Theil's Inequality Coef	3	0.9994	0.5417	1.0397	2.3756	1.1773	1.0579	1.0472	1.3945

29 Computers & Other

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	1083.6	598.7	1137.5	946.9	910.1	1080.8	827.1	499.8
RMS Percent Error	38	0.5274	0.2835	0.5759	0.4723	0.4295	0.7516	0.6304	0.2149
Mean Simulation Error	38	-913.23	-476.41	-993.94	-815.83	-748.00	1053.73	783.92	-354.54
Mean Percent Error	38	-0.4960	-0.2577	-0.5616	-0.4559	-0.4021	0.7144	0.5692	-0.1790
AAPE	38	0.4960	0.2577	0.5616	0.4559	0.4021	0.7144	0.5692	0.1790
Theil's Inequality Coef	3	0.9660	0.7866	0.9722	0.9010	0.9000	1.2845	1.3539	1.0041

30 Service Industry Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	59.1	155.8	142.5	90.9	92.0	124.2	126.9	67.3
RMS Percent Error	2	0.2592	0.6632	0.6417	0.3630	0.3889	0.5172	0.5419	0.2735
Mean Simulation Error	38	45.13	132.61	124.38	-74.18	68.87	-37.62	-40.32	-31.37
Mean Percent Error	38	0.2004	0.5655	0.5436	-0.2980	0.2930	-0.1545	-0.1736	-0.1207
AAPE	38	0.2243	0.5655	0.5436	0.3039	0.3185	0.4409	0.4145	0.2184
Theil's Inequality Coef	2	1.7253	3.5515	1.8798	2.3089	2.5391	3.8075	4.3025	2.1677

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

31 Communications Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	3	1551.6	647.2	1063.1	1695.3	951.2	1407.4	1245.8	1329.1
RMS Percent Error	4	0.4545	0.3245	0.3026	0.5079	0.3686	0.7189	0.6735	0.6918
Mean Simulation Error	3	-1276.88	135.55	-792.10	-1399.75	-261.12	1260.96	961.96	1193.02
Mean Percent Error	6	-0.4050	0.1430	-0.2286	-0.4487	0.0178	0.5869	0.4892	0.5630
AAPE	3	0.4120	0.2600	0.2723	0.4487	0.2922	0.5869	0.4979	0.5630
Theil's Inequality Coef	4	0.9844	0.8960	0.8736	1.2227	1.3660	1.6081	1.6947	1.6134

32 Heavy Electrical Machinery

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	4	163.4	141.3	79.8	319.5	167.7	260.6	202.5	231.6
RMS Percent Error	4	0.2322	0.2462	0.1408	0.4752	0.2869	0.3868	0.3254	0.3605
Mean Simulation Error	4	-102.59	-32.49	-1.47	-279.63	-38.98	-187.83	-103.06	-156.60
Mean Percent Error	6	-0.1321	-0.0194	0.0229	-0.4308	-0.0180	-0.2654	-0.1231	-0.2167
AAPE	4	0.2097	0.2152	0.1230	0.4308	0.2601	0.3451	0.3004	0.3399
Theil's Inequality Coef	4	1.0007	1.1207	0.9489	1.5999	1.2664	1.1390	1.3671	1.4231

33 Household Appliances

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	25.1	82.1	52.6	46.4	82.4	118.2	147.8	93.6
RMS Percent Error	2	0.1489	0.5511	0.3310	0.2495	0.5414	0.6969	0.8633	0.5934
Mean Simulation Error	6	7.27	28.80	50.05	-22.75	4.69	-72.22	-47.28	82.54
Mean Percent Error	2	0.0613	0.2040	0.3061	-0.1124	0.0725	-0.3940	-0.2497	0.5063
AAPE	2	0.1345	0.3751	0.3061	0.2139	0.4099	0.6113	0.6444	0.5080
Theil's Inequality Coef	2	1.0273	3.7630	1.2278	2.6461	3.7825	3.7299	7.5467	3.1658

34 Elec. Lighting & Wiring Equip

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	119.0	238.9	279.8	242.7	222.5	128.6	140.4	91.5
RMS Percent Error	38	0.2599	0.4578	0.5725	0.4745	0.4318	0.2494	0.2692	0.1876
Mean Simulation Error	38	99.36	208.74	267.75	-212.98	175.73	49.57	67.04	21.44
Mean Percent Error	38	0.2094	0.4069	0.5394	-0.4148	0.3425	0.0883	0.1230	0.0409
AAPE	38	0.2094	0.4069	0.5394	0.4339	0.3649	0.2276	0.2477	0.1591
Theil's Inequality Coef	4	1.6707	2.4555	1.5284	3.0919	2.9068	2.0335	2.1549	1.8071

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

35 Radio,T.V. Receiving, Phono

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	45.6	68.3	54.4	42.1	96.0	76.7	82.9	33.7
RMS Percent Error	38	0.2774	0.4535	0.4055	0.2565	0.6596	0.4902	0.5492	0.2258
Mean Simulation Error	38	-40.03	58.35	48.04	-26.14	86.79	52.12	69.55	-22.77
Mean Percent Error	38	-0.2562	0.3895	0.3421	-0.1629	0.5957	0.3310	0.4634	-0.1525
AAPE	5	0.2562	0.3895	0.3421	0.1881	0.5957	0.3723	0.4634	0.1922
Theil's Inequality Coef	4	1.0966	2.1586	1.0042	2.0478	2.0309	2.7749	2.7449	1.4878

36 Motor Vehicles

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	1256.6	1636.8	1483.4	2014.2	1843.9	1588.1	1664.5	2533.9
RMS Percent Error	7	0.6452	0.7143	0.8392	1.2433	0.5226	0.3714	0.4039	0.7762
Mean Simulation Error	2	43.12	91.29	429.50	316.22	-694.96	-781.72	-665.58	-1102.15
Mean Percent Error	6	0.2213	0.2605	0.3948	0.4619	-0.1160	-0.1808	-0.1224	-0.1709
AAPE	7	0.4597	0.5442	0.6010	0.7979	0.4486	0.2830	0.3359	0.6818
Theil's Inequality Coef	4	1.0295	1.1987	1.0108	1.3490	1.2302	1.0864	1.1778	1.4835

37 Aerospace

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	6	496.2	296.3	366.7	556.9	247.2	383.0	313.7	270.9
RMS Percent Error	8	0.4367	0.3397	0.3596	0.4960	0.3923	0.3279	0.3165	0.4279
Mean Simulation Error	38	-412.34	-145.33	-270.88	-448.93	90.62	-282.08	-150.59	-4.72
Mean Percent Error	3	-0.3467	-0.0542	-0.1947	-0.3695	0.1868	-0.2327	-0.0755	0.1063
AAPE	6	0.4177	0.2905	0.3305	0.4530	0.2710	0.2743	0.2929	0.3151
Theil's Inequality Coef	2	0.9858	1.1866	1.0562	1.4477	1.5599	1.1361	1.2763	1.4684

38 Ships & Boats

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	1971.4	347.7	565.5	129.5	821.8	44.2	32.1	140.8
RMS Percent Error	8	8.2691	1.7827	2.8449	0.6460	3.6942	0.1885	0.1510	0.7137
Mean Simulation Error	8	1367.94	329.52	517.57	111.45	624.95	-32.04	-7.70	-135.35
Mean Percent Error	8	5.9950	1.6814	2.6154	0.5618	2.9936	-0.1404	-0.0164	-0.6887
AAPE	8	6.5925	1.6814	2.6154	0.5618	2.9936	0.1664	0.1079	0.6887
Theil's Inequality Coef	7	37.7038	1.9383	2.9508	2.6874	7.8194	0.9050	0.9109	1.9262

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 10
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

39 Other Trans. Equip.

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	84.3	117.8	209.9	141.6	116.8	85.0	67.2	113.6
RMS Percent Error	8	0.5433	0.7078	1.2193	0.7782	0.7125	0.4214	0.3218	0.5721
Mean Simulation Error	8	70.97	102.93	184.43	-127.61	101.01	-75.99	-48.82	-91.23
Mean Percent Error	8	0.4362	0.6041	1.0641	-0.7175	0.5995	-0.4017	-0.2353	-0.4680
AAPE	8	0.4424	0.6041	1.0641	0.7175	0.5995	0.4017	0.2841	0.4680
Theil's Inequality Coef	3	0.9719	0.9066	1.3525	2.6993	1.0377	1.1951	1.5932	2.5596

40 Instruments

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	4	208.1	244.5	170.5	245.5	224.7	292.2	249.2	199.2
RMS Percent Error	2	0.2173	0.3580	0.2454	0.2598	0.3483	0.4418	0.3707	0.2814
Mean Simulation Error	8	-63.33	52.08	78.83	-122.62	82.10	77.98	19.98	30.31
Mean Percent Error	2	-0.0181	0.1354	0.1373	-0.0852	0.1623	0.1796	0.0994	0.0955
AAPE	2	0.1814	0.2611	0.1968	0.2174	0.2376	0.3082	0.2638	0.1875
Theil's Inequality Coef	2	1.0206	1.4207	1.0367	1.2061	1.2459	1.6282	1.6365	1.1716

41 Miscellaneous Manufacturing

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	135.4	167.3	177.9	101.2	190.6	127.6	152.4	86.1
RMS Percent Error	38	0.4347	0.5351	0.5658	0.2636	0.5901	0.3471	0.4338	0.2603
Mean Simulation Error	7	123.49	156.62	170.49	-67.52	186.31	-20.64	85.48	61.39
Mean Percent Error	7	0.3795	0.4806	0.5194	-0.1797	0.5614	-0.0630	0.2548	0.1943
AAPE	5	0.3795	0.4806	0.5194	0.2044	0.5614	0.3055	0.3245	0.2391
Theil's Inequality Coef	2	1.0464	1.5473	1.0757	1.8086	1.3779	2.1702	2.8250	1.3764

42 Railroads

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	8	2555.9	1839.0	2498.5	2961.8	1891.0	1794.8	1638.9	2796.6
RMS Percent Error	7	0.5046	0.6637	0.7332	0.5981	0.6357	0.3037	0.5323	0.6622
Mean Simulation Error	3	-1353.45	18.15	-766.14	-2041.89	-221.07	-912.46	-231.26	-1959.85
Mean Percent Error	7	-0.0881	0.3155	0.1677	-0.3553	0.2474	-0.0703	0.1994	-0.4243
AAPE	7	0.4269	0.5788	0.6072	0.5781	0.5455	0.2621	0.4530	0.6039
Theil's Inequality Coef	8	1.0653	0.8040	1.0824	1.2159	0.8544	0.8168	0.7292	1.2553

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 11
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

43 Air Transport

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	4	1722.5	3255.4	1596.9	1825.9	2617.3	4943.2	4843.2	3073.4
RMS Percent Error	4	0.2632	0.5883	0.2308	0.3468	0.4630	0.9021	0.8889	0.5964
Mean Simulation Error	6	-1406.21	1201.68	-1228.36	609.49	-289.21	3908.81	3455.12	2616.94
Mean Percent Error	6	-0.2136	0.2262	-0.1832	0.1497	-0.0153	0.6957	0.6178	0.4849
AAPE	4	0.2432	0.5154	0.1847	0.2988	0.3786	0.7492	0.7619	0.4849
Theil's Inequality Coef	4	0.9654	2.3344	0.9558	1.5391	2.1684	2.5334	2.8378	1.6298

44 Trucking & Other Transport

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	1249.0	1779.0	3759.1	2720.3	2925.8	2205.4	2512.6	1552.3
RMS Percent Error	2	0.1474	0.2249	0.4861	0.3381	0.3835	0.2843	0.3254	0.2006
Mean Simulation Error	6	-488.69	935.66	2837.62	-2049.14	-114.63	-1960.59	-2050.21	-1019.32
Mean Percent Error	6	-0.0481	0.1115	0.3663	-0.2517	-0.0322	-0.2474	-0.2613	-0.1324
AAPE	2	0.1311	0.1630	0.3920	0.2968	0.3333	0.2474	0.2613	0.1595
Theil's Inequality Coef	7	1.0729	1.1492	1.0836	1.5696	2.3084	0.8688	1.0126	0.9231

45 Communications Services

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	5	6021.2	3775.5	4530.3	1570.2	2993.1	3994.4	3724.2	2271.4
RMS Percent Error	5	0.3348	0.2176	0.2562	0.0842	0.1754	0.2653	0.2465	0.1442
Mean Simulation Error	6	-5545.67	-3233.53	-4247.76	-1144.77	424.69	2634.98	1854.90	-1543.63
Mean Percent Error	6	-0.3229	-0.1904	-0.2503	-0.0631	0.0508	0.1805	0.1360	-0.0931
AAPE	5	0.3229	0.1904	0.2503	0.0656	0.1572	0.2185	0.2108	0.1220
Theil's Inequality Coef	5	0.9692	1.3913	0.8622	0.6644	1.2749	1.8780	1.9313	1.1684

46 Electric Utilities

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	4	2288.6	2711.4	1995.9	2130.0	3220.3	3030.2	2280.7	2865.3
RMS Percent Error	4	0.2145	0.2717	0.1904	0.1938	0.3429	0.3252	0.2484	0.2784
Mean Simulation Error	4	-327.95	-1307.96	-183.55	-350.41	-2169.76	-1928.94	-854.01	-2006.09
Mean Percent Error	5	0.0231	-0.1224	0.0335	0.0132	-0.2552	-0.2207	-0.0647	-0.2402
AAPE	4	0.1686	0.2222	0.1412	0.1428	0.2631	0.2768	0.2159	0.2402
Theil's Inequality Coef	8	0.9837	0.8939	0.9357	0.9434	0.8924	0.7368	0.7285	0.9697

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS

Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

47 Gas,water & Sanitation

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	6	1436.3	1910.3	2119.3	2660.2	1425.6	2349.3	2398.4	3426.5
RMS Percent Error	6	0.4660	0.4352	0.5063	0.6484	0.3311	0.6023	0.6085	0.8619
Mean Simulation Error	2	437.04	-1613.82	-1976.59	-2491.64	-1087.16	-2300.34	-2340.05	-3337.34
Mean Percent Error	2	0.1756	-0.3847	-0.4909	-0.6252	-0.2474	-0.5976	-0.6048	-0.8565
AAPE	6	0.3342	0.3847	0.4909	0.6251	0.3000	0.5976	0.6048	0.8565
Theil's Inequality Coef	2	1.1170	1.3119	1.3078	1.7939	1.1635	1.3358	1.3843	1.8528

48 Wholesale & Retail trade

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	4	6714.2	8522.8	4155.1	9811.7	9985.6	11182.1	11525.8	14911.4
RMS Percent Error	4	0.2006	0.2557	0.1316	0.3107	0.3176	0.3447	0.3712	0.4919
Mean Simulation Error	4	-4889.52	-7210.12	-1645.49	-8884.22	-8933.44	-9651.89	-10234.43	-14001.29
Mean Percent Error	4	-0.1481	-0.2346	-0.0324	-0.3011	-0.3027	-0.3193	-0.3463	-0.4867
AAPE	4	0.1757	0.2346	0.1199	0.3011	0.3027	0.3193	0.3463	0.4867
Theil's Inequality Coef	6	0.9860	0.7590	0.7903	0.6773	0.6320	0.8067	0.7300	1.2808

49 Finance, Insurance & Services

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	3641.2	2249.4	2215.5	2805.6	2263.8	2868.6	2894.3	2181.7
RMS Percent Error	3	0.3607	0.1931	0.1931	0.2675	0.1957	0.2589	0.2686	0.1950
Mean Simulation Error	3	-2873.22	-1274.26	-1426.81	-2071.99	-1365.90	-1957.60	-1859.35	-1409.53
Mean Percent Error	3	-0.3322	-0.1171	-0.1462	-0.2283	-0.1327	-0.2064	-0.1842	-0.1474
AAPE	3	0.3322	0.1261	0.1462	0.2283	0.1327	0.2064	0.2083	0.1474
Theil's Inequality Coef	5	0.9154	0.7605	0.7527	0.7168	0.7544	0.8448	0.7701	0.7377

50 Real Estate

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	827.8	1476.0	1787.1	1847.3	2583.8	4166.5	3604.6	7524.9
RMS Percent Error	2	0.0978	0.1696	0.2155	0.2315	0.3009	0.5183	0.4493	0.9447
Mean Simulation Error	2	-203.46	451.67	782.13	-392.57	-1394.32	-4123.17	-3564.93	-7502.19
Mean Percent Error	2	-0.0226	0.0503	0.0953	-0.0597	-0.1658	-0.5148	-0.4455	-0.9411
AAPE	2	0.0794	0.1170	0.1925	0.1938	0.2348	0.5148	0.4455	0.9411
Theil's Inequality Coef	2	0.8356	1.1297	1.1509	1.5424	2.1997	1.1409	1.0101	2.2076

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

51 Hotels & Repairs Minus Auto

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	909.6	629.7	582.3	626.5	715.3	752.6	737.7	335.9
RMS Percent Error	38	0.2684	0.2547	0.2362	0.1845	0.2806	0.2254	0.2779	0.1323
Mean Simulation Error	8	-752.54	366.04	466.07	-506.74	523.05	-445.32	111.48	163.54
Mean Percent Error	8	-0.2376	0.1571	0.1823	-0.1611	0.2031	-0.1263	0.0646	0.0734
AAPE	38	0.2376	0.1978	0.1846	0.1611	0.2357	0.1803	0.2344	0.1088
Theil's Inequality Coef	38	1.1118	1.1690	0.9743	1.0520	1.7577	1.0120	1.6442	0.7238

52 Business Services

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	38	3417.2	2150.7	1914.1	1258.2	1934.4	3548.7	3435.2	1128.2
RMS Percent Error	38	0.3677	0.2243	0.1820	0.1663	0.2358	0.3904	0.3912	0.1289
Mean Simulation Error	6	-2853.27	-1712.98	-1204.20	-673.28	-368.51	-3092.74	-2975.32	-706.52
Mean Percent Error	6	-0.3308	-0.1942	-0.1195	-0.0673	0.0046	-0.3650	-0.3531	-0.0772
AAPE	38	0.3313	0.1942	0.1339	0.1259	0.2312	0.3650	0.3531	0.1056
Theil's Inequality Coef	3	1.2224	0.7854	0.9611	1.2193	1.1644	0.8157	0.8366	0.8075

53 Auto Repair

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	7	1877.9	1530.3	1424.7	1190.5	1319.5	1173.6	1344.7	1542.2
RMS Percent Error	5	0.2905	0.2682	0.2141	0.1951	0.2380	0.2130	0.2455	0.2456
Mean Simulation Error	7	-1257.99	-1181.55	-795.63	-898.58	-958.98	-698.02	-859.45	-1122.30
Mean Percent Error	4	-0.2170	-0.2301	-0.1198	-0.1709	-0.1852	-0.1229	-0.1557	-0.2060
AAPE	4	0.2257	0.2301	0.1551	0.1709	0.2136	0.1871	0.2060	0.2060
Theil's Inequality Coef	5	1.0176	0.8214	0.9173	0.7030	0.7721	0.8318	0.9344	0.8992

54 Movies & Amusements

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	215.3	286.4	307.0	380.3	381.4	580.1	437.6	1123.4
RMS Percent Error	2	0.1291	0.1883	0.1989	0.2406	0.2399	0.3624	0.2498	0.6831
Mean Simulation Error	2	32.19	185.82	182.44	167.57	300.70	552.42	313.91	1096.45
Mean Percent Error	2	0.0343	0.1228	0.1219	0.1181	0.1838	0.3340	0.1705	0.6516
AAPE	2	0.1140	0.1444	0.1539	0.1829	0.1907	0.3340	0.2169	0.6516
Theil's Inequality Coef	6	0.8731	0.8891	1.0311	1.6759	0.8068	0.9789	1.8118	1.9096

Table 5.3 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS

Single-Equation Simulations - Estimated to 1977

Simulation 2: Autoregressive Model
Simulation 3: Accelerator Model
Simulation 4: Cobb-Douglas Model
Simulation 5: CES Model I
Simulation 6: CES Model II
Simulation 7: Generalized Leontief Putty-Clay Model
Simulation 8: Generalized Leontief Putty-Putty Model
Simulation 38: Dynamic Factor Demand Model

55 Medical & Ed. Services

Simulation :1978 to 1985	Best	2	3	4	5	6	7	8	38
Root Mean Square Error	2	1590.6	2386.7	1812.8	1753.1	1796.2	3227.9	3051.0	2281.3
RMS Percent Error	5	0.1673	0.2090	0.1628	0.1624	0.1691	0.2821	0.2739	0.1972
Mean Simulation Error	2	-467.42	-1684.93	-1071.69	-818.69	-951.78	-2561.24	-2071.36	-1631.29
Mean Percent Error	2	-0.0111	-0.1393	-0.0794	-0.0517	-0.0641	-0.2279	-0.1681	-0.1368
AAPE	5	0.1561	0.1836	0.1491	0.1445	0.1561	0.2386	0.2481	0.1651
Theil's Inequality Coef	3	0.9257	0.7928	0.8579	1.2022	0.8780	0.9184	1.2429	0.8852

Ranking of Simulations by Each Statistic

Simulation :	2	3	4	5	6	7	8	38
Root Mean Square Error	14	5	5	3	4	6	7	9
RMS Percent Error	12	6	5	5	2	8	7	8
Mean Simulation Error	11	5	5	3	8	3	10	8
Mean Percent Error	12	6	4	4	9	2	10	6
AAPE	11	7	5	6	3	7	7	7
Theil's Inequality Coef	15	7	9	4	8	5	2	3

Total RMSE and MSE Across all Industries

Simulation :	2	3	4	5	6	7	8	38
Root Mean Square Error	63164.6	62374.1	61489.7	79269.9	65984.3	72578.8	69241.7	83717.7
Mean Simulation Error	-13489.37	-5731.05	-509.06	-3394.96	-5910.91	-26124.89	-21178.01	-46511.20

Single Equation Simulations Estimated to 1977

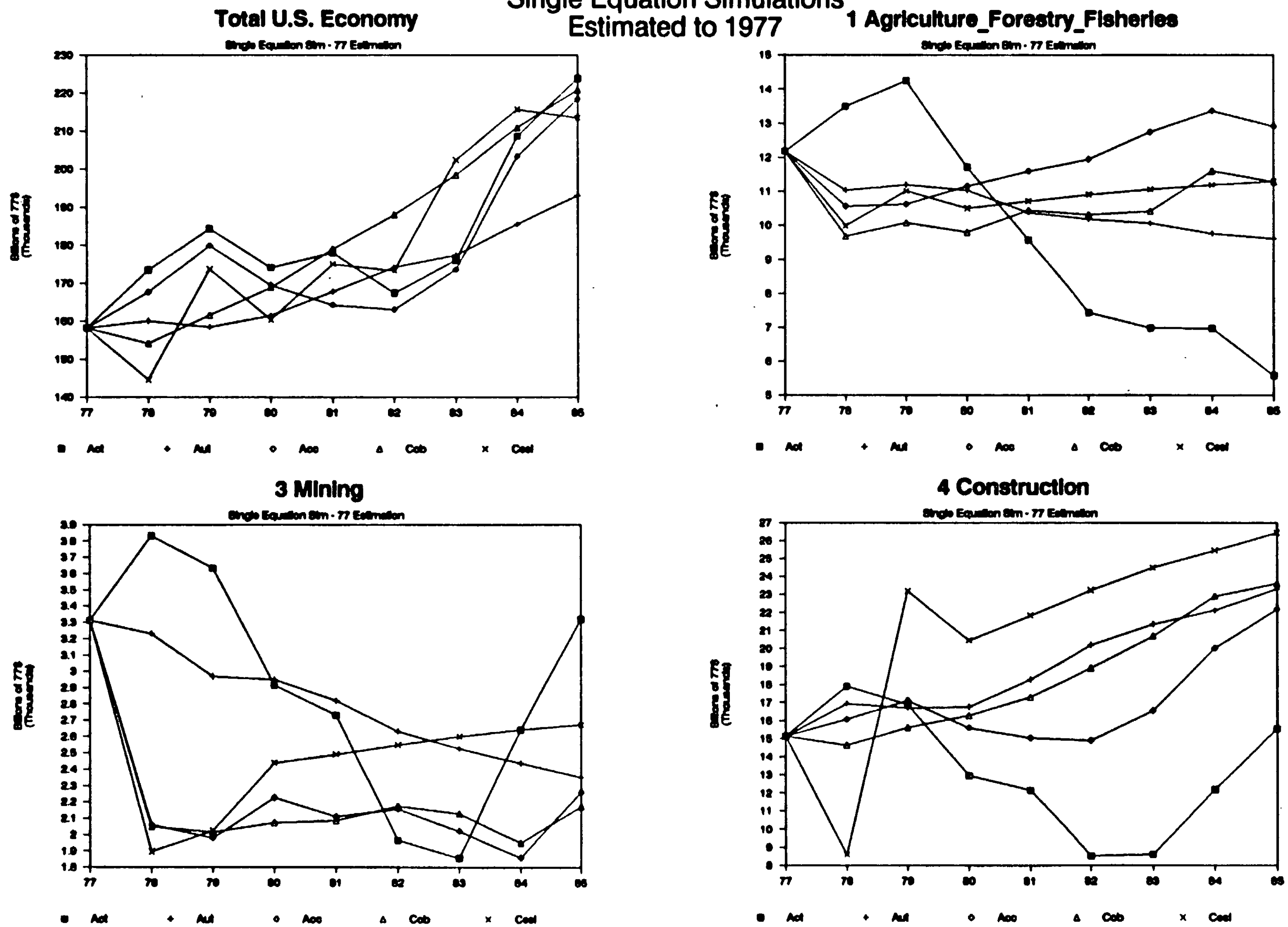


Figure 5.3.a

Single Equation Simulations
Estimated to 1977

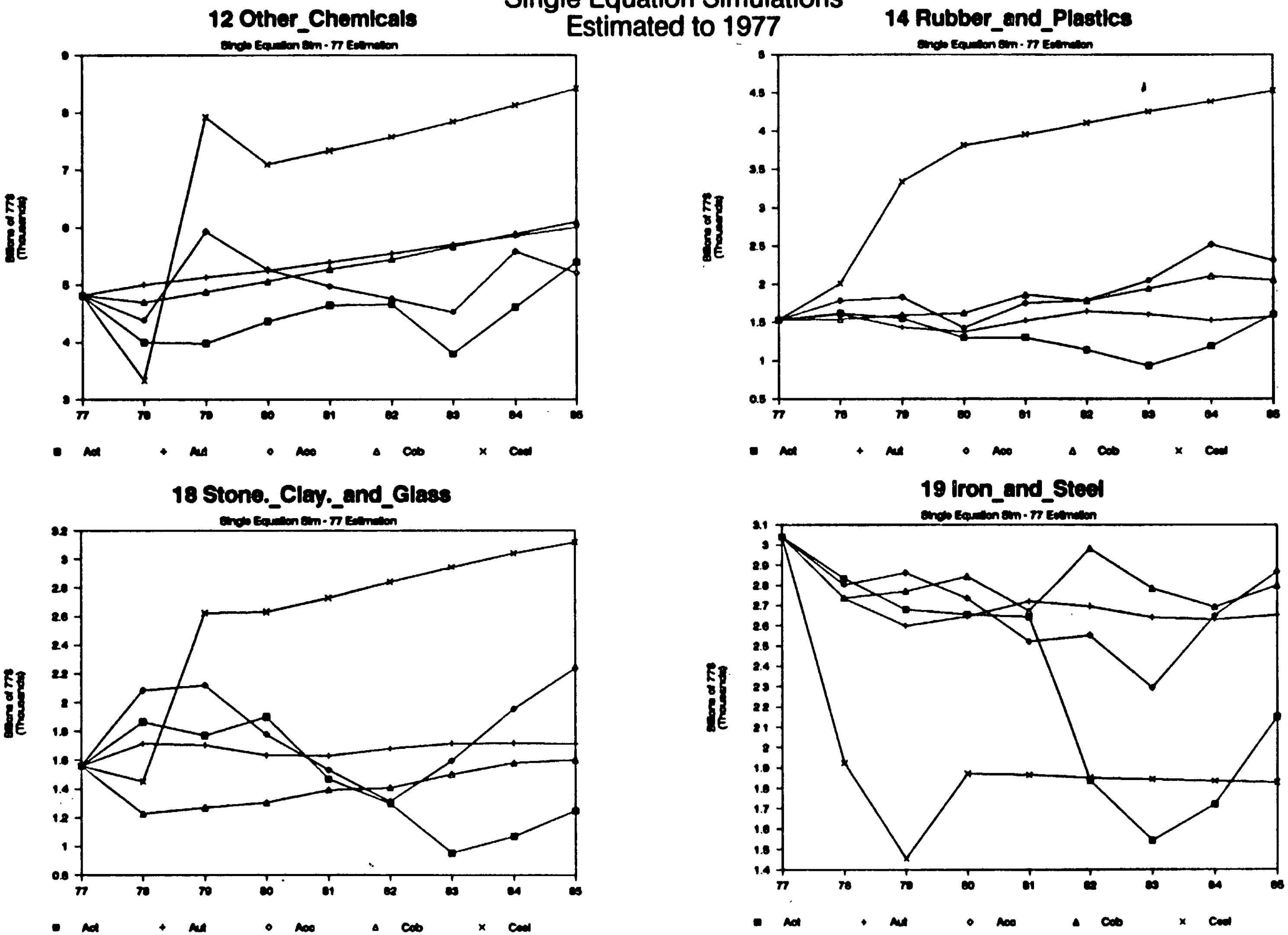
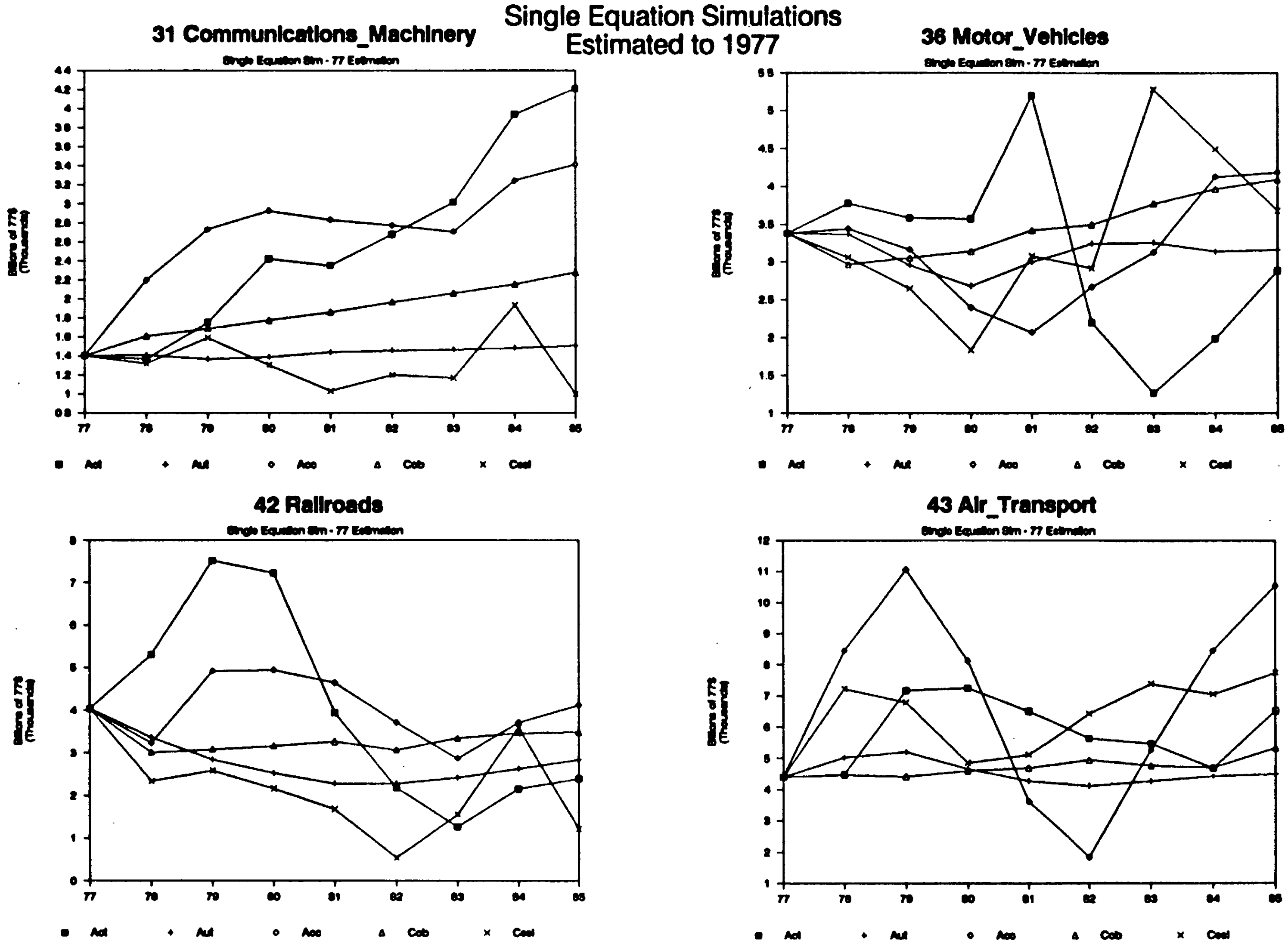


Figure 5.3.b



Single Equation Simulations
Estimated to 1977
31 Communications_Machinery
Single Equation Sim - 77 Estimation
Billions of 77$ (Thousands)
36 Motor_Vehicles
Single Equation Sim - 77 Estimation
42 Railroads
Single Equation Sim - 77 Estimation
43 Air_Transport
Single Equation Sim - 77 Estimation
77 78 79 80 81 82 83 84 85
Act
Aut
Aco
Cob
Cesl

Figure 5.3.c

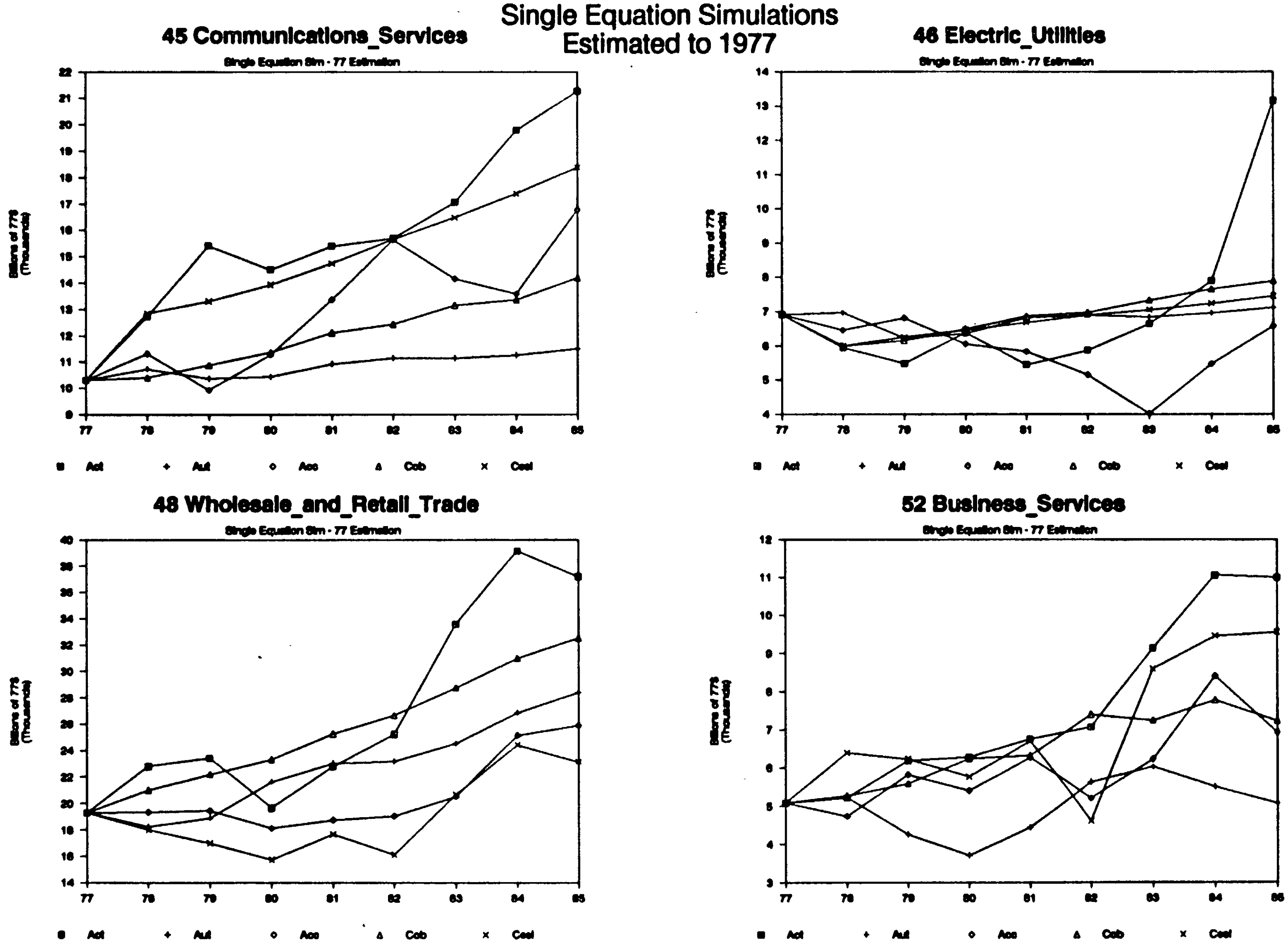

Single Equation Simulations
Estimated to 1977
45 Communications_Services
Single Equation Sim - 77 Estimation
46 Electric_Utilities
Single Equation Sim - 77 Estimation
48 Wholesale_and_Retail_Trade
Single Equation Sim - 77 Estimation
52 Business_Services
Single Equation Sim - 77 Estimation
Billions of 77$ (Thousands)
Act
Aut
Acc
Cob
Cesl

Figure 5.3.d

Single Equations Simulations
Estimated to 1977

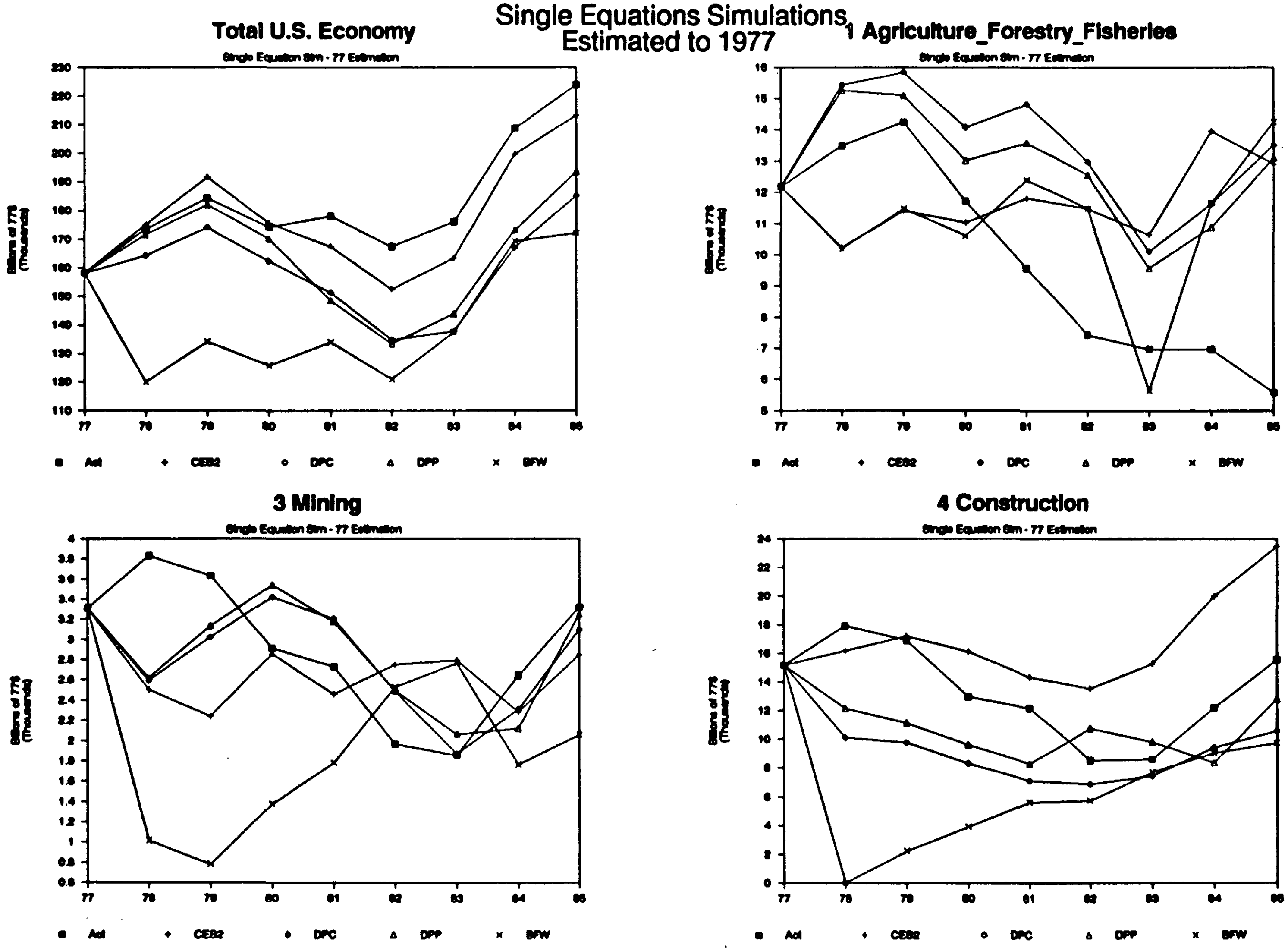


Figure 5.3.e

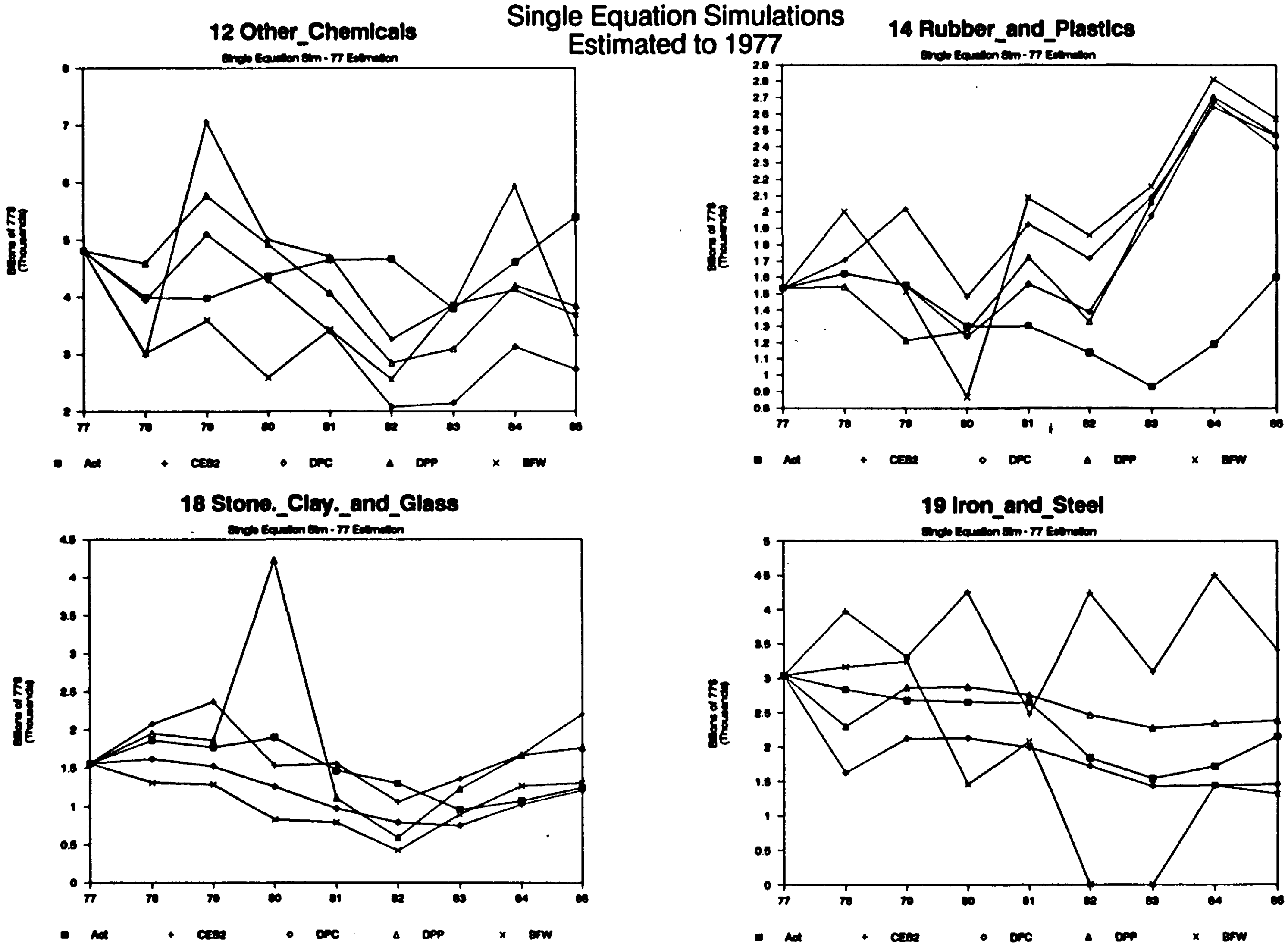

Single Equation Simulations
Estimated to 1977
12 Other_Chemicals
Single Equation Sim - 77 Estimation
14 Rubber_and_Plastics
Single Equation Sim - 77 Estimation
18 Stone._Clay._and_Glass
Single Equation Sim - 77 Estimation
19 Iron_and_Steel
Single Equation Sim - 77 Estimation
Act
CES2
DPC
DPP
BFW

Figure 5.3.f

Single Equation Simulations
Estimated to 1977

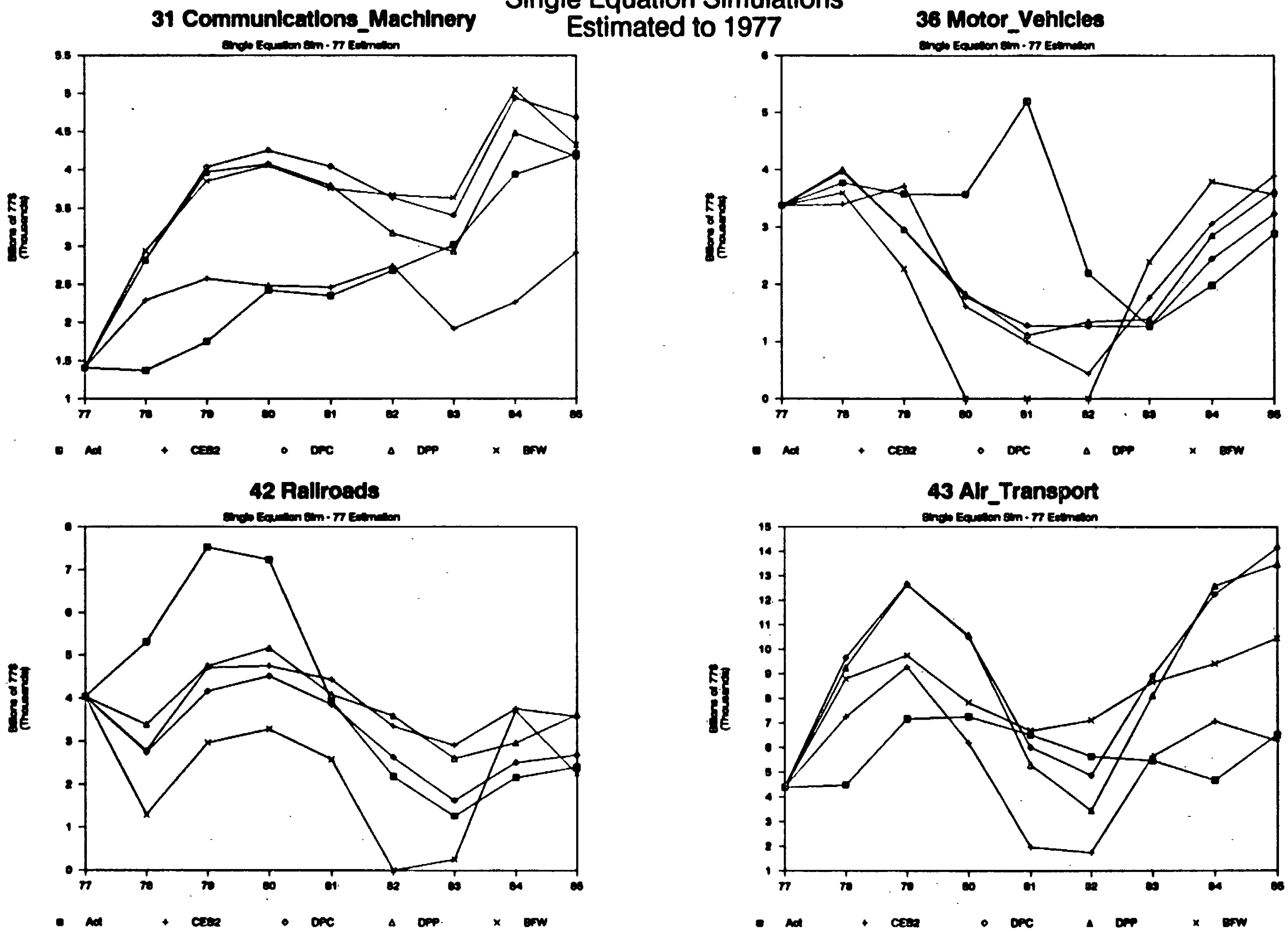


Figure 5.3.8

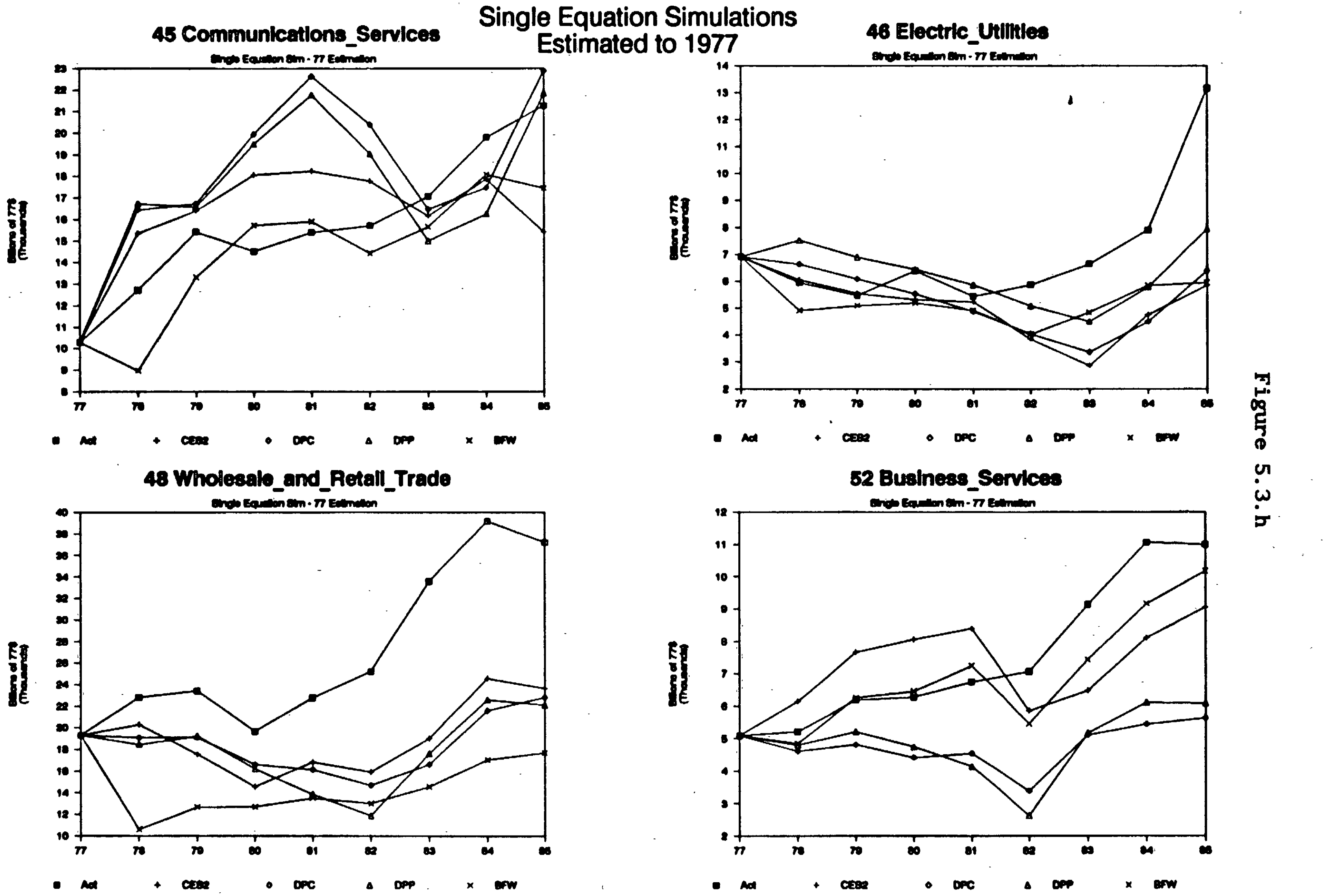

Single Equation Simulations
Estimated to 1977
45 Communications_Services
Single Equation Sim - 77 Estimation
46 Electric_Utilities
Single Equation Sim - 77 Estimation
48 Wholesale_and_Retail_Trade
Single Equation Sim - 77 Estimation
52 Business_Services
Single Equation Sim - 77 Estimation
Act
CES2
DPC
DPP
BFW

Figure 5.3.h

investment for the entire economy is the Accelerator Model, followed by the CES II Model. The *GL* models pick up the turning points well, but fall short of the proper level. The Cobb-Douglas and CES Model I don't follow the turning points very well, but end up at the correct trend value in 1985. The Autoregressive model utterly fails to capture the upturn of investment starting in 1984, but since this only lasts for two years in this sample, the model is not penalized too heavily.

3.b. Real-Side Simulations

Table 5.4 displays the summary simulation performance statistics for the final set of simulations: the out-of-sample simulations using the entire real side of the INFORUM model. This set of simulations is not only the most strenuous test of the equations, but also the most similar to the use to which the equations would be put in a real-world forecasting environment. Forecasts with the INFORUM model are typically made for years *outside* the period of estimation, and the full model is normally used to perform simulations.

Again, the Autoregressive Model performs best in most industries, as judged by counts of all statistics except for the *MSE* and *MPE,* for which the *GL* Putty-Putty Model dominates. Ranked in terms of total *RMSE*, the models fall into three groups: (1) the Cobb-Douglas Model, the *GL* Putty-Clay Model, the Autoregressive

Model, and the *GL* Putty-Putty Model, all with total *RMSE* in the range of 60,000 to 65,000; (2) the two CES models and the Accelerator Model, with total *RMSE* in the range of 70,000 to 75,000; and (3) the Dynamic Factor Demand Model, with total *RMSE* of about 94,000. If the ranking is done by total *MSE* aggregated across industries, then the Cobb-Douglas Model emerges as the clear winner.

The story told by looking at total *MSE* is the same as that of the graphs for the total U.S. economy, in Figures 5.4.a and 5.4.e. All of the models except the Cobb-Douglas Model underpredict in the aggregate, and the Cobb-Douglas Model comes the closest in forecasting total U.S. equipment investment. Many of the individual industry graphs reveal some of the same features as their predecessors in the previous sections. None of the models picks up the declines in investment in the Agriculture, Forestry and Fisheries (1) industry. Only the *GL* models track investment behavior closely in the Construction (4) industry. The Dynamic Factor Demand Model and the CES Model I are unacceptable for many industries. The two *GL* models yield qualitatively similar forecasts, yet sometimes at different levels.

3.c. Summary of Out-Of-Sample Simulations

A number of conclusions can be drawn from this last set of simulations. The Autoregressive model continues to be a safe bet, even when forecasting out-of-sample, at least within the time frame considered in these simulations. The Dynamic Factor Demand and the CES I models can be ruled out of consideration as desirable forecasting models.

In general, the performance of the out-of-sample simulations is significantly worse than the within-sample simulations, which is to be expected. However, in these simulations, the simulation fits for the *GL* Models, the Accelerator Model and the Cobb-Douglas Model are almost as good on average as those of the Autoregressive Model, and in many industries, they are better.

One problem with the Autoregressive Model is that it can be expected to do much worse in a long-term forecast, say, out to the year 2000, whereas models such as the Generalized Leontief or the Cobb-Douglas would be more likely to maintain investment at a reasonable level with respect to output and prices. Another problem with the Autoregressive Model is that simulations that change the path of industry outputs and prices with respect to a base case will have no impact on investment, which is contrary to experience. The *GL* Putty-Clay and the Cobb-Douglas both outperform the Autoregressive Model in the out-of-sample simulation in terms of total *RMSE* summed across all industries. The *GL* Putty-Putty model is not far behind. This criteria is likely to be more important than a mere industry count, since it weights each industry by its relative size in terms of equipment investment.

Since the two *GL* models are the richest in terms of the types of impacts that can be investigated, I would venture that based on the results of the simulations presented in this chapter, they are probably the preferred models. However, there remains much room for improvement, since none of these models provided simulation results that would inspire great confidence. A possible drawback of the *GL* models is that the many influences they incorporate into the equipment investment equation can cause the forecasts to go astray. If energy prices, wages or capital costs are forecasted inaccurately, then the investment forecast will be adversely affected. A simpler model like the Autoregressive or the Accelerator Model does not share this problem. However, the latter models severely limit the types of questions that can be asked with the model. For this reason I conclude that either of the Generalized Leontief models appears to be the most appealing, even though they are dominated by the Autoregressive in many respects.

Table 5.4

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS

Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

1 Agriculture

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	2680.6	4181.4	3926.8	4502.0	3650.2	4407.4	4498.5	5941.4
RMS Percent Error	18	0.3711	0.6183	0.5510	0.6698	0.5388	0.6902	0.7029	0.8987
Mean Simulation Error	22	906.88	2329.68	938.61	2195.08	566.89	1755.90	1728.23	1083.54
Mean Percent Error	18	0.1952	0.3953	0.2469	0.3953	0.1971	0.3374	0.3388	0.3293
AAPE	18	0.3089	0.4931	0.4301	0.5205	0.4059	0.5069	0.5154	0.6085
Theil's Inequality Coef	18	0.9922	1.1352	1.5700	1.4563	1.4898	2.2007	2.2617	3.1512

2 Crude Petroleum

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	19	1685.0	1271.6	2012.0	1686.8	1796.0	1683.7	1638.0	1445.2
RMS Percent Error	33	0.4281	0.4591	0.5152	0.4166	0.4817	0.4244	0.4222	0.3599
Mean Simulation Error	19	-1376.80	-219.10	-1487.50	-1171.15	-1526.95	-1180.52	-1145.32	-1025.38
Mean Percent Error	19	-0.3917	0.0516	-0.4021	-0.2931	-0.4479	-0.2965	-0.2869	-0.2586
AAPE	33	0.3917	0.3859	0.4579	0.3588	0.4479	0.3803	0.3745	0.3200
Theil's Inequality Coef	33	1.0658	1.0873	1.6491	1.3378	1.3225	1.1817	1.0924	1.0468

3 Mining

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	579.3	1022.3	935.5	782.9	998.4	490.0	499.9	1470.8
RMS Percent Error	23	0.2221	0.2999	0.2743	0.2702	0.2914	0.1543	0.1647	0.4299
Mean Simulation Error	18	-123.70	-785.31	-706.90	-253.40	-744.66	-292.27	-131.23	-962.56
Mean Percent Error	18	0.0040	-0.2307	-0.2076	-0.0279	-0.2168	-0.0965	-0.0295	-0.2565
AAPE	23	0.1815	0.2642	0.2408	0.2274	0.2568	0.1341	0.1504	0.3821
Theil's Inequality Coef	23	1.0000	1.4588	1.4646	1.4881	1.5539	0.7524	0.8046	2.2306

4 Construction

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	24	7986.1	6725.3	7912.4	6638.9	10756.7	3868.2	3486.6	7893.4
RMS Percent Error	24	0.8157	0.6022	0.7416	0.5675	0.8509	0.2783	0.2484	0.4965
Mean Simulation Error	24	6363.67	6133.35	6793.08	5825.58	2944.80	2882.52	2170.22	-6128.38
Mean Percent Error	22	0.6124	0.5172	0.6086	0.4806	0.1491	0.2151	0.1581	-0.4098
AAPE	24	0.6282	0.5172	0.6086	0.4962	0.6340	0.2449	0.2372	0.4164
Theil's Inequality Coef	36	1.0388	1.1524	0.7452	1.5284	5.4942	1.2714	1.2823	2.1909

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 2
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

5 Food, Tobacco

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	1018.8	1258.7	867.7	1266.5	529.6	354.0	459.7	2734.3
RMS Percent Error	23	0.2824	0.3441	0.2387	0.3460	0.1519	0.0969	0.1297	0.7475
Mean Simulation Error	23	970.23	1207.90	776.41	1220.43	297.36	142.19	314.95	-2611.59
Mean Percent Error	23	0.2655	0.3278	0.2112	0.3310	0.0852	0.0441	0.0906	-0.7094
AAPE	23	0.2655	0.3278	0.2112	0.3310	0.1222	0.0813	0.1072	0.7094
Theil's Inequality Coef	36	1.0028	0.9589	0.9168	0.9361	2.2262	1.0679	1.1242	3.9389

6 Textiles

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	158.6	663.6	296.7	524.6	195.7	224.1	375.7	428.8
RMS Percent Error	18	0.1943	0.7614	0.3479	0.6121	0.2126	0.2596	0.4341	0.5013
Mean Simulation Error	22	132.22	634.77	286.24	454.85	59.68	92.78	318.31	386.20
Mean Percent Error	22	0.1606	0.7261	0.3313	0.5253	0.0775	0.1065	0.3655	0.4480
AAPE	22	0.1669	0.7261	0.3313	0.5253	0.1645	0.2166	0.3655	0.4480
Theil's Inequality Coef	18	0.9611	3.1593	1.1866	3.8008	2.1874	2.4500	2.8917	3.2529

7 Knitting, Hosiery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	37.5	71.7	147.4	74.5	67.4	59.6	46.4	73.6
RMS Percent Error	18	0.1862	0.5243	1.0384	0.5171	0.3914	0.3189	0.3033	0.4238
Mean Simulation Error	24	-19.75	44.65	108.79	48.62	-40.77	-42.89	1.68	-56.73
Mean Percent Error	24	-0.0790	0.3208	0.7593	0.3495	-0.2063	-0.2102	0.0522	-0.3058
AAPE	18	0.1595	0.3697	0.7958	0.4111	0.3312	0.2961	0.2417	0.3875
Theil's Inequality Coef	18	1.0054	2.0458	1.5249	1.3581	2.4998	1.6262	1.4304	2.1267

8 Apparel

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	142.5	623.3	442.4	503.6	465.6	212.4	326.6	294.5
RMS Percent Error	18	0.4522	1.8917	1.3295	1.5404	1.4435	0.6799	1.0215	0.9232
Mean Simulation Error	18	132.98	615.19	439.96	498.70	438.65	193.84	317.62	271.15
Mean Percent Error	18	0.4137	1.8518	1.3167	1.5075	1.3402	0.6040	0.9729	0.8347
AAPE	18	0.4137	1.8518	1.3167	1.5075	1.3402	0.6040	0.9729	0.8347
Theil's Inequality Coef	18	0.8150	2.9619	1.6612	2.3271	3.1954	1.6368	1.8118	2.0891

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 3
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

9 Paper

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	507.3	404.5	329.4	378.8	836.9	396.1	478.4	1320.6
RMS Percent Error	36	0.1264	0.1086	0.0950	0.1208	0.2693	0.1200	0.1484	0.3990
Mean Simulation Error	36	-223.25	-214.90	-102.21	210.87	-514.46	-244.27	-255.23	-1153.25
Mean Percent Error	36	-0.0517	-0.0569	-0.0233	0.0706	-0.1651	-0.0736	-0.0782	-0.3500
AAPE	19	0.0972	0.0792	0.0825	0.0936	0.2438	0.1032	0.1306	0.3500
Theil's Inequality Coef	21	0.9824	1.0778	0.7690	0.7672	2.5438	0.9636	1.1526	1.8717

10 Printing

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	21	335.6	167.0	250.3	160.2	327.6	225.9	239.3	875.7
RMS Percent Error	21	0.1304	0.0832	0.1040	0.0804	0.1705	0.1172	0.1138	0.4729
Mean Simulation Error	24	-235.29	70.14	-172.14	56.93	78.32	110.75	-27.49	744.35
Mean Percent Error	24	-0.1033	0.0420	-0.0779	0.0361	0.0364	0.0636	-0.0044	0.3887
AAPE	21	0.1033	0.0712	0.0877	0.0584	0.1419	0.1016	0.1022	0.3887
Theil's Inequality Coef	21	0.8752	0.8232	0.8928	0.8138	2.0589	1.0799	1.2135	3.2359

11 Agri. Fertilizers

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	24	1059.1	672.7	1509.1	759.7	719.0	331.3	290.7	389.1
RMS Percent Error	33	4.0733	2.7005	5.9764	2.9928	2.7156	1.2507	0.9786	0.8744
Mean Simulation Error	24	985.00	523.21	1309.77	519.05	201.84	164.82	46.91	-201.94
Mean Percent Error	33	3.3018	1.9730	4.5656	2.0379	1.2757	0.7447	0.3916	-0.2073
AAPE	24	3.3018	2.0256	4.5656	2.1931	1.9537	0.8773	0.6688	0.8592
Theil's Inequality Coef	23	1.2126	1.6530	1.8093	2.3688	3.8037	1.0832	1.1970	1.3633

12 Other Chemicals

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	19	1118.5	900.2	1240.9	1341.4	1380.0	1555.0	1223.3	1313.4
RMS Percent Error	19	0.2711	0.2192	0.2960	0.3189	0.3286	0.3428	0.2784	0.2970
Mean Simulation Error	24	1053.84	661.28	1132.85	139.49	-266.97	-948.79	-20.69	-1093.96
Mean Percent Error	24	0.2474	0.1583	0.2635	0.0429	-0.0515	-0.2030	0.0099	-0.2449
AAPE	19	0.2474	0.1682	0.2635	0.2356	0.2630	0.2855	0.2182	0.2606
Theil's Inequality Coef	18	1.0173	1.4154	1.1251	3.3095	3.0626	1.8506	2.1552	1.6177

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulatioff 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

13 Petroleum Refining

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	1059.2	1467.0	677.1	1375.2	1122.5	1107.9	1058.1	1346.7
RMS Percent Error	36	0.4511	0.6414	0.2913	0.6047	0.4808	0.5036	0.5248	0.5901
Mean Simulation Error	36	-905.95	-1251.76	-497.01	-920.35	-939.09	-732.70	-640.80	-1211.37
Mean Percent Error	36	-0.3908	-0.5481	-0.2057	-0.3557	-0.3998	-0.2670	-0.2196	-0.5440
AAPE	36	0.4227	0.5718	0.2540	0.5284	0.4483	0.4622	0.4992	0.5440
Theil's Inequality Coef	36	1.0420	1.1533	0.8883	1.4629	1.0589	1.4030	1.5248	1.1110

14 Rubber & Plastics

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	335.5	696.3	774.0	758.9	649.5	588.9	667.1	814.3
RMS Percent Error	18	0.3250	0.6361	0.6926	0.6540	0.5669	0.5107	0.5863	0.7162
Mean Simulation Error	18	207.87	551.67	662.06	630.80	421.53	315.06	268.55	475.66
Mean Percent Error	18	0.1981	0.4700	0.5538	0.5192	0.3630	0.2659	0.2359	0.4221
AAPE	18	0.2237	0.4700	0.5538	0.5192	0.4108	0.4031	0.4459	0.6018
Theil's Inequality Coef	18	1.0580	1.4192	1.2654	1.2605	1.5859	1.9424	2.5680	2.3080

15 Footwear & Leather

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	22	53.7	91.8	49.7	121.4	38.9	69.8	89.5	73.5
RMS Percent Error	22	0.7639	1.1371	0.6884	1.3549	0.5706	0.8644	1.0996	0.9549
Mean Simulation Error	33	51.42	29.29	48.01	71.28	34.60	43.82	60.61	-2.96
Mean Percent Error	33	0.6971	0.3064	0.6433	0.8086	0.4814	0.5392	0.7489	-0.0829
AAPE	22	0.6971	1.0009	0.6433	1.0548	0.4814	0.5941	0.7569	0.8135
Theil's Inequality Coef	18	1.2244	3.6587	1.5282	5.3412	1.5020	3.2702	4.3337	3.6549

16 Lumber

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	369.9	798.7	809.7	753.1	1644.1	526.8	600.8	760.3
RMS Percent Error	18	0.4891	0.9998	1.0301	0.9213	1.7261	0.5658	0.6580	0.7573
Mean Simulation Error	33	203.37	617.07	667.76	549.52	273.52	153.17	255.45	22.44
Mean Percent Error	33	0.2998	0.7481	0.8077	0.6598	0.3564	0.2031	0.3154	0.1643
AAPE	23	0.3839	0.7481	0.8077	0.6598	1.0732	0.3784	0.4002	0.6206
Theil's Inequality Coef	36	1.1259	1.4440	1.0633	1.5536	8.9006	2.3099	2.4465	3.2410

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 5
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

17 Furniture

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	82.7	138.7	127.8	88.0	58.8	44.5	62.3	89.6
RMS Percent Error	23	0.3024	0.4785	0.4519	0.3143	0.2083	0.1552	0.2224	0.2722
Mean Simulation Error	22	66.03	131.82	113.85	78.22	14.70	15.49	25.74	-53.64
Mean Percent Error	23	0.2348	0.4374	0.3845	0.2676	0.0588	0.0504	0.0850	-0.1499
AAPE	23	0.2452	0.4374	0.3845	0.2676	0.1637	0.1081	0.1678	0.2320
Theil's Inequality Coef	21	1.0161	1.1119	1.0914	0.9738	2.0135	1.3714	1.7196	2.0269

18 Stone,Clay & Glass

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	24	430.1	577.9	511.9	573.4	856.4	353.1	282.6	721.8
RMS Percent Error	24	0.3977	0.5131	0.4363	0.4561	0.6384	0.2318	0.2222	0.4292
Mean Simulation Error	24	239.83	338.95	205.30	221.74	-519.87	-250.25	80.13	-523.51
Mean Percent Error	24	0.2389	0.3108	0.2205	0.2113	-0.3833	-0.1624	0.0793	-0.3089
AAPE	24	0.3043	0.3830	0.3396	0.3901	0.5489	0.1961	0.1879	0.3544
Theil's Inequality Coef	23	0.9965	1.3719	1.6819	2.1065	2.6129	0.8884	0.9141	1.7152

19 Iron & Steel

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	616.8	615.4	650.9	1622.4	795.4	426.4	594.3	958.5
RMS Percent Error	23	0.3642	0.3508	0.3781	0.8698	0.4153	0.1685	0.3492	0.4386
Mean Simulation Error	24	406.92	431.53	450.67	1394.08	352.63	-352.52	347.72	-649.80
Mean Percent Error	23	0.2376	0.2429	0.2564	0.7084	0.2056	-0.1418	0.2093	-0.2902
AAPE	23	0.2546	0.2646	0.2824	0.7226	0.3062	0.1486	0.2378	0.3516
Theil's Inequality Coef	18	0.9361	1.0689	1.3233	3.7798	3.4547	1.0374	1.3810	2.7245

20 Non-Ferrous Metals

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	24	257.6	404.9	500.7	484.2	483.2	306.9	189.0	573.4
RMS Percent Error	24	0.2410	0.3594	0.4640	0.4355	0.4134	0.2677	0.1678	0.4629
Mean Simulation Error	24	171.55	361.02	447.65	417.08	-160.35	-245.81	36.45	-466.92
Mean Percent Error	24	0.1608	0.3174	0.4019	0.3711	-0.1517	-0.2133	0.0280	-0.3818
AAPE	24	0.1988	0.3174	0.4019	0.3711	0.3784	0.2179	0.1297	0.3818
Theil's Inequality Coef	18	1.1592	1.1596	1.2899	1.9545	2.9276	1.2198	1.2010	1.9103

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 6
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

21 Metal Products

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	434.8	760.7	760.9	712.1	640.6	624.0	654.7	662.3
RMS Percent Error	18	0.2722	0.4363	0.4497	0.4074	0.2964	0.3008	0.3374	0.3542
Mean Simulation Error	23	285.20	586.71	590.13	487.49	-120.77	52.01	184.90	191.91
Mean Percent Error	22	0.1730	0.3295	0.3361	0.2793	-0.0354	0.0483	0.1201	0.1343
AAPE	18	0.1935	0.3582	0.3500	0.3264	0.2583	0.2713	0.2854	0.2820
Theil's Inequality Coef	18	1.0239	1.4401	1.3028	1.9265	2.5270	1.8228	1.7729	1.8426

22 Engines & Turbines

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	64.1	103.6	131.5	90.9	221.2	140.7	112.3	102.2
RMS Percent Error	18	0.2114	0.3530	0.4498	0.3058	0.6191	0.3906	0.3386	0.3047
Mean Simulation Error	18	2.67	11.64	109.19	38.61	-107.59	-93.28	-36.74	-84.91
Mean Percent Error	18	0.0448	0.0837	0.3658	0.1567	-0.2826	-0.2383	-0.0628	-0.2584
AAPE	18	0.1817	0.2653	0.3747	0.2782	0.5138	0.3335	0.2700	0.2584
Theil's Inequality Coef	33	1.1580	1.4761	1.4422	1.2555	2.2175	1.3055	1.4299	0.7065

23 Agri. Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	24	129.6	109.0	170.0	103.1	97.8	100.1	97.2	143.0
RMS Percent Error	23	1.0047	0.8406	1.2970	0.8032	0.4418	0.4200	0.6012	0.6607
Mean Simulation Error	24	102.73	71.08	127.77	59.56	-34.32	-38.42	-0.80	-67.00
Mean Percent Error	22	0.7096	0.5410	0.9033	0.4794	-0.0588	-0.0607	0.1747	-0.1925
AAPE	22	0.7096	0.5776	0.9066	0.5562	0.3460	0.3670	0.4874	0.5312
Theil's Inequality Coef	21	1.3317	1.0844	1.2395	1.0552	1.8150	1.5374	1.4417	2.0254

25 Metalworking Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	19	76.0	70.3	80.2	126.7	86.6	235.3	256.7	131.7
RMS Percent Error	19	0.2287	0.1718	0.2405	0.3319	0.1886	0.5866	0.6314	0.3977
Mean Simulation Error	23	8.85	-12.21	23.90	103.50	-47.97	8.13	87.37	115.43
Mean Percent Error	19	0.0558	-0.0151	0.0948	0.2759	-0.0942	-0.0233	0.1955	0.3276
AAPE	19	0.1808	0.1314	0.1814	0.3008	0.1438	0.5591	0.4800	0.3276
Theil's Inequality Coef	18	1.0396	1.5306	1.4543	1.4936	1.1889	2.8382	3.5606	1.3209

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 7
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

27 Special Industry Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	22	46.2	50.0	49.6	60.4	41.9	109.8	96.8	70.3
RMS Percent Error	22	0.2771	0.2940	0.2921	0.3504	0.2523	0.5306	0.5434	0.4139
Mean Simulation Error	24	35.97	34.84	36.08	52.36	31.70	-85.23	-5.04	60.64
Mean Percent Error	24	0.2034	0.1960	0.2035	0.2840	0.1791	-0.4069	0.0280	0.3324
AAPE	22	0.2195	0.2287	0.2325	0.2840	0.1817	0.4069	0.4498	0.3324
Theil's Inequality Coef	18	0.9431	1.7659	1.6340	1.4232	1.0799	3.4298	4.6321	1.1290

28 Misc.nonelec. Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	19	233.1	205.9	399.2	255.2	830.1	554.7	374.4	760.7
RMS Percent Error	19	0.1815	0.1277	0.2996	0.1587	0.5025	0.3676	0.2400	0.4866
Mean Simulation Error	21	69.46	-45.24	251.05	-28.52	-504.39	-434.10	-199.60	-712.45
Mean Percent Error	21	0.0654	-0.0159	0.1894	-0.0053	-0.3017	-0.2882	-0.1291	-0.4581
AAPE	19	0.1282	0.1024	0.2276	0.1292	0.4143	0.3061	0.2129	0.4581
Theil's Inequality Coef	18	0.9994	1.0674	1.2230	1.4607	4.5774	1.1421	1.2626	2.1727

29 Computers & Other

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	1083.6	1022.0	946.1	1056.4	959.9	826.3	963.2	1103.1
RMS Percent Error	19	0.5274	0.4872	0.4948	0.5133	0.4979	0.5328	0.5844	0.5487
Mean Simulation Error	23	-913.23	-836.57	-829.18	-889.81	-839.77	-233.91	-336.97	-925.60
Mean Percent Error	23	-0.4960	-0.4532	-0.4817	-0.4852	-0.4813	0.0056	-0.0803	-0.5244
AAPE	23	0.4960	0.4532	0.4817	0.4852	0.4813	0.4507	0.4932	0.5244
Theil's Inequality Coef	18	0.9660	1.3720	1.2176	0.9970	1.3103	2.5876	3.5351	1.7312

30 Service Industry Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	59.1	129.8	170.3	89.9	92.3	147.0	106.9	99.5
RMS Percent Error	18	0.2592	0.5517	0.7497	0.3753	0.3665	0.6311	0.4610	0.4071
Mean Simulation Error	24	45.13	98.90	152.65	43.05	-81.23	-85.79	-35.15	-81.10
Mean Percent Error	24	0.2004	0.4281	0.6632	0.1870	-0.3319	-0.3670	-0.1589	-0.3341
AAPE	18	0.2243	0.4675	0.6632	0.3164	0.331ns+#Ks#3;s33k			
Theil's Inequality Coef	18	1.7253	3.3383	2.1350	2.8927	1.8400	3.3034	3.2913	2.3849

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 8

Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

31 Communications Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	1551.6	993.0	835.7	1228.0	1837.8	1547.7	1377.3	1301.7
RMS Percent Error	36	0.4545	0.3412	0.2547	0.4244	0.5650	0.6844	0.6080	0.4285
Mean Simulation Error	33	-1276.88	-411.40	-528.27	-585.28	-1467.66	-290.77	-393.94	-138.79
Mean Percent Error	24	-0.4050	-0.0442	-0.1271	-0.0881	-0.4918	0.0930	0.0220	0.0740
AAPE	36	0.4120	0.2885	0.2285	0.3758	0.4918	0.5840	0.5186	0.3507
Theil's Inequality Coef	36	0.9844	1.2368	0.9319	1.3535	2.8196	2.0248	2.0953	2.8947

32 Heavy Electrical Machinery

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	163.4	161.6	82.1	184.8	323.8	313.1	226.4	298.9
RMS Percent Error	36	0.2322	0.2617	0.1550	0.3045	0.4910	0.4656	0.3769	0.4657
Mean Simulation Error	36	-102.59	-65.01	22.14	-68.76	-281.69	-216.78	-94.54	-266.56
Mean Percent Error	36	-0.1321	-0.0679	0.0606	-0.0630	-0.4437	-0.2979	-0.0942	-0.4247
AAPE	36	0.2097	0.2301	0.1312	0.2768	0.4437	0.4250	0.3437	0.4247
Theil's Inequality Coef	18	1.0007	1.3423	1.0147	1.4610	2.3102	1.5319	1.7929	2.3240

33 Household Appliances

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	25.1	58.2	58.5	68.9	31.0	97.6	89.0	61.1
RMS Percent Error	18	0.1489	0.3924	0.3560	0.4490	0.1593	0.5683	0.5832	0.3767
Mean Simulation Error	21	7.27	32.33	57.49	0.25	-23.60	-83.26	-56.71	57.63
Mean Percent Error	21	0.0613	0.2141	0.3430	0.0389	-0.1253	-0.4806	-0.3680	0.3451
AAPE	22	0.1345	0.2907	0.3430	0.3439	0.1300	0.4806	0.4214	0.3451
Theil's Inequality Coef	18	1.0273	2.7034	1.3778	3.3176	1.3114	2.3592	3.7135	1.5539

34 Elec. Lighting & Wiring Equip

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	33	119.0	227.6	339.7	225.7	245.9	113.4	114.5	73.7
RMS Percent Error	33	0.2599	0.4439	0.6762	0.4431	0.4782	0.2275	0.2283	0.1573
Mean Simulation Error	33	99.36	190.37	321.31	158.82	-229.68	16.71	27.64	-3.68
Mean Percent Error	33	0.2094	0.3746	0.6402	0.3116	-0.4481	0.0292	0.0512	-0.0048
AAPE	33	0.2094	0.4030	0.6402	0.3805	0.4481	0.1880	0.2106	0.1282
Theil's Inequality Coef	33	1.6707	2.7445	2.4780	3.4110	2.5251	2.0694	2.1139	1.3498

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 9
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

35 Radio,T.V. Receiving, Phono

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	45.6	90.4	64.1	85.3	66.5	53.7	53.9	82.4
RMS Percent Error	18	0.2774	0.5709	0.4909	0.6202	0.3919	0.3595	0.3563	0.4749
Mean Simulation Error	19	-40.03	16.17	56.20	78.12	-35.79	17.74	17.05	-55.59
Mean Percent Error	24	-0.2562	0.1809	0.4103	0.5505	-0.2208	0.1579	0.1498	-0.3313
AAPE	22	0.2562	0.5014	0.4103	0.5505	0.2247	0.3177	0.3098	0.3417
Theil's Inequality Coef	18	1.0966	3.3594	1.7398	2.0789	4.0129	2.0313	1.9660	2.9770

36 Motor Vehicles

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	1256.6	1725.7	1627.5	1845.4	2051.1	1571.4	1633.4	2497.7
RMS Percent Error	23	0.6452	0.8473	0.8918	0.6438	1.1790	0.4728	0.5074	0.8517
Mean Simulation Error	18	43.12	252.02	519.49	-341.96	475.48	183.91	204.15	-826.97
Mean Percent Error	33	0.2213	0.3479	0.4402	0.0636	0.5082	0.1747	0.1900	0.0003
AAPE	23	0.4597	0.6109	0.6494	0.5527	0.8293	0.4200	0.4520	0.7480
Theil's Inequality Coef	18	1.0295	1.2412	1.0805	1.3608	1.4765	1.3295	1.3573	1.4135

37 Aerospace

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	21	496.2	360.9	298.4	247.1	521.1	337.7	267.1	265.8
RMS Percent Error	24	0.4367	0.3854	0.3100	0.3593	0.4660	0.3050	0.2576	0.3902
Mean Simulation Error	21	-412.34	-221.37	-220.91	48.19	-434.49	-230.93	-155.87	-66.76
Mean Percent Error	33	-0.3467	-0.1308	-0.1578	0.1190	-0.3716	-0.1806	-0.1094	0.0333
AAPE	24	0.4177	0.3628	0.2857	0.2756	0.4247	0.2734	0.2287	0.3050
Theil's Inequality Coef	36	0.9858	1,4030	0.9689	1.9627	1.3728	1.2692	1.2697	1.4591

38 Ships & Boats

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	1971.4	354.6	586.6	819.9	305.5	34.8	43.2	149.7
RMS Percent Error	23	8.2691	1.8291	2.9197	3.7086	1.6155	0.1962	0.2376	0.7769
Mean Simulation Error	24	1367.94	325.98	527.74	624.13	162.41	11.95	-5.57	-137.71
Mean Percent Error	24	5.9950	1.6656	2.6561	2.9969	0.8606	0.0714	-0.0193	-0.7133
AAPE	23	6.5925	1.6656	2.6561	2.9969	1.4479	0.1516	0.2104	0.7133
Theil's Inequality Coef	23	37.7038	2.7406	3.4116	8.0610	9.6894	0.9070	1.0872	2.0223

Table 5.4 (continued)

Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

39 Other Trans. Equip.

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	24	84.3	121.4	210.7	121.8	143.4	61.7	52.3	115.5
RMS Percent Error	24	0.5433	0.7420	1.2298	0.7426	0.7564	0.3227	0.2853	0.5891
Mean Simulation Error	24	70.97	103.62	184.30	103.88	-130.31	-54.14	-36.96	-95.38
Mean Percent Error	24	0.4362	0.6155	1.0669	0.6165	-0.7008	-0.2855	-0.1844	-0.4976
AAPE	24	0.4424	0.6182	1.0669	0.6182	0.7008	0.3045	0.2736	0.4976
Theil's Inequality Coef	18	0.9719	1.0479	1.3876	1.0487	2.9235	1.3604	1.4772	2.4892

40 Instruments

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	208.1	280.9	226.9	245.2	272.5	378.1	315.0	331.0
RMS Percent Error	18	0.2173	0.3799	0.3246	0.3627	0.3072	0.5132	0.4115	0.3168
Mean Simulation Error	19	-63.33	-14.58	139.07	46.81	-121.77	-70.59	-104.92	-208.69
Mean Percent Error	18	-0.0181	0.0664	0.2125	0.1284	-0.0995	0.0255	-0.0465	-0.1987
AAPE	18	0.1814	0.3117	0.2672	0.2685	0.2264	0.4147	0.3032	0.2387
Theil's Inequality Coef	18	1.0206	1.7202	1.3950	1.4263	2.1683	2.1242	2.2634	2.0776

41 Miscellaneous Manufacturing

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	22	135.4	179.5	160.5	208.9	82.0	104.3	155.0	131.9
RMS Percent Error	22	0.4347	0.5716	0.4996	0.6485	0.2351	0.3155	0.4873	0.4382
Mean Simulation Error	22	123.49	169.72	150.77	203.74	-33.89	38.07	117.55	109.09
Mean Percent Error	22	0.3795	0.5185	0.4569	0.6133	-0.0830	0.1219	0.3581	0.3443
AAPE	22	0.3795	0.5185	0.4569	0.6133	0.2108	0.2576	0.3773	0.3443
Theil's Inequality Coef	18	1.0464	1.4261	1.2403	1.3558	1.5038	2.1655	2.5370	1.4185

42 Railroads

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	19	2555.9	2233.6	2538.5	2284.5	3231.6	2719.5	2726.2	4277.6
RMS Percent Error	18	0.5046	0.6964	0.6999	0.6174	0.5720	0.5681	0.6686	0.8539
Mean Simulation Error	19	-1353.45	-446.79	-913.21	-766.73	-2123.85	-1461.25	-1080.84	-3083.82
Mean Percent Error	24	-0.0881	0.2246	0.1178	0.1077	-0.3218	-0.1867	-0.0195	-0.6410
AAPE	18	0.4269	0.6072	0.5954	0.5478	0.5283	0.5322	0.6009	0.7983
Theil's Inequality Coef	19	1.0653	0.8981	1.0720	0.9078	1.1432	0.9994	0.9820	1.4920

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

43 Air Transport

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	1722.5	10318.6	1548.9	4950.0	2369.2	4624.5	4389.6	3448.7
RMS Percent Error	36	0.2632	1.8899	0.2272	0.8451	0.4242	0.8277	0.7362	0.6432
Mean Simulation Error	36	-1406.21	-7574.83	-1186.75	-3782.98	-1402.09	-2729.39	-3207.85	-1836.89
Mean Percent Error	36	-0.2136	-1.3272	-0.1757	-0.6227	-0.2222	-0.4722	-0.5296	-0.3057
AAPE	36	0.2432	1.6020	0.1887	0.7856	0.3610	0.7177	0.6685	0.5635
Theil's Inequality Coef	36	0.9654	2.7257	0.9387	1.9141	1.8776	1.6581	1.9589	1.8088

44 Trucking & Other Transport

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	1249.0	2612.5	3904.7	5252.4	4699.4	2930.1	3044.0	4491.1
RMS Percent Error	18	0.1474	0.3396	0.5060	0.6788	0.5725	0.3567	0.3793	0.5620
Mean Simulation Error	18	-488.69	-1445.65	2898.83	-3659.68	-3376.01	-2613.15	-2751.03	-4044.63
Mean Percent Error	18	-0.0481	-0.1878	0.3740	-0.4749	-0.4081	-0.3233	-0.3434	-0.5052
AAPE	18	0.1311	0.2967	0.3867	0.5598	0.5203	0.3233	0.3434	0.5052
Theil's Inequality Coef	24	1.0729	1.6976	1.3268	2.6314	2.8933	1.1308	1.0369	1.6813

45 Communications Services

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	22	6021.2	2609.4	3930.1	3938.4	1556.7	3620.3	3618.2	4477.9
RMS Percent Error	22	0.3348	0.1463	0.2222	0.2119	0.0832	0.2251	0.2216	0.2650
Mean Simulation Error	23	-5545.67	-2262.56	-3665.45	-1392.80	-1131.48	-358.18	-891.65	-4026.50
Mean Percent Error	23	-0.3229	-0.1327	-0.2163	-0.0530	-0.0623	0.0097	-0.0242	-0.2411
AAPE	22	0.3229	0.1327	0.2163	0.1659	0.0648	0.1882	0.1957	0.2411
Theil's Inequality Coef	22	0.9692	0.7298	0.8441	1.5134	0.6500	1.6094	1.6036	1.4449

46 Electric Utilities

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	2288.6	2753.3	1953.3	3319.5	2142.7	2733.8	2088.4	2843.9
RMS Percent Error P	22	0.2145	0.2649	0.2095	0.3591	0.1946	0.3013	0.2142	0.3183
Mean Simulation Error	36	-327.95	-1575.22	78.89	-2474.88	-351.22	-1921.79	-972.49	-2354.16
Mean Percent Error	22	0.0231	-0.1677	0.0720	-0.3076	0.0135	-0.2345	-0.0946	-0.3056
AAPE	22	0.1686	0.2277	0.1686	0.3156	0.1435	0.2728	0.1959	0.3056
Theil's Inequality Coef	23	0.9837	0.7960	0.9373	0.7912	0.9516	0.7328	0.8150	0.7914

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS — PAGE 12
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

47 Gas,water & Sanitation

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	21	1436.3	1822.4	2062.4	1385.0	2640.3	1974.9	1908.1	3490.7
RMS Percent Error	21	0.4660	0.4195	0.4929	0.3233	0.6381	0.4810	0.4553	0.8751
Mean Simulation Error	18	437.04	-1579.67	-1925.44	-1073.27	-2461.74	-1872.23	-1778.41	-3386.29
Mean Percent Error	18	0.1756	-0.3802	-0.4805	-0.2457	-0.6152	-0.4740	-0.4460	-0.8674
AAPE	21	0.3342	0.3802	0.4805	0.2969	0.6152	0.4740	0.4460	0.8674
Theil's Inequality Coef	18	1.1170	1.3190	1.3070	1.1435	1.6679	1.2426	1.2884	1.8234

48 Wholesale & Retail trade

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	6714.2	8793.0	3574.8	10278.6	10015.0	8575.1	10008.7	15647.1
RMS Percent Error	36	0.2006	0.2678	0.1179	0.3307	0.3195	0.2854	0.3733	0.5271
Mean Simulation Error	36	-4889.52	-7671.05	-1359.83	-9348.48	-9013.47	-7647.77	-8882.95	-14869.72
Mean Percent Error	36	-0.1481	-0.2546	-0.0279	-0.3209	-0.3080	-0.2654	-0.3244	-0.5232
AAPE	36	0.1757	0.2546	0.1095	0.3209	0.3080	0.2654	0.3244	0.5232
Theil's Inequality Coef	36	0.9860	0.8364	0.8228	0.8445	1.2308	0.8585	1.3146	1.4519

49 Finance, Insurance & Services

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	3641.2	2288.0	1328.5	2253.5	2705.3	1803.7	2083.4	2417.2
RMS Percent Error	36	0.3607	0.2051	0.1151	0.2002	0.2705	0.1790	0.2121	0.2501
Mean Simulation Error	36	-2873.22	-1489.59	-374.39	-1489.72	-2103.71	-711.72	-1080.64	-1904.56
Mean Percent Error	36	-0.3322	-0.1525	-0.0115	-0.1543	-0.2409	-0.0430	-0.0899	-0.2268
AAPE	36	0.3322	0.1527	0.0863	0.1543	0.2409	0.1467	0.1884	0.2268
Theil's Inequality Coef	36	0.9154	0.8025	0.6405	0.7501	0.7451	0.8917	0.9079	0.7959

50 Real Estate

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	827.8	1270.6	1716.5	1508.9	1873.2	2981.3	3210.6	7753.7
RMS Percent Error	18	0.0978	0.1499	0.2074	0.1885	0.2293	0.3643	0.3927	0.9665
Mean Simulation Error	19	-203.46	88.25	859.47	-1181.41	-657.91	-2889.70	-3114.70	-7717.91
Mean Percent Error	19	-0.0226	0.0066	0.1054	-0.1476	-0.0822	-0.3578	-0.3859	-0.9646
AAPE	18	0.0794	0.1223	0.1798	0.1664	0.1953	0.3578	0.3859	0.9646
Theil's Inequality Coef	18	0.8356	0.8949	1.0248	1.0042	1.7435	1.1363	1.2202	2.2578

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 13
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

51 Hotels & Repairs Minus Auto

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	33	909.6	953.3	645.8	1763.5	831.7	939.8	1044.8	432.6
RMS Percent Error	33	0.2684	0.3822	0.2541	0.6551	0.2674	0.3154	0.3830	0.1563
Mean Simulation Error	24	-752.54	502.98	539.11	802.97	-775.62	-208.16	79.33	160.18
Mean Percent Error	24	-0.2376	0.2148	0.2086	0.3164	-0.2604	-0.0493	0.0480	0.0740
AAPE	33	0.2376	0.2957	0.2153	0.4854	0.2604	0.3052	0.3503	0.1315
Theil's Inequality Coef	33	1.1118	2.2225	1.2007	3.7932	1.1157	1.7549	2.3562	0.9966

52 Business Services

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	22	3417.2	2247.2	3875.9	1872.6	1325.7	2044.8	2440.5	1843.3
RMS Percent Error	22	0.3677	0.2356	0.3926	0.1815	0.1473	0.2099	0.2765	0.2406
Mean Simulation Error	22	-2853.27	-1817.48	-3107.09	-958.82	-502.52	-1421.77	-1893.25	-1569.37
Mean Percent Error	22	-0.3308	-0.2087	-0.3485	-0.0830	-0.0426	-0.1458	-0.2142	-0.2050
AAPE	22	0.3313	0.2087	0.3485	0.1449	0.1109	0.1861	0.2529	0.2050
Theil's Inequality Coef	23	1.2224	0.9908	1.1959	1.0167	1.6056	0.9572	1.3492	1.3304

53 Auto Repair

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	23	1877.9	1622.8	1129.0	1542.3	1487.2	732.6	884.0	1633.4
RMS Percent Error	36	0.2905	0.2762	0.1697	0.2607	0.2337	0.1698	0.1936	0.2598
Mean SimulationPError	23	-1257.99	-1271.43	-643.43	-1114.05	-1030.03	157.25	-546.06	-1188.02
Mean Percent Error	23	-0.2170	-0.2468	-0.0995	-0.2113	-0.1874	0.0663	-0.1115	-0.2184
AAPE	36	0.2257	0.2468	0.1196	0.2187	0.1960	0.1471	0.1584	0.2184
Theil's Inequality Coef	19	1.0176	0.7963	0.8264	0.8957	1.0435	0.8851	0.8010	0.9562

54 Movies & Amusements

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	18	215.3	339.2	399.0	354.9	366.6	438.6	333.6	993.6
RMS Percent Error	18	0.1291	0.2247	0.2413	0.2233	0.2319	0.2674	0.1866	0.5995
Mean Simulation Error	18	32.19	225.13	325.29	284.51	171.54	362.13	260.03	936.65
Mean Percent Error	18	0.0343	0.1483	0.1931	0.1732	0.1130	0.2163	0.1447	0.5549
AAPE	18	0.1140	0.1641	0.1993	0.1801	0.1828	0.2216	0.1558	0.5549
Theil's Inequality Coef	36	0.8731	1.0121	0.6757	0.7027	1.4733	1.0149	1.4468	1.9575

Table 5.4 (continued)

COMPARISONS OF INVESTMENT SIMULATIONS USING SUMMARY STATISTICS PAGE 14
Real Side Simulations - Estimated to 1977

Simulation 18: Autoregressive Model
Simulation 19: Accelerator Model
Simulation 36: Cobb-Douglas Model
Simulation 21: CES Model I
Simulation 22: CES Model II
Simulation 23: Generalized Leontief Putty-Clay Model
Simulation 24: Generalized Leontief Putty-Putty Model
Simulation 33: Dynamic Factor Demand Model

55 Medical & Ed. Services

Simulation :1978 to 1985	Best	18	19	36	21	22	23	24	33
Root Mean Square Error	36	1590.6	2760.3	1586.2	2195.5	1768.1	2261.5	2571.8	2711.5
RMS Percent Error	36	0.1673	0.2467	0.1516	0.2106	0.1707	0.2246	0.2549	0.2390
Mean Simulation Error	18	-467.42	-2023.33	-761.12	-1298.62	-984.75	-1073.05	-1513.46	-2042.09
Mean Percent Error	18	-0.0111	-0.1734	-0.0479	-0.1018	-0.0737	-0.0692	-0.1246	-0.1773
AAPE	36	0.1561	0.2147	0.1397	0.1849	0.1520	0.2031	0.2212	0.2034
Theil's Inequality Coef	36	0.9257	1.0571	0.8929	1.1663	1.0065	1.2797	1.5382	1.0019

Ranking of Simulations by Each Statistic

Simulation :	18	19	36	21	22	23	24	33
Root Mean Square Error	16	5	9	3	5	7	6	2
RMS Percent Error	16	4	9	2	6	7	5	4
Mean Simulation Error	9	5	7	3	5	6	14	4
Mean Percent Error	10	3	6	2	7	6	13	6
AAPE	12	4	8	2	10	8	6	3
Theil's Inequality Coef	24	2	11	4	1	6	1	4

Total RMSE and MSE Across all Industries

Simulation :	18	19	36	21	22	23	24	33
Root Mean Square Error	63164.6	72382.3	61364.5	75071.7	73235.5	62964.1	64447.4	94362.9
Mean Simulation Error	-13489.37	-15843.87	3871.04	-15132.40	-28596.83	-24397.16	-24446.35	-63222.35

Real Side Simulations
Estimated to 1977

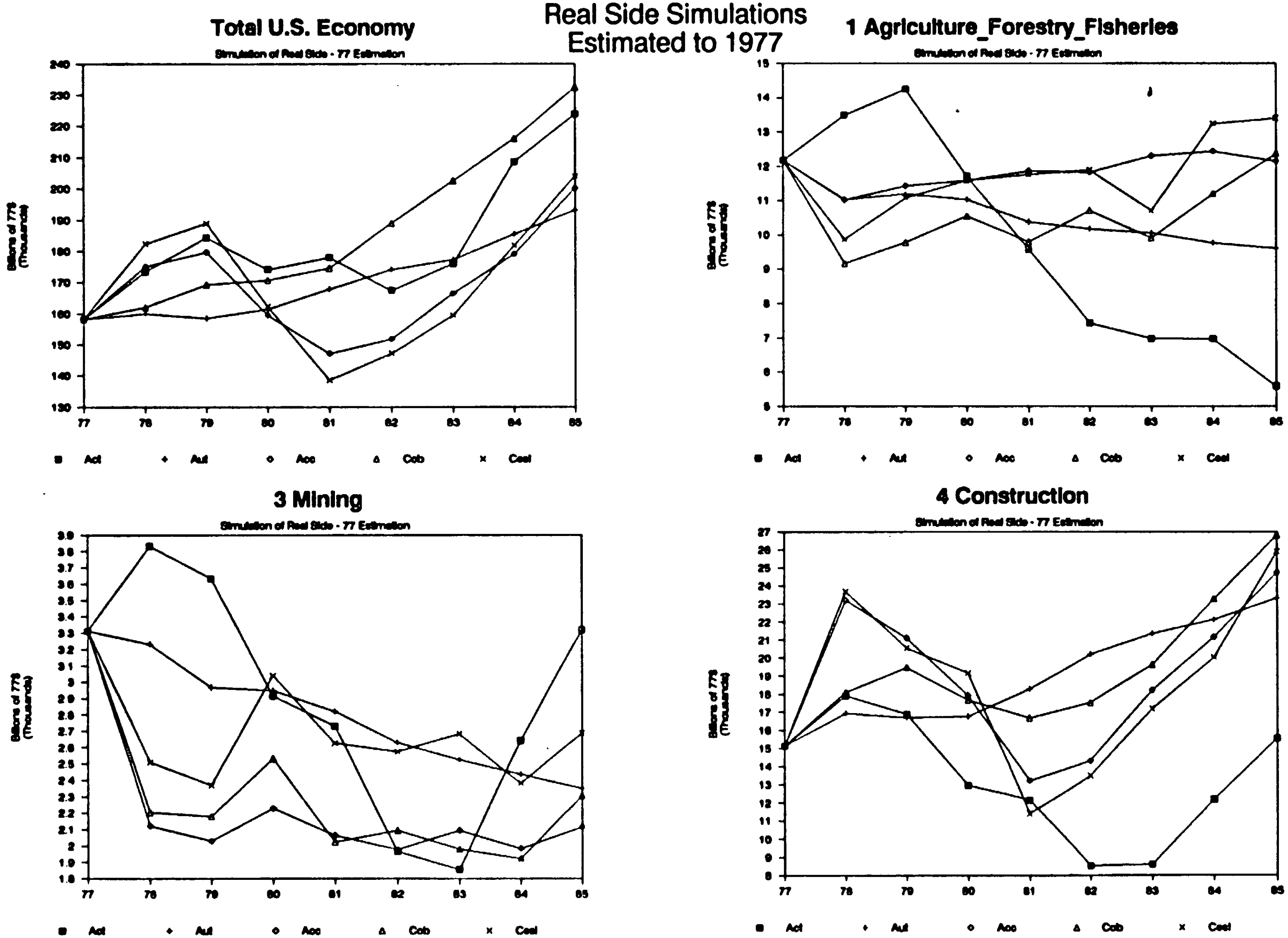


Figure 5.4.a

Real Side Simulations
Estimated to 1977

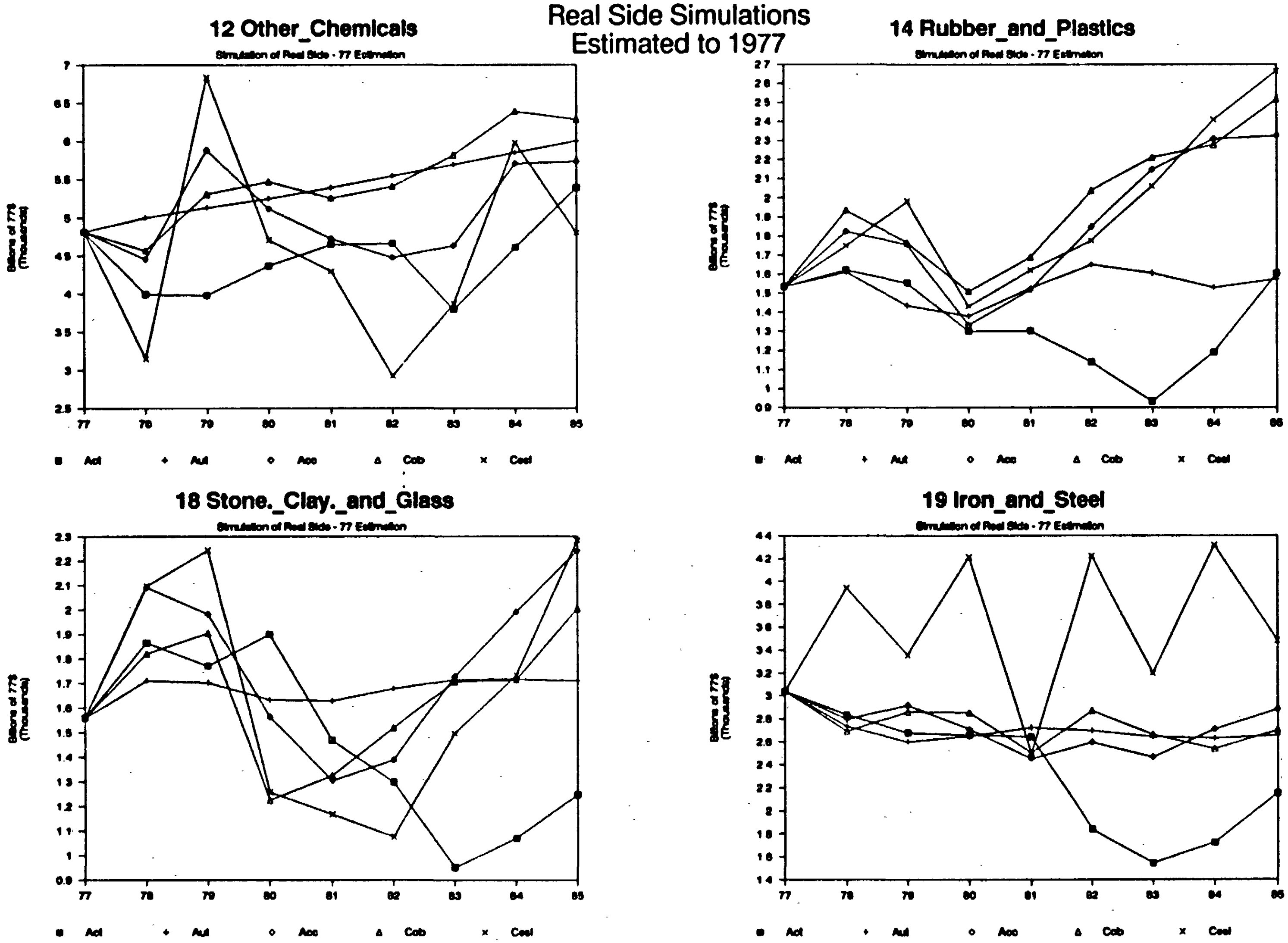


Figure 5.4.b

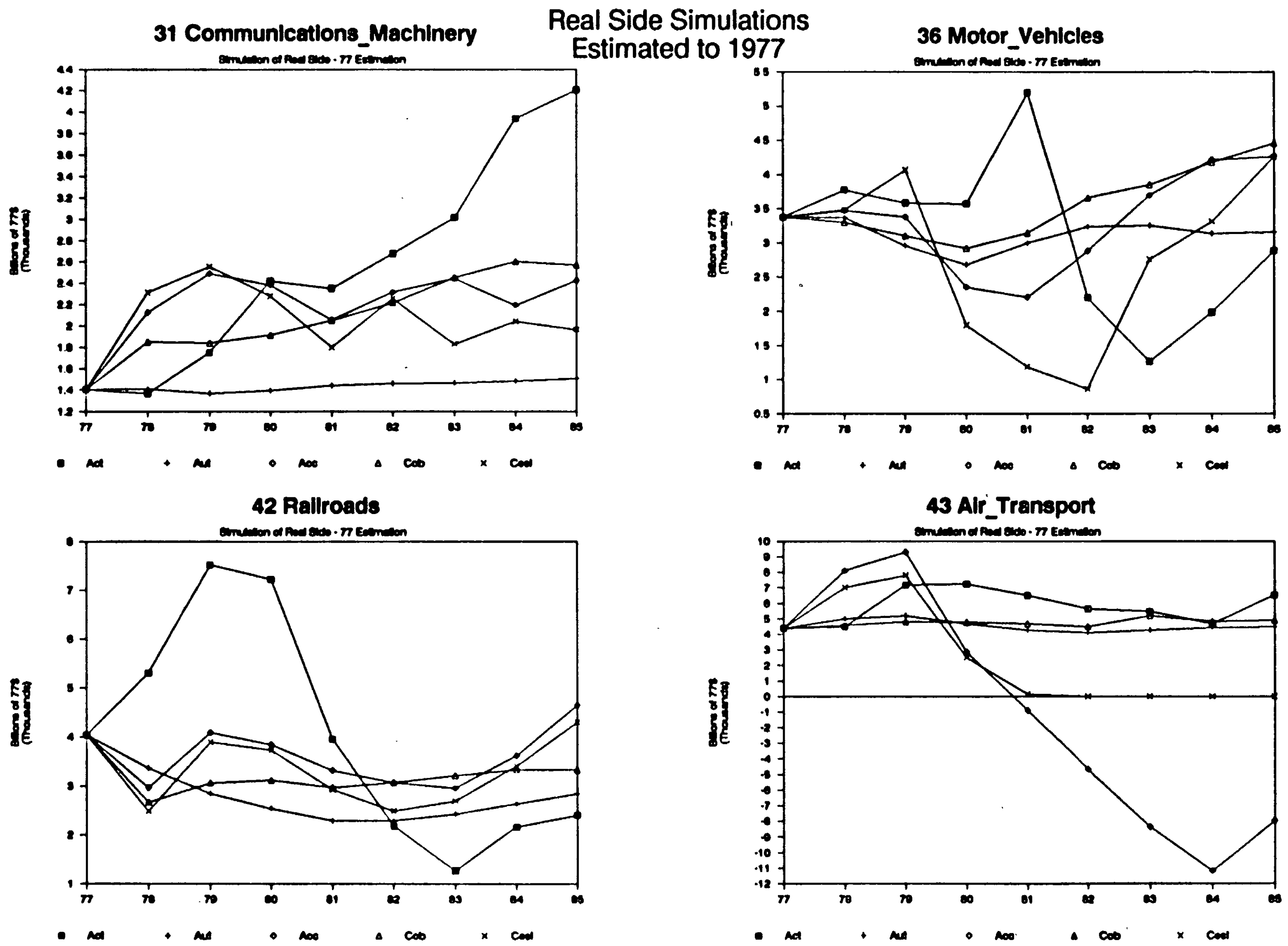

Real Side Simulations
Estimated to 1977
31 Communications_Machinery
Simulation of Real Side - 77 Estimation
Billions of 77$ (Thousands)
Act
Aut
Acc
Cob
Ceel
36 Motor_Vehicles
Simulation of Real Side - 77 Estimation
42 Railroads
Simulation of Real Side - 77 Estimation
43 Air_Transport
Simulation of Real Side - 77 Estimation

Figure 5.4.c

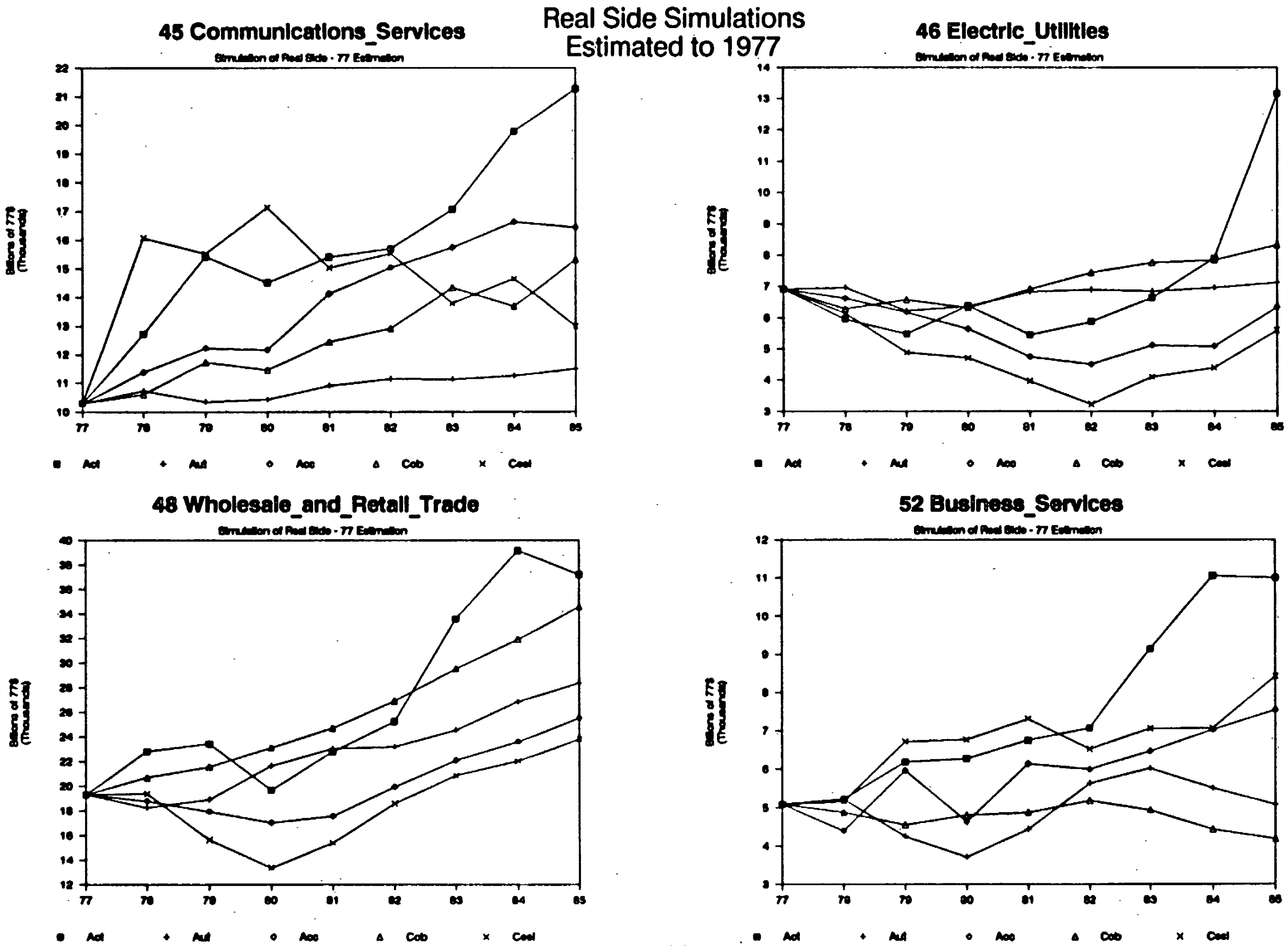

Real Side Simulations
Estimated to 1977
45 Communications_Services
Simulation of Real Side - 77 Estimation
Act
Aut
Acc
Cob
Ceel
46 Electric_Utilities
Simulation of Real Side - 77 Estimation
Act
Aut
Acc
Cob
Ceel
48 Wholesale_and_Retail_Trade
Simulation of Real Side - 77 Estimation
Act
Aut
Acc
Cob
Ceel
52 Business_Services
Simulation of Real Side - 77 Estimation
Act
Aut
Acc
Cob
Ceel

Figure 5.4.d

Real Side Simulations
Estimated to 1977

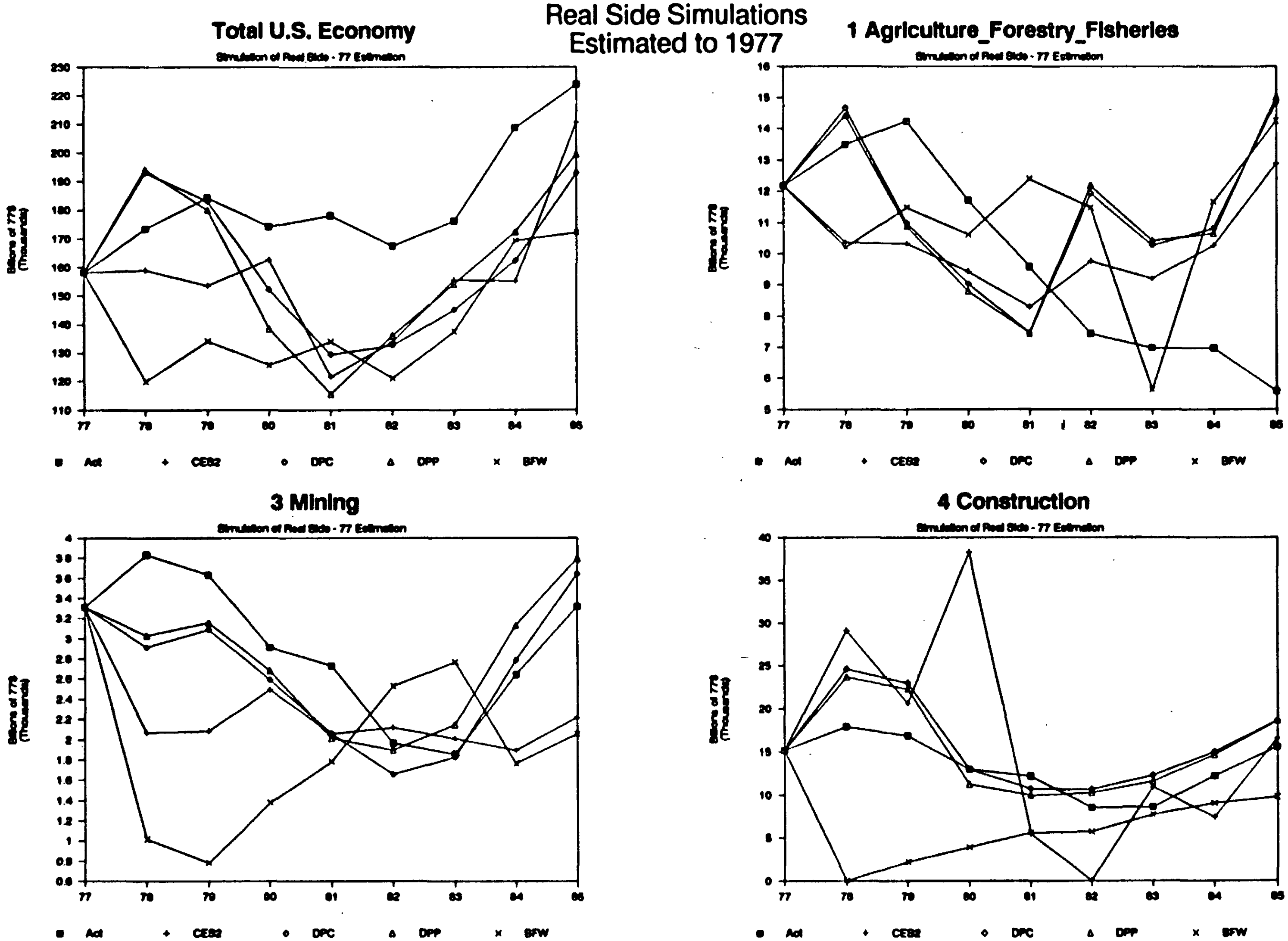


Figure 5.4.e

Real Side Simulations
Estimated to 1977

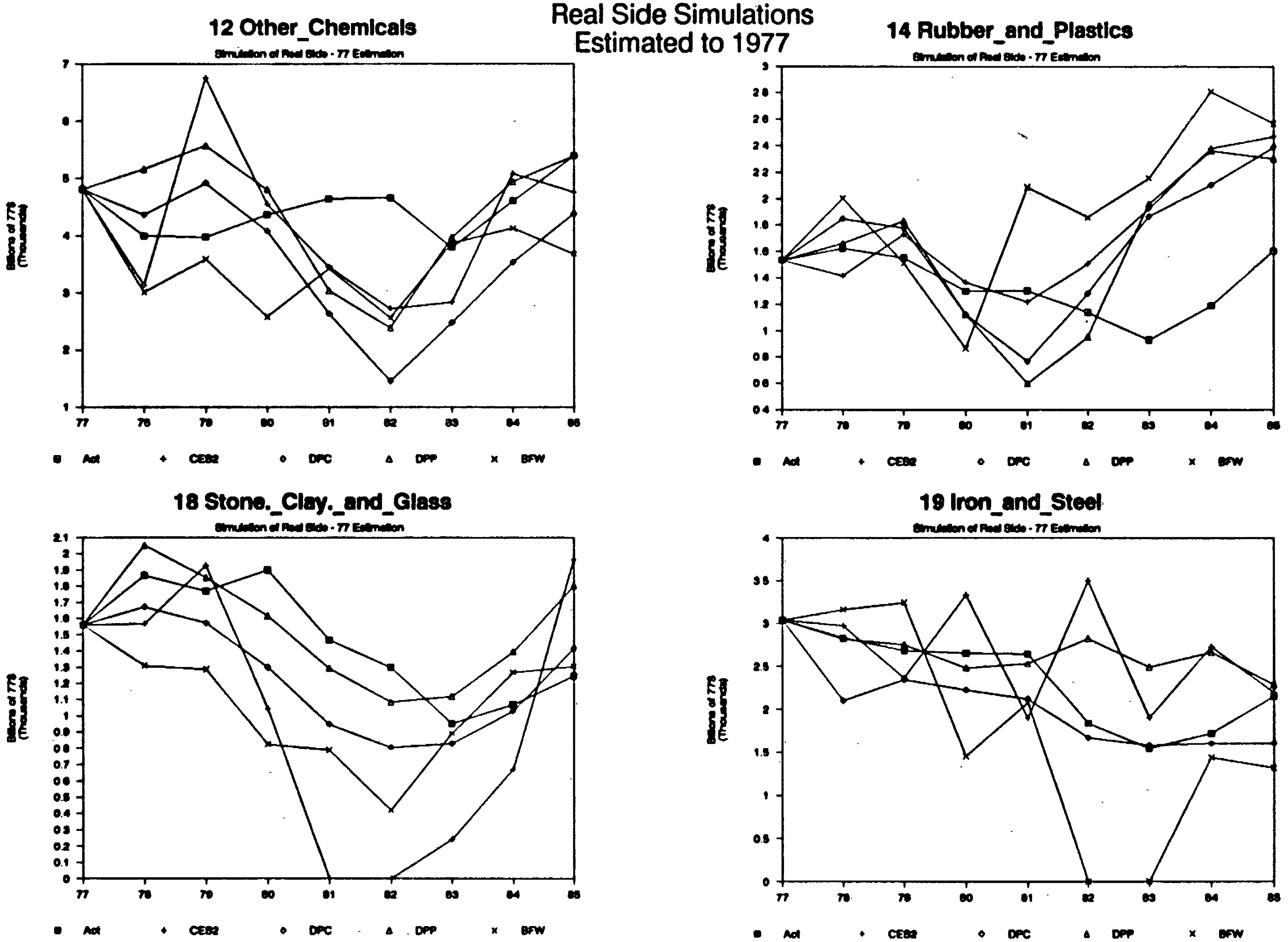


Figure 5.4.f

Real Side Simulations
Estimated to 1977

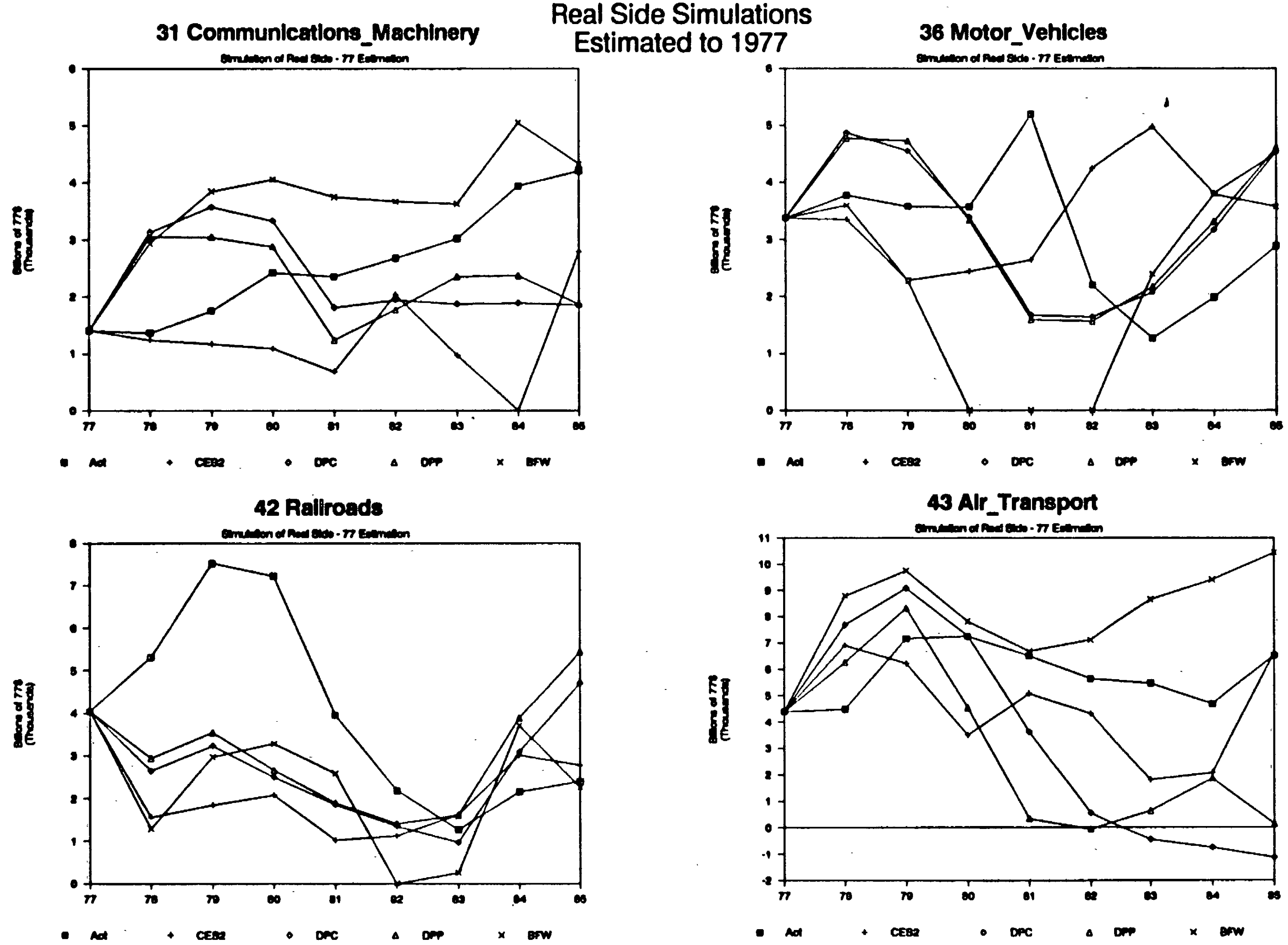
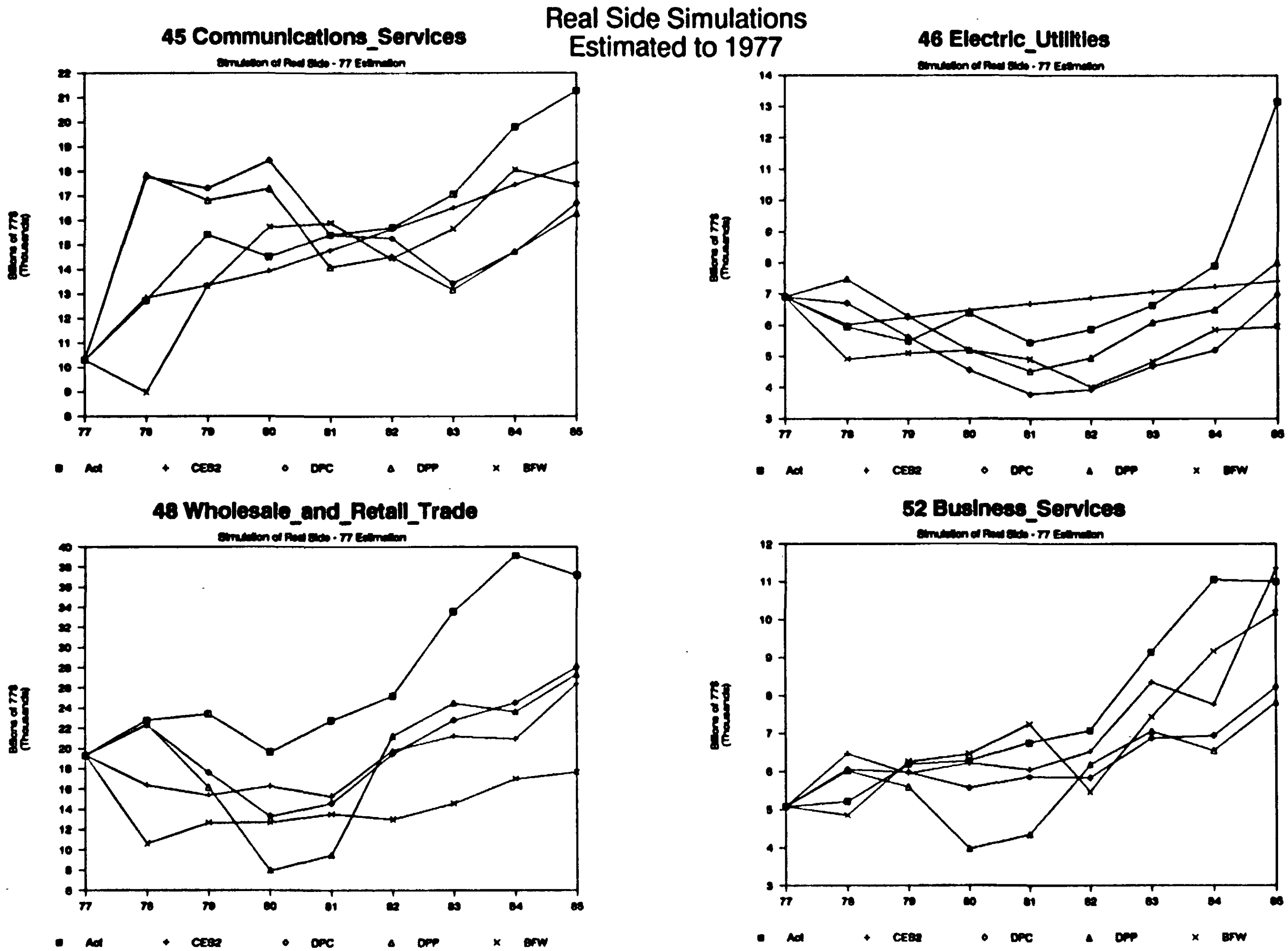


Figure 5.4.8



Real Side Simulations
Estimated to 1977
45 Communications_Services
Simulation of Real Side - 77 Estimation
46 Electric_Utilities
Simulation of Real Side - 77 Estimation
48 Wholesale_and_Retail_Trade
Simulation of Real Side - 77 Estimation
52 Business_Services
Simulation of Real Side - 77 Estimation
Billions of 77$ (Thousands)
Act
CES2
DPC
DPP
BFW

Figure 5.4.h

CHAPTER VI

CONCLUSIONS

A great deal of effort went into producing the results presented in this study. The entire real side of the INFORUM model was re-programmed by the author to enable it to perform the simulation tests in Chapter V. The INFORUM database of equipment investment for 53 industries, from 1947 to 1985, was recalculated to be consistent with detailed PDE data, capital flow matrices, and unpublished BEA capital stock and investment data, in order to ensure that the most accurate industry-level data was used.[71] Furthermore, all of the models presented here required numerous iterations of specification, estimation and simulation before settling on the final versions included in Chapter IV.[72] Literally hundreds of simulations of the INFORUM model were necessary before arriving at the 32 simulations presented in Chapter V.

Now it is time to critically assess what has been gained from all this effort, and decide what unique contribution this study has

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[71]See Appendix A.

[72]For a representative dynamic factor demand model, versions based on the work of Morrison (1987), Pindyck and Rotemberg (1983a), Mahmud, Robb and Scarth (1986, 1987) and Shapiro (1986c) were tried, with even less success than the Berndt, Fuss and Waverman (1980) style of model finally used.

made to the understanding of the econometric modeling of equipment investment. How do the results from this study conform with those of Clark [1979] and Kopcke [1982], and how do the current results extend our knowledge about which determinants of investment behavior are most important?

Table 6.1 on the following page provides a summary of the results of the simulation exercises discussed in the last chapter. In every set of simulations, the Autoregressive model does the best in terms of counting industries in which it had the lowest *RMSE.* However, as judged by other criteria, such as total *RMSE* across all industries, other models such as the Cobb-Douglas and the Accelerator did the best. Also, in the out-of-sample, real side simulations, the rankings were fairly close in terms of total *RMSE.* In summary, this study seems to confirm Kopcke's findings, i.e., that some form of Autoregressive model seems to be the best performer in terms of squared error criteria such as the *RMSE.* However, models that combine output and relative price determinants do almost as well as the Autoregressive, and are relatively favored in out-of-sample simulations.

Unfortunately, the most serious and wide-ranging finding of this study is rather negative. None of the models do as well as one would hope, either in within-sample or in out-of-sample simulations. This may partly be a function of the data we are trying to model. Equipment investment is notoriously volatile. A simulation study using personal consumption data would probably obtain much better

Table 6.1 - Summary of Simulation Results

	Within-Sample, Single Equation	Within-Sample, full Real Side	Out-Of-Sample, Single Equation	Out-Of-Sample, full Real Side
Autoregressive Model	RMSE best in 15 industries **(Rank 1)**; Total RMSE: 36685	RMSE best in 25 industries **(Rank 1)**; Total RMSE: 36685	RMSE best in 14 industries **(Rank 1)**; Total RMSE: 63165	RMSE best in 16 industries **(Rank 1)**; Total RMSE: 63165
Accelerator Model	RMSE best in 14 industries **(Rank 2)**; Total RMSE: 35646	RMSE best in 4 industries **(Rank 5)**; Total RMSE: 53192	RMSE best in 5 industries **(Rank 5 or 6)**; Total RMSE: 62374	RMSE best in 5 industries **(Rank 6)**; Total RMSE: 72382
Cobb-Douglas Model	RMSE best in 7 industries **(Rank 4)** Total RMSE: 41359	RMSE best in 9 industries **(Rank 2)**; Total RMSE: 39183	RMSE best in 5 industries **(Rank 5 or 6)**; Total RMSE: 61490	RMSE best in 9 industries **(Rank** Total RMSE: 61365
CES Model I	RMSE best in 1 industry **(Rank 8)**; Total RMSE: 66694	RMSE best in 5 industries **(Rank 4)**; Total RMSE: 63770	RMSE best in 3 industries **(Rank 8)**; Total RMSE: 79270	RMSE best in 3 industries: **(Rank 7)**; Total RMSE: 75072
CES Model II	RMSE best in 8 industries **(Rank 3)**; Total Rmse: 39700	RMSE best in 6 industries **(Rank 3)**; Total RMSE: 52751	RMSE best in 4 industries **(Rank 7)**; Total RMSE: 65984	RMSE best in 5 industries **(Rank 5)**; Total RMSE: 73236
Generalized Leontief Putty-Putty	RMSE best in 2 industries **(Rank 7)**; Total RMSE: 50738	RMSE best in 3 industries **(Rank 6)**; Total RMSE: 62964	RMSE best in 6 industries **(Rank 4)**; Total RMSE: 72579	RMSE best in 7 industries **(Rank 3)**; Total RMSE: 62964
Generalized Leontief Putty-Clay	RMSE best in 3 industries **(Rank 5 or 6)**; Total RMSE: 49853	RMSE best in 1 industry **(Rank 7)**; Total RMSE: 64447	RMSE best in 7 industries **(Rank 3)**; Total RMSE: 69242	RMSE best in 6 industries **(Rank 4)**; Total RMSE: 64447
Dyamic Factor Demand	RMSE best in 3 industries **(Rank 5 or 6)** ; Total RMSE: 89245	RMSE best in no industries **(Rank 8)**; Total RMSE: 110001	RMSE best in 9 industries **(Rank 2)**; Total RMSE: 83718	RMSE best in 2 industries **(Rank 8)**; Total RMSE: 94363
General Comments	Autoregressive best by industry count of best RMSE. Accelerator best by total RMSE. DFD and CES2 out of the running	Autoregressive best by a wider margin judged by industry count. Cobb-Douglas a close second by Total RMSE.	Autoregressive, then DFD, they GL Putty-Clay, as judged by industry count. Cobb-Douglas and Accelerator best by Total RMSE.	Autogressive, followed by Cobb-Douglas, then GL models by industry count. Cobb-Douglas and GL Putty-Clay best by Total RMSE.

measures of *RMSE,* for instance. And unlike most published studies, this study undertakes to model disaggregated, industry-level data, which is more difficult to model than aggregate data for the entire economy or the manufacturing sector.[73]

It is also quite possible that, at least for some industries, there are important variables that are not adequately accounted for in any of these equations. Perhaps more attention to the constraints involved in financing investment would be useful. Theoretical models from literature in the fields of finance and industrial organization suggest that distinctions between internal and external financing are important with respect to investment spending. Also, the appropriate rate of return variable to include in the user cost of capital calculation is different for different firms because of differences in capital availability, credit ratings, etc. Using the more general triple-A bond rate does help to signal overall changes in credit market conditions, but may not be relevant in some industries.

A related weakness in most of these equations might be the traditional, simplified user cost of capital measure employed. This measure does not distinguish between the percentage of debt and equity financing. It ignores subtleties such as using "effective" tax rates and "effective" tax credits instead of the legislated

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[73] I was able to replicate fairly easily the results of Berndt, Fuss and Waverman (1980) in fitting their model to the aggregate U.S. Manufacturing data published in their study. This data set has been heavily used throughout the 80s in studies of investment and factor demand. However, the results of trying to fit this sort of model to more volatile industry level data were nothing short of disastrous.

rates. Finally, expected capital gains and capital gains taxes do not enter into the calculation. However, the measure used in this study can be constructed with readily available data, and it does use industry-specific equipment price deflators and depreciation rates, and uses a calculation for the present value of a dollar of depreciation that makes use of data on shares of depreciation methods used by industry. In the models for which the ratio of the user cost to output price is included, we are using industry-specific output prices.

Some other reasons these models might fail to do well include: 1) Inadequacy of the capital stock measures (this can be caused by an incorrect depreciation rate or an incorrect measure of investment, or we could be using a constant depreciation rate when we should be using a rate that changes); 2) Capital utilization has not been accounted for (the effective quantity of capital depends on its utilization rate); 3) Capital measurement could be a problem, in the sense that capital measures have not been adjusted for quality differences; 4) The level of aggregation may still be too high, in that our industry definitions encompass too many different types of firms; 5) Price deflators used to deflate equipment investment data to constant dollars may be incorrect (The latter problem is related to that of quality adjustment. It is particularly a problem in the areas of high-tech and computers, but also for automobiles); and 6) There may be a methodological problem in trying to link *desired* investment to the *desired* capital stock. These notions may simply not be descriptive of the factors influencing the firm when it expands production capacity in the form of a chosen set of investment goods, or when capital stock is replaced.

Whatever reason for the poor performance of these equations, these results point up some serious flaws in our ability to apply the latest developments in microeconomic theory to the estimation of investment equations. This fact is usually glossed over in papers investigating the use of theoretical investment or factor demand models used to explain investment time series. Rarely are simulation tests of estimated results attempted. Rather, the usual procedure is to present parameter results along with Chi-Square tests for significance. This study suggests that the value of many of these models may be subject to doubt, at least as simulation or forecasting tools.

A second major conclusion from this study is that the benefit-cost ratio of attempting to build more complex, theoretically-based models appears to be small, if not actually negative.[74] The difficulties in estimation are compounded by difficulties that arise in simulation testing. Generally, the more variables an equation uses, the more likely is it to demonstrate some quirk in responses to those variables, that were not obvious from

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[74] It generally took only about 10 minutes to estimate the Cobb-Douglas model for all 53 industries using the *G* regression package on an 80386 IBM-compatible PC. Estimating the dynamic factor demand model on the same PC generally took about 13 hours. The quadratic programming algorithm used to estimate the Generalized Leontief models takes about 6 hours on a Prime minicomputer.

looking at the regression parameters or regression fits. Of course, models such as the Generalized Leontief or Dynamic Factor Demand may still be desirable if they shed light on the types of responses we can expect to output and price changes.

A third conclusion, drawn from Chapter IV, is that parameter estimates are generally quite sensitive to the estimation period chosen, suggesting that the economic relationships between investment and output and relative prices are changing significantly over time. The fitting abilities of the equations are also highly sensitive to the estimation period chosen, since all of the models fit significantly worse for the 53 to 85 period as compared to the 53 to 77 period. Therefore, conclusions drawn from estimations using these time periods cannot necessarily be extended to other time periods. This also casts doubt on our ability to successfully forecast investment in a long-term model with a horizon of 10 to 15 years, since the parameters could be expected to change over that period. The author of this study has not studied this problem in more detail, but it would be useful to try to detect major areas of parameter shift over the historical period, in order to draw conclusions about how much the parameters would be likely to change in the future.

Another observation is that different models performed better for different industries, either in the estimation stage, the simulation stage, or both. Even a model such as the Dynamic Factor Demand Model, which generally performed poorly, performed quite well in certain industries. Can any characteristics be identified in the data that would lead one model to do better than another?

A final finding, which is actually a positive one, is that the Generalized Leontief and Cobb-Douglas Models *can* improve upon the Autoregressive Model in an out-of-sample simulation, at least as measured in terms of total *RMSE* summed across all industries. This is heartening, since these models allow for both output and price effects, and are to be preferred on the criteria of reasonable response patterns.

I conclude that for industry level forecasting, one of the Generalized Leontief models is probably superior for a number of reasons: 1) these models provide more policy levers, in the form of tax policy parameters embodied in the cost of capital calculation, energy prices, wage rates, and output growth; 2) a reasonable long-term path of the capital-output ratio is built into both these models; and 3) as mentioned above, these models compete fairly well in out-of-sample simulations in which the entire real side of the INFORUM model is active.

I also would suggest that a healthy scepticism is needed when confronting the types of results obtained by practitioners estimating investment equations using dynamic factor demand models or flexible functional forms. This study has demonstrated that even reasonably close fits and sensible parameter estimates are no guarantee that an equation can be safely used to determine policy implications or to do forecasting.

For future research there are a number of ways in which the results of this study may be extended. It would be useful to try some other forms of investment models, since the set included in this work is by no means exhaustive. An explicit modeling of the shape of the distributed lag function would be a desirable contribution, as attempted implicitly in the dynamic factor demand or adjustment cost literature. The reaction of equipment investment to output in many industries seems to follow a "humped" lag distribution, whereas most of the adjustment cost models imply a simple, geometrically declining lag structure. It would also be useful to perform the same type of simulation tests used in this study to different intervals, perhaps as long as 15 years or more. Finally, it would be useful to perform these tests at different levels of aggregation, to determine whether or not aggregate forecasting is more accurate than industry-level forecasting. This study has broken new ground in the area of detailed simulation testing of a large scale model of the U.S. economy. More studies of this kind need to be done before we can confidently assess the quality of the forecasts from the various equipment investment models in current use.

Appendix A

The Derivation of Sectoral Investment Data and the Capital Flow Matrix

I. Introduction

This appendix describes the derivation of sectoral investment data used in the investment sector of the INFORUM model in both current dollars (CU$) and constant dollars (77$). Also described here is the derivation of the capital flow tables (CFT), which serve as a bridge between investment demand by buyer and the sales of producers' durable equipment (PDE). Data sources used to obtain investment data, PDE and the capital flow tables will be discussed as well as the techniques used to maintain consistency between these items.

The investment data used by INFORUM must satisfy a number of requirements. First, it must be consistent with the published investment series in the National Income and Product Accounts (NIPA), since the macroeconomic aggregates forecast by the INFORUM model are based on the NIPA definitions. Thus, the total NIPA investment figure is used as a control for our current dollar investment estimates, and also control the producers' durable equipment (PDE) estimates to the separate categories published in NIPA tables 5.6, which is the table for PDE in current dollars. Theconstant dollar series is not scaled to agree with the NIPA constant dollar PDE table (5.7), but rather the constant dollar series of investment is derived from a constructed constant dollar series of PDE This PDE, in turn is derived in a different manner than the NIPA PDE (see below). A second requirement that the investment data must fulfill is that it be consistent with the capital coefficient matrix and the PDE series, both in current and constant dollars. The capital coefficient matrix, or B-matrix, is defined as the coefficient matrix obtained by dividing the capital flow matrix by its column totals. Therefore, the following identity should hold for all years for which we have a PDE vector and an estimated capital flow matrix:

$$\mathbf{p}_t = \mathbf{B}_t \mathbf{v}'_t$$

where:

$\mathbf{p}$ is an $r \times 1$ vector of PDE.

$\mathbf{B}$ is the $r \times s$ capital coefficient matrix.

$\mathbf{v}_t$ is an $s \times 1$ vector of investment.

In other words, by multiplying the capital coefficient matrix for a given year by the vector of investment for that year, one should obtain the PDE vector for that year, whether working in current or constant dollars. In the INFORUM model, this makes it possible to obtain the known vectors of PDE from a known vector of investment without generating a PDE discrepancy. A third requirement is that the data can be updated in a timely fashion, to provide an estimate of current investment behavior. Thus, a variety of sources are used. Some of the sources discussed below provide excellent detail, and are the best quality available, such as the Census Bureau's *Annual Survey of Manufactures* (ASM). Other sources, such as BEA's *Quarterly Survey of Plant and Equipment Expenditures* (P&E) are not as reliable, but can provide current estimates, which can be revised later, as better data are made available. A final requirement is that the data be collected at a useful level of aggregation. INFORUM has chosen an aggregation scheme comprised of some 55 industries, based on the availability of data, and the general level of aggregation available in the capital flow tables.

II. Data Sources for Current Dollar Equipment Investment

Unfortunately, there does not exist a single comprehensive, current data source for equipment investment expenditures that comprises all sectors of the economy, and which is also consistent with the NIPA and the existing capital flow tables. Therefore raw data must be drawn from a number of different sources, and judgement must be used to bring these data into consistency with published benchmarks. This section describes the data sources used, and the relative merits or problems of each source are evaluated.

For the manufacturing sectors, data is obtained from a time series of investment by manufacturing industries at the 4-digit Standard Industrial Classification (SIC) level. These data are from the *Census of Manufacturing* (CM) for Census years (at present the Census is collected every 5 years, in years ending in a 2 or a 7) and from the *Annual Survey of Manufactures* (ASM) in the 4 years between each Census. The CM and the ASM are both establishment surveys.

This means that the data are collected at the plant, or site of manufacture, instead of from company headquarters. The CM covers all establishments employing one person or more and engaged primarily in manufacturing. This sample comprises about 225,000 manufacturing establishments in the U. S., making the CM the most comprehensive (and therefore most reliable) source of data for manufacturing investment. The ASM covers a sample of about 55,000 establishments selected from the Census sample. Both of these surveys provide a figure on expenditures on new equipment. New equipment expenditures are aggregated from the 4-digit level to the 55 sector level to get the series for manufacturing industries. The main advantage of ASM and CM data is that it is very accurate. The disadvantage is that it is available only with a lag of up to three years.

Another source of primary investment data is the unpublished investment data set derived by the Bureau of Economic Analysis (BEA) in deriving their time series of capital stocks. This capital stock study (hereafter referred to as CS) derives capital stocks for about 60 industries comprising the U. S. economy. The capital stock estimates are published occasionally in the *Survey of Current Business* (SCB), and are updated annually. As NIPA revisions occur, this series is also revised to be consistent with the NIPA. This CS study draws on quite a few sources, including the Censuses, the ASM, the *Quarterly Plant and Equipment Survey* (discussed below), *Transport Statistics in the United States*, *Statistics of Income* and trade association data. Modified capital flow tables for 1963, 1967, 1972 and 1977 are used to disaggregate these investment data to investment by type of asset for each industry. The modifications in these tables are from a use to an ownership basis, and from an I-O to a NIPA industry classification. These modified capital flow tables are then interpolated, and the PDE implied by the investment data mentioned above in combination with the modified capital flow tables is compared to the NIPA PDE data. Whenever discrepancies are found between the NIPA PDE data by type of asset and the derived CS investment data, the CS investment data is revised so that it is consistent with the asset data. The CS investment data is comprehensive, and available with a lag of only one or two years, which suggests that it might be the best source for non-manufacturing data.

Unfortunately, there are a number of important differences between the definition of industries in the CS data and the industry definitions of the column controls in the capital flow table that make the direct use of these data for some sectors problematic. As I have mentioned above, the CS data are compiled on an ownership basis, whereas the capital flow table is compiled on a use basis. For a buying sector such as the railroad industry, which leases much of its rolling stock, this causes a large discrepancy between the investment figure in the capital flow table and the CS figure. Much of this discrepancy could be expected to turn up in another sector, such as finance, where much of railroad equipment is actually purchased. Another important difference is due to the fact that the makers of the capital flow table have gathered force-account construction (construction performed on-site by an investing industry) from all industries and allocated it to the construction industry, whereas this force-account construction remains classified as investment by the buying industry in the CS data. This of course causes a large discrepancy in the construction industry between the two sources, and a discrepancy in any other sectors that perform appreciable amounts of force-account construction. Nevertheless, for some sectors such as services and transportation, the CS data seems to be the best data available, so I have used it to obtain an estimate of year to year changes in investment, benchmarking the base year to the capital flow table. (See Table A-1, which shows which sources are used to update investment for each sector.)

A third source used primarily to bring estimates of equipment investment expenditures up to date is the *Quarterly Plant and Equipment Survey* (P&E), published in the *Survey of Current Business.* These estimates are usually available with a lag of only a few quarters, making the P&E Survey an excellent source for updating investment data. Data on plant and equipment as a total are compiled for 23 industries. Data are also compiled showing the proportion of plant and equipment investment in the total figure for durable and non-durable manufacturing, mining, transportation, public utilities and commercial and other. The P&E Survey collects investment data on an ownership basis, and the unit of reporting is at the company level. Companies that are involved in producing goods and services in more than one industry are classified in the industry in which they do the most business. The sample size is rather small, comprised of only about 9000 large companies. Therefore, although the P&E Survey is the most current source of data, its detail is limited, and a number of sources of bias exist. In order to use these data to update the investment series, an estimate of equipment expenditures by industry is obtained by multiplying the total figure for plant and equipment by the appropriate ratio of equipment to the total. Next a regression is run of each INFORUM investment series on the corresponding P&E series. Finally, the INFORUM investment data are moved forward with the index of the predicted value from these regressions. A weakness of the ratios used to split out investment in the P&E survey is that they are not available at the industry level. Although the P&E Survey contains estimates of investment expenditures for 9 durable manufacturing sectors, only one time series of ratios is published for all durables. This introduces further bias into the equipment investment estimates. However, to obtain current updates of equipment investment data, this source is the only available alternative.

For some sectors other sources for equipment investment data are necessary. Investment by Agriculture, Forestries and Fisheries(1) is obtained from the U. S. Department of Agriculture (USDA) publication *Economic Indicators of the Farm Sector*, and consists of the sum of Motor Vehicles plus Machinery and Equipment in the table labeled "Farm Gross Capital Expenditures". Another USDA publication *Inputs* is used to move these data forward, since it contains a figure for anticipated expenditures on farm machinery and equipment. For other sectors, namely Crude Petroleum and Natural Gas(2), Mining(3), Construction(4), and Railroads(42), we start with the series of PDE on the largest item purchased by each sector. For example, we use a series on railroad equipment to obtain a preliminary estimate of investment by the railroad industry, and a series of PDE of mining and oilfield machinery to obtain an estimate for the petroleum and natural gas sector. These PDE series are later benchmarked to a series of capital flow tables, which inflates the PDE figures to the proper level. The estimate for the Sales of Used Equipment(57) is derived directly from NIPA Table 5.6, as the difference between Private Purchases of PDE (line 32), and Private Purchases of New Equipment (line 38). This is always a negative number, since sales of used equipment exceed purchases. Table A-1 at the end of this paper shows which of the above sources for CU$ equipment investment data is used as a starting point for each of the 55 sectors for which we compile investment data.

III. Obtaining Current Dollar Investment Series

In order to be consistent with the capital flow tables, the time series of CU$ equipment investment must be equal to the column totals of the capital flow tables for 1958, 1963, 1967, 1972 and 1977. Therefore column controls must first be derived for each capital flow matrix at the 55 sector level, and then benchmark our CU$ series derived from the above sources to these controls.

For 1977, controls are available at the 55 sector level from the construction of the 1977 capital flow matrix. During the balancing procedure for this matrix, the matrix was scaled to the PDE row controls, and the resulting column sums were regarded as the 1977 investment controls (see Section IV.) For 1958, 1963, 1967 and 1972, column totals were available at the BEA 77 sector level from the publications *The Capital Flow Matrix, 1958*, *Interindustry Transactions in New Structures and Equipment, 1963 and 1967*, and the July, 1980 issue of the *Survey of Current Business* for the 1972 matrix. Table A-2 shows that although for many sectors the conversion of the 77 sector BEA scheme to the 55 sector INFORUM scheme is a simple matter of aggregation, some BEA sectors need to be disaggregated into one or more INFORUM sectors.

This disaggregation was accomplished by controlling the preliminary INFORUM equipment investment estimates to the 77 sector BEA controls in the following manner. The INFORUM and BEA categories are first aggregated to a classification scheme of 45 sectors, which is the finest level of aggregation that can be obtained without having to split sectors from either aggregation scheme. Then the preliminary INFORUM data for the benchmark years are scaled to conform to the 45 sector totals, and the result is taken to be the benchmark for current dollar equipment investment for that year. For most of the sectors that require disaggregation this method is adequate. The disaggregation of other sectors requires more careful consideration. One example is the transportation sector. The BEA classification scheme includes one overall category for transportation, whereas the INFORUM scheme identifies three transportation sectors: Railroads(42), Air Transportation(43), and Trucking and Other Transportation(44). While the preliminary estimates for sectors 43 and 44 was taken from the CS data, we found that using the PDE figure for railroad equipment led to a faster and more reasonable balancing of the capital flow matrices (see Section VI). Since the PDE for railroad equipment does not include the margins and other entries in the column of the capital flow matrix for investment by Railroads, scaling the three INFORUM transportation figures to the 45 sector control will result in an estimate for a benchmark for Railroads that is too small. Therefore, information on the structure of the 1977 matrix, and on the PDE items included in the BEA column for transportation were used to derive more sensible controls. The following diagram will make this clearer.

Large Entries in the 1977 Matrix for Transportation

PDE Category	Railroads	Air Transport	Truck & Other	Total
Truck and Bus Bodies	24.1	24.0	433.0	481.1
Truck Trailers	29.7	29.6	534.7	594.0
Motor Vehicles and Parts	140.8	140.2	2532.1	2813.1
Aircraft	0.0	2162.3	0.0	2162.3
Aircraft Engines and Parts	0.0	76.6	0.0	76.6
Ship Building and Repair	0.0	0.0	1565.4	1565.4
Boat Building and Repair	0.0	0.0	56.6	56.6
Railroad Equipment	2655.6	0.0	0.0	2655.6
Sum	2850.2	2432.7	5121.8	
Column Control	4035.7	4374.7	6942.0	

Derivation of Controls for 1963 Transportation Entries

PDE Category	Railroads	Air Transport	Truck & Other	Total
Truck and Bus Bodies	**2.9**	**2.9**	**52.3**	58.1
Truck Trailers	**4.5**	**4.5**	**79.0**	88.0
Motor Vehicles and Parts	**29.1**	**29.1**	**525.6**	583.9
Aircraft	**0.0**	**287.0**	**0.0**	287.0
Aircraft Engines and Parts	**0.0**	**16.1**	**0.0**	16.1
Ship Building and Repair	**0.0**	**0.0**	**305.9**	305.9
Boat Building and Repair	**0.0**	**0.0**	**29.0**	29.0
Railroad Equipment	**929.8**	**0.0**	**0.0**	929.8
Sum	**966.3**	**339.6**	**991.8**	
Derived Column Controls	**1367.7**	**610.5**	**1344.2**	**3321.0**
Published BEA Total				3209.7
Final Controls	**1321.3**	**589.7**	**1298.7**	

In the latter table, derived figures are printed in bold. For the 1963 matrix, we are given the total cells on the right for BEA's sector for transportation(65). These are the cells in the transportation column for which we can make the most reasonable inferences. In the 1977 matrix, these cells have already been disaggregated using best judgement. Therefore, the first step is to split the total BEA cell for 1963 using the ratios of the split in the 1977 matrix. After dividing all the transportation PDE items in this manner, these are summed. Then the ratio of the column control to the corresponding sum in the 1977 matrix is calculated, and this ratio is applied to the 1963 sums. The result is the derived column control at the bottom of the table. One can see that the sum of the derived controls is 3321.0 million dollars, which corresponds quite well to the published BEA total of 3209.7. The last step is to scale the three estimated controls to this BEA total, giving the final controls in the bottom line of the table. When we have obtained estimates of column controls for each capital flow table, then they are scaled so that they sum to the total of current dollar PDE published in NIPA Table 5.6. This is done because BEA does not maintain exact consistency between the historical capital flow tables and the NIPA. Table A-3 shows the estimated benchmark vectors for each benchmark year, and the scaling ratio that was required to conform to the NIPA control total.

Now that controls have been derived for these capital flow table years, we are ready to benchmark the preliminary current dollar investment series to these controls. Although there are many alternative ways to benchmark a data series to a certain control, I chose a technique that is quite simple. For the years before the first benchmark point, I scale all data so that the series conforms to that point. A similar scaling is performed for the years after the last benchmark point. For years between two benchmark points, ratios of the series to the benchmark for both points are calculated. Then the ratio is linearly interpolated for the intervening years. Finally the ratio is multiplied by each data point, yielding the benchmarked series.

After the current dollar series is benchmarked, the entire series is scaled to conform to NIPA controls. Since the benchmark points have already been scaled, this really only involves scaling the data for the intervening years. There is one intricacy in the use of the NIPA controls that deserves mention. We use for our NIPA control Line 38 of Table 5.6, Private Purchases of New Equipment. The total of INFORUM sectors 1 through 55 are scaled to equal this total. Since sector 57 (Used Equipment and Scrap) is derived as the difference between Line 32 (Private Purchases of PDE) and Line 38, the total of sectors 1 through 57 will equal Line 32. All sectors are scaled equally to get to the control, since the scaling factors are generally rather small. A fair amount of consistency with the NIPA is obtained through the benchmarking process.

At this point, a complete set of current dollar investment data has been obtained, incorporating information from the capital flow tables, and consistent with the NIPA. Before discussing how constant dollar investment data is derived, I will review the process of deriving the capital flow tables and the PDE series. I will return to the discussion of obtaining constant dollar data in Section VII.

IV. The Derivation of the 1977 Capital Flow Table

The capital flow matrix provides a link between investment byindustry and Producers' Durable Equipment (PDE) by commodity, and it is through the derivation of the capital flow matrix that investment data and PDE data are brought into consistency. This section contains a general outline of the process of constructing the capital flow matrix for 1977. First the BEA capital flow workfile tape is read, which contains records with allocations of purchases of PDE by I-O commodity to BEA purchasing industry. Next these records are aggregated, so that multiple records relating one PDE category to one purchasing category are combined into one record. This record contains information on the producer's value, margins and taxes, as well as some documentation on how allocations were made in the BEA workfile. To create the preliminary INFORUM capital flow matrix certain BEA sectors were proportioned into certain INFORUM sectors, and margins were inserted into the appropriate margin rows. Meanwhile, PDE controls are derived in a way that preserves consistency with known output data, and the PDE data published in the NIPA (see Section V). Once these PDE controls have been derived, a final INFORUM capital flow matrix is derived for 1977 by scaling to these controls. The 1977 estimate for INFORUM investment is then the column sums resulting from this scaling to 1977 PDE. This scaling is necessary because the capital flow matrix is not completely consistent with the benchmark NIPA revision of December 1985.

The Capital Flow Workfile tape for 1977 consists of about 17,000records, each containing the following information:

Row code : 537 sector I-O commodity purchased.

SIC code : Corresponding Standard Industrial Classification code for 1977.

Item code : 4 to 7 character code serving as an abbreviation for this type of capital good.

GFPI : Gross Private Fixed Investment category, permitting the grouping of workfile items by the categories published in NIPA Table 5.6.

Column code : 77 order BEA buying sector.

Basic value : Value of investment good in producers' prices, exclusive of commodity taxes.

Commodity tax : Federal excise taxes that must be added to arrive at the producers' value as defined in the CFT published in the SCB.

Railroad margin : Purchased railroad freight required to deliver an item to the buyer in the capital flow table.

Trucking margin : Purchased trucking costs required to deliver an item.

Water margin : Water freight costs required to deliver an item.

Air margin : Air freight costs required to deliver an item.

Wholesale trade margin : Margin paid to wholesalers to deliver a PDE item.

Wholesale tax : Excise and sales taxes imposed at the wholesale trade level.

Retail trade margin : Margin paid to retailers.

Retail sales tax : Sales taxes imposed at the retail level.

Purchasers' value : Sum of the above ten items.

Documentation : Description of the procedure used by BEA to distribute this capital goods item to its various using industries.

These records are first combined into a 537 by 77 sector capital flow table, by aggregating multiple records for one PDE commodity and one buying sector. The documentation from the individual records in the file is saved for later use. Row and column tables are made at the 537 by 77 level for reference. A row table is a listing arranged by row, showing the basic value, margins and taxes for each buyer from that row. A column table is arranged by column, showing the same information for each seller to that buyer.

The next step is to convert this 537 by 77 table to a 480 by 58 sector table at the INFORUM level of classification. (The 480 sector scheme is a direct aggregation from the 537 sector scheme.) Converting the rows to 480 sectors is a simple matter of aggregation from 537 to 480 sectors. However, going from the BEA 77 sector scheme to the INFORUM 55 sectors requires special attention, as can be seen by looking at Table A-2, which shows the concordance of the BEA and INFORUM classification schemes. Some of the BEA sectors are split into two or more INFORUM sectors. In other cases, a total of two or more BEA sectors are split into two or more INFORUM sectors. Altogether 5 BEA sectors are split to obtain 14 INFORUM sectors. First the column controls are split, using data available at the 4-digit level from the Census of Manufactures. To split each cell requires subjective judgement. In some cases it is obvious that one PDE commodity should be sold to only one buyer from the relevant columns. Fortunately many of the large entries in the column are of this type. For some entries, information from the capital flow workfile documentation can be used to allocate certain percentages to one sector or another. This documentation tells how BEA allocated goods of this PDE category. However, for other entries, such as motor vehicles, we must use what we know about the technology of each industry to make a reasonable allocation. Associated with each allocation are the respective margins, which are also allocated to that column. Finally, each of the columns that was derived by this splitting procedure are scaled. Those entries that were determined subjectively are scaled so that the total for the column equals the column control derived by splitting the BEA column controls with Census information.

The final step in deriving the capital flow matrix for 1977 is to scale the rows to a 1977 vector of PDE, consistent with the NIPA PDE published in Table 5.6. After scaling, the column sums of this new matrix are used as the benchmark for current dollar investment for 1977.

V. The Derivation of the Current Dollar and 77$ PDE Series

Before balancing the capital flow matrix for 1977 and for the other years in the interval of available investment controls, a series of current dollar PDE at the 480 sector level is also needed, consistent with the 480 sector output series, and with the NIPA.

PDE is estimated via a commodity-flow approach, similar to the methods underlying the derivation of the NIPA PDE. However, the techniques used thus far have yielded estimates of current dollar PDE which diverge significantly from those made by BEA, especially as one movesaway from a benchmark year such as 1977. Thus the current dollar PDE data must be brought into consistency with the NIPA. To estimate current dollar PDE, current dollar 5-digit product shipments data from the Annual Survey of Manufactures (ASM) and the Census of

Manufactures are adjusted by adding imports and subtracting exports. The ratio of PDE to this number for a base year (such as 1977) is applied to the entire time series, yielding an estimate of PDE expenditures by 5-digit category.

Beginning with PDE estimates from the 5-digit product shipments, next a current dollar PDE vector at the 540 sector level for each year is derived This is consistent with the current dollar PDE published in the NIPA tables, and uses information on margins from the 1977 I-O work, and the 1977 PDE bridge, which relates the detailed categories of PDE to the PDE published in NIPA Table 5.6. Margin flows are estimated for each year by using the 1977 ratios of margins as a share of producer's value, and adjusting for changes in relative prices, so that the ratios are more or less constant in real terms. Finally the PDE in producer's values and the associated margins are scaled to be consistent with the PDE from NIPA Table 5.6 in purchaser's values by estimating a new PDE bridge (540 detailed PDE categories by 24 NIPA PDE categories) for each year, and adjusting this bridge so that the 24 column totals each sum to the corresponding NIPA PDE. The detailed PDE in purchaser's values from this bridge is then split back into PDE in producer's values and margins, using the ratios described above. The margins are summed across detailed PDE categories, and the total of these margins becomes the PDE estimate for the margin sectors, which is used in the balancing as the row control for these sectors. During the scaling of the PDE bridge to the NIPA totals, the estimate for category 535 (Used and Secondhand) must also be made consistent with the published

NIPA estimates of Used and Secondhand Equipment from Table 5.6, which is available as the difference between line 32 (Total Private Purchases of PDE), and line 38 (Private Purchases of New PDE), and which is a negative number. (This negative value indicates that sales of used equipment exceed purchases.) Part of this difference is scrap, which is forced to be equal to line 30 in Table 5.6 (scrap), during the scaling of the PDE bridge. Another large component, is PDE of Used Autos, which is forced to be equal to the published estimate of this number in NIPA Table 1.17, line 8. Taking into account these two constraints, the rest of the entries in the row of the PDE bridge for sector 535 are scaled using a method that takes into account the fact that some of the components of this row are positive and others are negative.[75]

After completing this scaling using the PDE-NIPA bridge, a current dollar PDE series which is consistent with all available information from the current dollar NIPA tables has been obtained. This series is aggregated to 480 sectors before serving as a control for the balancing.

Constant dollar PDE is derived in a similar manner to the current dollar PDE from the 5-digit work, except that product shipments, imports and exports are all deflated by shipments, import and export deflators, respectively, before imports are added and exports subtracted. (Actually this is true for every PDE item except

[75] In this method, if the desired total is greater than the sum, negative numbers become less negative, and positive numbers more positive. On the other hand, if the total is less than the sum, negative numbers become more negative, and positive numbers less positive.

for computers, margins and scrap. I have tried to use the deflator in NIPA Table 7.13, line 4 to deflate computers. It should be noted that BEA has this deflator falling drastically, so that the PDE for computers in a year such as 1984 is almost twice as large as previous estimates. I am not totally convinced, however, that BEA has chosen the most useful concept for their deflator of computers, and after attempting to use data created from this deflator, we have decided to revert to using a constant deflator of 1.0 for computers. Margins are deflated with the deflators from the 480-order output work, and scrap is deflated by an implied deflator for the PDE of used autos, created by dividing line 8 of Table 1.17 by line 8 of Table 1.18, and basing to 1977.) BEA, on the other hand, derives constant dollar PDE by deflating their current dollar PDE estimates by a set of weighted producer price indexes. This method does not reflect the prices of imports of PDE, which have been cheaper than domestically produced PDE for the last few years. With the increasing share of imports in the purchases of PDE goods throughout the early 1980's, we feel that their estimates for constant dollar PDE are generally too low, since they overstate the increases in PDE prices. Since I feel that this method is more realistic within a model, I do not try to control the constant dollar data to the NIPA constant dollar total. Table A-4 shows a comparison of INFORUM constant dollar PDE estimates to the NIPA estimates for the years 1959 to 1984.

VI. Obtaining a Series of Current and Constant Dollar Capital Flow Tables

With a series of current dollar PDE and equipment investment data at hand, estimates for a series of current dollar capital flow tables can be derived, starting from the 1977 table. The procedure use to derive these estimated tables is called the rAs balancing technique. This method is so called, because given a starting matrix **A**, the method is equivalent to finding diagonal matrices *r* and *s* such that the matrix *r***A***s* has the required row and column sums (PDE and investment controls). In practice this method is implemented by scaling the rows and columns iteratively to the controls until convergence within a specified tolerance is achieved. Scaling may either start with the row or the column, in different circumstances. A problem arises in using this method when some flows are large, and the flow is either not consistent with the row or column control, or the row and column control for this flow are not consistent with each other. In this case the small flows for that row or column may be reduced to unrealistically small levels, or the balancing will simply not converge. It is possible when using this balancing method to express varying degrees of confidence in the different flows, so that some will be scaled more than others. However, since both the PDE and the investment series are estimates, we decided to take a more critical look at these series when problems were encountered.

In order to get an idea of what kind of data problems might be encountered in doing a balance for a time series of matrices, a preliminary balance was performed for the 1982 matrix. For the first attempt, a one pass scaling of the 1977 matrix was performed, first to the 1982 investment (column) controls and then to the 1982 PDE (row) controls. Then the results of this balancing operation were displayed in a manner that showed column differences both as actual differences and as ratios. Where the differences between the investment data and the column sums from the one pass balance diverged significantly, the sources used to move investment for these sectors were critically evaluated. The sectors that required particular examination were Petroleum and Natural Gas(2), Mining(3), Textiles(6), Rubber and Plastic(14), Computers and Office Machinery(29), Communications Machinery(31), Motor Vehicles(36), Railroads(42), Air Transport(43) and Movies and Amusements(54).

From this evaluation, the data sources for Crude Petroleum and Natural Gas(2), Mining(3) and Railroads(42) were changed to be consistent with the detailed PDE series. Since the PDE series only go back to 1958 they were moved back previous to that date with the available estimate of investment for these sectors. Using these new data, the 1982 matrix fully converged in 10 iterations, at a tolerance of 0.1%. (The largest ratio of change was between .999 and 1.001)

At this point, a set of data sources for the CU$ gross investment series has been obtained that makes it possible to achieve convergence in the balancing of a matrix such as that for 1982 within a few iterations. Now it is time to balance the entire time series of matrices. Instead of using the 1977 matrix as the starting point for our whole time series, the following procedure was adopted.

First a 1972 capital flow table was constructed from data originating from the 1972 capital workfile tape. Any splitting of BEA sectors that was required was done using ratios from the 1977 table. A one pass scaling to the 1972 PDE controls yielded a set of column totals that were used as the 1972 benchmark for the investment data. In order to obtain initial estimates of the capital flow tables for the years 1973 to 1976, a linear interpolation of the coefficients implied by the 1972 and 1977 tables was performed. These initial estimates were then used in the balancing sequence described below. In the process of interpolating the 1972 and 1977 matrices, discrepancies in the structure of the two matrices revealed themselves. In particular, for some cells there was a zero in one matrix whereas the other matrix had a non zero value. For these cells, the discrepancies were printed, but the matrices were interpolated nevertheless. None of the discrepancies constituted more than 2% of its respective column total.

In the process of balancing a matrix with the rAs procedure, theend result of course very sensitive to the choice of a starting matrix. In previous attempts at updating or 'rejuvenating' the capital flow matrix with the rAs balancing procedure, the matrix for the new base year was constructed using the old base year as a starting point. For example, for the previous estimate of the 1977 capital flow table, the 1972 matrix was used as the starting matrix. The structural changes occurring in a five year period can be fairly significant, and the results of the first pass scaling heavily influence the outcome of the balance. For this reason the following method was used. For the years 1978 to 1984, the balancing was done in a stairstep fashion. The starting point for balancing the 1978 matrix was the 1977 matrix. The resulting 1978 balanced matrix was then used as the starting point for the 1978 balancing, and so on. This procedure was carried forward to 1984, thus providing a link between the structure of the matrices for each successive year. For each matrix, a maximum of 40 iterations was allowed, to get the matrix to converge within a tolerance of 0.1%. For the years 1972 to 1976, the matrices derived from the interpolation were used as starting points. Finally, the matrices from 1958 to 1971 were balanced in a stairstep fashion, but this time going down the stairs, or backwards in time. In other words, the 1972 matrix was used as the starting point for the 1971 balance, the 1971 balanced matrix was used as the starting point for the 1970 balance, and so on. Although it would be ideal to have the detailed information for the 1958, 1963 and 1967 matrices on hand, these were not available at the time of this balancing. However, it seems that the sequential balancing process preserves some of the information contained in the year to year movement of investment and PDE to construct a matrix for a year that is fairly distant from the matrix for which we have good information. When the tape for the 1982 matrix is made available, it would be useful to compare our estimated matrix with this 'actual' matrix.

Once a series of current dollar capital flow matrices has been obtained, constant dollar matrices can be derived from these by simply deflating each row by the appropriate PDE deflator. I have chosen to simply scale each row of the current dollar matrix to conform to a constant dollar PDE row control, which in this case is equivalent to deflation.

VII. Derivation of the 77$ Investment Series

At this point INFORUM has PDE available for the years 1958 to 1984, and so the capital flow matrices for these years have also been derived. The column sums for these matrices are combined to form a history of 77$ investment. The 77$ investment series is then extended back to 1947, and forward to the most current year of deflators available (now 1985).

To extend the 77$ series back beyond 1958 to 1947, a set of equipment deflators is created by weighting the 78-order output deflators by the 78 X 58 B-matrix of coefficients for 1958. The data from 1947 to 1958 is then deflated with these deflators, and is scaled to link smoothly to the 1958 data derived as the column sums of the 1958 capital flow matrix. (The 480-order deflators aren't used because they are not available before 1958.) To update the 77$ series to the most current year possible, a series of 480-order PDE deflators is derived by aggregating current dollar and 77$ PDE at the 540 sector level to 480 sectors, and then dividing current dollar PDE by constant dollar PDE, to yield a time series of PDE deflators. These PDE deflators are moved forward for actual PDE categories with the movement of the appropriate deflators from Table 7.13. Deflators for the margins are moved forward by the GNP Deflator for Non-farm Business, which is NIPA Table 7.6, line 5. The deflator for non-comparable imports is moved forward by the aggregate import deflator, in NIPA Table 7.14, line 8. Finally, the deflator for used equipment and scrap is moved forward by the ratio of CU$/82$ used PDE for autos, based to equal 1.0 in 1977. The CU$ number is taken from NIPA Table 1.17, line 8, and the 82$ number is from Table 1.18, line 8. Once 480-order output deflators have been obtained, they are weighted by the 1984 B-matrix in coefficient form. The CU$ investment series is deflated from 1984 to the most current year of available deflators in the NIPA bank, and then scaled so that the series will link on in 1984 to the data created by taking the column sums of the history of capital flow matrices.

At this point, a 77$ series from 1947 to the most current year of NIPA deflators has been derived. Gross investment data in 77$ is also now available back to 1927 from previous data work. These data are used to derive the capital stocks used in the investment equations. To create a new set of data from 1927 to the present we scale this data to link on to our series in 1947. Finally, for 1947 to the most current year available, a set of implicit equipment investment deflators are created by dividing the CU$ series by the 77$ series. This series of deflators is used as the price of equipment variable in the investment equation estimation.

Constant dollar NIPA controls for investment are derived from the data published in NIPA Table 5.7, in the same manner as the current dollar controls described in section III. The estimate for Used and Secondhand is deflated with the deflator for the PDE of used autos implicit in NIPA tables 1.17 and 1.18. Table A-6 shows the ratio of the total 55 INFORUM sectors to the NIPA control total derived from NIPA Table 5.7.

Table A-1

Sources for Sectoral Investment Data

1 Agriculture	USDA - Economic Indicators of Farm Sector
2 Crude Petroleum	PDE for Oilfield Machinery (SIC 3533)
3 Mining	PDE for Construction Machinery plus Mining Machinery (Weighted average of SIC 3531 and 3532)
4 Construction	PDE for Construction Machinery (SIC 3531)
5-41 Manufacturing	*Annual Survey of Manufactures* and *Census of Manufactures*
42 Railroads	PDE for Railroad Equipment (SIC 3740)
43-55	Corresponding aggregation of sectors from the BEA Capital Stock Study

Table A-2

Concordance for Various Classification Schemes

The following table shows the relationship between the INFORUM 540 order classification scheme, the scheme used in the BEA Capital Stock Study (BEACS), the scheme for the BEA capital flow matrix (BEA77), and the scheme for the Plant and Equipment survey (P&E). In the first column we have given the sector number for the INFORUM 540 category, followed by the corresponding sector numbers for each of the other classification schemes. The SIC codes and titles for the 540-order categories are to the right of these. Following this table are sector titles for the INFORUM 55 sector ordering, the BEACS classification, the BEA input-output classification, and the Plant and Equipment survey classification.

540	55	BEACS	BEA77	P&E	1977 SIC	
1	1	1	1	0	241	DAIRY FARM PRODUCTS
2	1	1	1	0	250	POULTRY AND EGGS
3	1	1	1	0	210	MEAT ANIMALS
4	1	1	1	0	270	MISC. LIVESTOCK-HORSES, BEES, HONEY, ETC
5	1	1	2	0	131	COTTON
6	1	1	2	0	111, 112, 119pt	FOOD GRAINS: WHEAT, RYE, RICE, BUCKWHEAT
7	1	1	2	0	115, 119, pt139	FEED GRAINS: CORN, OATS, BARLEY, HAY, SORGHUM
8	1	1	2	0	139 pt	GRASS SEEDS
9	1	1	2	0	132	TOBACCO
10	1	1	2	0	170 pt	FRUITS
11	1	1	2	0	173 179	TREE NUTS
12	1	1	2	0	134, 161, 139, 119	VEGETABLES
13	1	1	2	0	133	SUGAR CROPS
14	1	1	2	0	139 pt 119 pt	MISC. CROPS INCL HOPS, MINT, POPCORN
15	1	1	2	0	116, 119pt 139pt	OIL BEARING CROPS, INCL SOYBEANS, PEANUTS
17	1	1	2	0	180 pt	GREENHSE & NURSERY PROD
18	1	2	3	0	810-840, 970	FORESTRY PRODUCTS: STUMPAGE, GUMS, SYRUP
19	1	2	3	0	910	COMMERCIAL FISHING

540	55	BEACS	BEA77	P&E	1977 SIC	
20	1	2	4	0	700,850,920,254	AG,FOR,FISH SERVICES
21	1	2	4	0	780	LANDSCAPE & HORTICULTURAL SERVICES
22	3	3	5	16	1010 1060	IRON & FERROALLOY ORE M
23	3	3	6	16	1020	COPPER ORE MINING
24	3	3	6	16	1030-50,1080,90	NONFERR MET ORE MIN EXC COPPER
25	3	4	7	16	1111-12,1211,13	COAL MINING
26	2	5	8	16	1311 1320 1380	CRUDE PETRO.
27	2	5	8	16	1312	NATURAL GAS
28	3	6	9	16	1410 1420	CRUSHED & BROKEN STONE
29	3	6	9	16	1440	SAND & GRAVEL MINING
30	3	6	9	16	1450	CLAY, CERAMIC, & REFRACTORY MINERALS MINING
31	3	6	9	16	1480 1490	NONMETALLIC MINERAL SERV. & MISC MINERALS MINING.
32	3	6	10	16	1470	CHEM & FERT MINERAL MIN
69	4	7	12	0		MAINT & REPAIR, RESIDENTIAL
70	4	7	12	0		MAINT&REPAIR,OTH NONFARM BLDG
71	4	7	12	0		MAINT & REPAIR, FARM RESID BLDG
72	4	7	12	0		MAINT & REPAIR, FARM SERVICE FACIL
73	0	7	12	0		MAINT & REPAIR, TELEPHONE & TELEGRAPH
74	0	7	12	0		MAINT & REPAIR, RAILROAD
75	0	7	12	0		MAINT & REPAIR, ELEC. UTIL
76	0	7	12	0		MAINT & REPAIR, GAS UTIL
77	0	7	12	0		MAINT & REPAIR, PETRO PIPELINES
78	0	7	12	0		MAINT & REPAIR, WATER SUPPLY
79	0	7	12	0		MAINT & REPAIR, SEWER FACILITIES
80	0	7	12	0		MAINT & REP, LOCAL TRANSIT
81	4	7	12	0		MAINT & REP, MILITARY FACIL
82	4	7	12	0		MAINT & REP, CONSER. &DEVELOPMENT FACIL
83	4	7	12	0		MAINT & REP, HIGHWAYS & STS
84	0	7	12	0		MAINT&REP, OIL&N.GAS WELLS
85	4	7	12	0		MAINT & REP, OTH NONBLD FACIL
86	37	16	12	6	3761	COMPLETE GUIDED MISSILE
87	21	12	13	2	3483	AMMUNITION, EXC. SMALL ARMS
88	39	16	13	4	3795	TANKS & TANK COMPONENTS
89	21	12	13	2	3484	SMALL ARMS
90	21	12	13	2	3482	SMALL ARMS AMMUNITION
91	21	12	13	2	3489	OTH ORDNANCE & ACCESSORIES
92	5	19	14	9	2011	MEAT PACKING PLANTS
93	5	19	14	9	2013	SAUSAGES & OTH PREP MEA
94	5	19	14	9	2016	POULTRY DRESSING PLANTS
95	5	19	14	9	2017	POULTRY & EGG PROCESSIN
96	5	19	14	9	2021	CREAMERY BUTTER
97	5	19	14	9	2022	CHEESE, NATURAL & PROCESSED
98	5	19	14	9	2023	MILK, DRIED,CONDENSED,EVAPORATED
99	5	19	14	9	2024	ICE CREAM & FROZEN DESSERTS
100	5	19	14	9	2026	FLUID MILK
101	5	19	14	9	2091	CANNED & CURED SEA FOOD
102	5	19	14	9	2032	CANNED SPECIALTIES
103	5	19	14	9	2033	CANNED FRUITS & VEGETABLES

540	55	BEACS	BEA77	P&E	1977 SIC	
104	5	19	14	9	2034	DEHYDRATED FOOD PRODUCT
105	5	19	14	9	2035	PICKLES, SAUCES, SALAD DRESSING
106	5	19	14	9	2092	FISH, FRESH OR FROZEN PACKAGED
107	5	19	14	9	2037	FROZEN FRUITS, JUICES, VEGETABLES
108	5	19	14	9	2038	FROZEN SPECIALTIES
109	5	19	14	9	2041	FLOUR & OTH GRAIN MILL PRODUCTS
110	5	19	14	9	2043	CEREAL BREAKFAST FOODS
111	5	19	14	9	2045	BLENDED & PREPARED FLOUR
112	5	19	14	9	2047	DOG, CAT, & OTH PET FOODS
113	5	19	14	9	2048	PREPARED FEEDS, N.E.C.
114	5	19	14	9	2044	RICE MILLINGS
115	5	19	14	9	2046	WET CORN MILLING
116	5	19	14	9	2051	BREAD, CAKE, & RLTD PRODUCTS
117	5	19	14	9	2052	COOKIES & CRACKERS
118	5	19	14	9	2061 2062 2063	SUGAR
119	5	19	14	9	2065	CONFECTIONERY PRODUCTS
120	5	19	14	9	2066	CHOCOLATE & COCOA PRODS
121	5	19	14	9	2067	CHEWING GUM
122	5	19	14	9	2082	MALT BEVERAGES
123	5	19	14	9	2083	MALT
124	5	19	14	9	2084	WINES BRANDY & BRANDY SPIRITS
125	5	19	14	9	2085	DISTILLED LIQUOR, EXC BRANDY
126	5	19	14	9	2086	BOTTLED & CANNED SOFT DRINKS
127	5	19	14	9	2087	FLAVOR EXTRACTS & SIRUP
128	5	19	14	9	2074	COTTONSEED OIL MILLS
129	5	19	14	9	2075	SOYBEAN OIL MILLS
130	5	19	14	9	2076	VEGETABLE OIL MILLS, NE
131	5	19	14	9	2077	ANIMAL & MARINE FATS &
132	5	19	14	9	2095	ROASTED COFFEE
133	5	19	14	9	2079	SHORTENING & COOKING OILS
134	5	19	14	9	2097	MANUFACTURED ICE
135	5	19	14	9	2098	MACARONI & SPAGHETTI
136	5	19	14	9	2099	FOOD PREPARATIONS, NEC
137	5	20	15	9	2110	CIGARETTES
138	5	20	15	9	2120	CIGARS
139	5	20	15	9	2130	CHEWING & SMOKING TOBACCO
140	5	20	15	9	2140	TOBACCO STEM & REDRYING
141	6	21	16	10	2210-30,2261,62	BRDWOV FAB MILLS & FINISHING PLANTS
142	6	21	16	10	2240	NARROW FABRIC MILLS
143	6	21	16	10	2269 2281-83	YARN MILLS & TEXTILE FINISHING NEC
144	6	21	16	10	2284	THREAD MILLS
145	6	21	17	10	2270	FLOOR COVERINGS
146	6	21	17	10	2291	FELT GOODS N.E.C.
147	6	21	17	10	2292	LACE GOODS
148	6	21	17	10	2293	PADDING & UPHOLSTERY FILLING
149	6	21	17	10	2294	PROCESSED TEXTILE WASTE
150	6	21	17	10	2295	COATED FABRICS, NOT RUBBERIZED
151	6	21	17	10	2296	TIRE CORD & FABRIC
152	6	21	17	10	2298	CORDAGE & TWINE

540	55	BEACS	BEA77	P&E	1977	SIC	
153	6	21	17	10	2297		NONWOVEN FABRICS
154	6	21	17	10	2299		TEXTILE GOODS, N.E.C.
155	7	21	18	10	2251		WOMENS HOSIERY, EXC SOCKS
156	7	21	18	10	2252		HOSIERY, N.E.C.
157	7	21	18	10	2253		KNIT OUTERWEAR MILLS
158	7	21	18	10	2254		KNIT UNDERWEAR MILLS
159	7	21	18	10	2259		KNITTING MILLS, N.E.C.
160	7	21	18	10	2257	2258	KNIT FABRIC MILLS
161	8	22	18	10	2300	-2390	APPAREL FROM PURCHASED
162	8	22	19	10	2391		CURTAINS & DRAPERIES
163	8	22	19	10	2392		HOUSEFURNISHINGS, N.E.C
164	8	22	19	10	2393		TEXTILE BAGS
165	8	22	19	10	2394		CANVAS PRODUCTS
166	8	22	19	10	2395		PLEATING & STITCHING
167	8	22	19	10	2396		AUTO & APPAREL TRIMMING
168	8	22	19	10	2397		SCHIFFLI MACH EMBROIDERIES
169	8	22	18/19	10	2399	39996	FAB TEXTILE PRODUCTS, NEC
170	16	8	20	8	2411		LOGGING CAMPS & CONTRACTORS
171	16	8	20	8	2421		SAWMILLS & PLANING MILL
172	16	8	20	8	2426		HRDWD DIM & FLOOR MILLS
173	16	8	20	8	2429		SPEC PROD SAWMILLS NEC
174	16	8	20	8	2431		MILLWORK
175	16	8	20	8	2434		WOOD KITCHEN CABINETS
176	16	8	20	8	2435	2436	VENEER & PLYWOOD
177	16	8	20	8	2439		STRUC WOOD MEMBERS, NEC
178	16	8	20	8	2452		PREFAB WOOD BUILDINGS
179	16	8	20	8	2491		WOOD PRESERVING
180	16	8	20	8	2448		WOOD PALLETS & SKIDS
181	16	8	20	8	2492		PARTICLEBOARD
182	16	8	20	8	2499		WOOD PRODUCTS, N.E.C.
183	16	8	21	8	2441	2449	WOOD CONTAINERS
184	17	9	22	8	2511		WOOD HOUSEHOLD FURNITURE
185	17	9	22	8	2519		HOUSEHOLD FURNITURE, NE
186	17	9	22	8	2517		WOOD TV & RADIO CABINET
187	17	9	22	8	2512		UPHOLSTERED HSHLD FURNITURE
188	17	9	22	8	2514		METAL HOUSEHOLD FURNITURE
189	17	9	22	8	2515		MATTRESSES & BEDSPRINGS
190	17	9	23	8	2521		WOOD OFFICE FURNITURE
191	17	9	23	8	2522		METAL OFFICE FURNITURE
192	17	9	23	8	2531		PUBLIC BUILDING FURNITURE
193	17	9	23	8	2541		WOOD PARTITIONS & FIXTURES
194	17	9	23	8	2542		METAL PARTITIONS & FIXTURES
195	17	9	23	8	2591		BLINDS, SHADES, & DRAPERY HARDWARE
196	17	9	23	8	2599		FURNITURE & FIXTURES, NEC
197	9	23	24	11	2610		PULP MILLS
198	9	23	24	11	2620		PAPER MILLS, EXC BLDG PAPER
199	9	23	24	11	2630		PAPERBOARD MILLS
200	9	23	24	11	2642		ENVELOPES
201	9	23	24	11	2647		SANITARY PAPER PRODUCTS

540	55	BEACS	BEA77	P&E	1977 SIC	
202	9	23	24	11	2660	BUILDING PAPER & BOARD MILLS
203	9	23	24	11	2641	PAPER COATING & GLAZING
204	9	23	24	11	2643	BAGS, EXCEPT TEXTILES
205	9	23	24	11	2645	DIE-CUT PAPER & BOARD
206	9	23	24	11	2646	PRESSED & MOLDED PULP G
207	9	23	24	11	2648	STATIONERY PRODUCTS
208	9	23	24	11	2649	CONVERTED PAPER PROD, NEC
209	9	23	25	11	2650	PAPERBOARD CONTAINERS & BOXES
210	10	24	26	15	2710	NEWSPAPERS
211	10	24	26	15	2720	PERIODICALS
212	10	24	26	15	2731	BOOK PUBLISHING
213	10	24	26	15	2732	BOOK PRINTING
214	10	24	26	15	2740	MISC. PUBLISHING
215	10	24	26	15	2751 2752 2754	COMMERCIAL PRINTING
216	10	24	26	15	2795	LITHOGRAPHIC PLATEMAKING
217	10	24	26	15	2760	MANIFOLD BUSINESS FORMS
218	10	24	26	15	2782	BLANKBOOKS & LOOSELEAF BINDERS
219	10	24	26	15	2770	GREETING CARD PUBLISHIN
220	10	24	26	15	2753	ENGRAVING & PLATE PRINTING
221	10	24	26	15	2789	BOOKBINDING & RELATED WORK
222	10	24	26	15	2791	TYPESETTING
223	10	24	26	15	2793	PHOTOENGRAVING
224	10	24	26	15	2794	ELECTROTYPING & STEREOTYPING
225	12	25	27	12	2810 2865 2869	INDL CHEM, INORG & ORG
226	11	25	27	12	2873 2874	FERTILIZERS, NITROG&PHOSPH
227	11	25	27	12	2875	FERTILIZERS MIXING ONLY
228	11	25	27	12	2879	AGRIC CHEMICALS, NEC
229	12	25	27	12	2861	GUM & WOOD CHEMICALS
230	12	25	27	12	2891	ADHESIVES & SEALANTS
231	12	25	27	12	2892	EXPLOSIVES
232	12	25	27	12	2893	PRINTING INK
233	12	25	27	12	2895	CARBON BLACK
234	12	25	27	12	2899	CHEMICAL PREPARATIONS,N
235	12	25	28	12	2821	PLASTICS MATLS & RESINS
236	12	25	28	12	2822	SYNTHETIC RUBBER
237	12	25	28	12	2823	CELLULOSIC MAN-MADE FIBERS
238	12	25	28	12	2824	NONCELLULOSIC FIBERS
239	12	25	29	12	2830	DRUGS
240	12	25	29	12	2841	SOAP & OTHER DETERGENTS
241	12	25	29	12	2842	POLISHES & SANITATION G
242	12	25	29	12	2843	SURFACE ACTIVE AGENTS
243	12	25	29	12	2844	TOILET PREPARATIONS
244	12	25	30	12	2850	PAINTS & ALLIED PRODUCT
245	13	26	31	13	2911	PETROLEUM REFINING
246	13	26	31	13	2915	FUEL OIL (BEA 245part - Inforum split)
247	13	26	31	13	2992 2917	LUBRICATING OILS & GREASES
248	13	26	31	13	2999	PRODUCTS OF PETROLEUM AND COAL, NEC
249	13	26	31	13	2951	PAVING MIXTURES & BLOCK
250	13	26	31	13	2952	ASPHALT FELTS & COATING

540	55	BEACS	BEA77	P&E	1977 SIC	
251	14	27	32	14	3010	TIRES & INNER TUBES
252	14	27	32	14	3020	RUBBER & PLASTIC FOOTWE
253	14	27	32	14	3030	RECLAIMED RUBBER
254	14	27	32	14	3060	FABRICATED RUBBER PROD,
255	14	27	32	14	3070	MISC.PLASTIC PRODUCTS
256	14	27	32	14	3040	RUBBER&PLASTIC HOSE&BEL
257	15	28	33	15	3110	LEATHER TANNING & FINIS
258	15	28	34	15	3130	FOOTWEAR CUT STOCK
259	15	28	34	15	3143 3144 3149	SHOES, EXCEPT RUBBER
260	15	28	34	15	3142	HOUSE SLIPPERS
261	15	28	34	15	3150	LEATHER GLOVES & MITTEN
262	15	28	34	15	3160	LUGGAGE
263	15	28	34	15	3171	WOMENS HANDBAGS & PURSE
264	15	28	34	15	3172	PERSONAL LEATHER GOODS
265	15	28	34	15	3190	LEATHER GOODS, N.E.C.
266	18	10	35	7	3210 3229 3230	GLASS & GLASS PROD,NEC
267	18	10	35	7	3221	GLASS CONTAINERS
268	18	10	36	7	3240	CEMENT, HYDRAULIC
269	18	10	36	7	3251	BRICK & STRUCTURAL CLAY TILE
270	18	10	36	7	3253	CERAMIC WALL & FLOOR TILE
271	18	10	36	7	3255	CLAY REFRACTORIES
272	18	10	36	7	3259	STRUCTURAL CLAY PROD,NEC
273	18	10	36	7	3261	VITREOUS PLUMBING FIXTURES
274	18	10	36	7	3262	VITREOUS CHINA FOOD UTENSILS
275	18	10	36	7	3263	FINE EARTHWARE FOOD UTENSILS
276	18	10	36	7	3264	PORCELAIN ELEC SUPPLIES
277	18	10	36	7	3269	POTTERY PRODUCTS, N.E.C
278	18	10	36	7	3271	CONCRETE BLOCK & BRICK
279	18	10	36	7	3272	CONCRETE PRODUCTS, N.E.
280	18	10	36	7	3273	READY-MIXED CONCRETE
281	18	10	36	7	3274	LIME
282	18	10	36	7	3275	GYPSUM PRODUCTS
283	18	10	36	7	3280	CUT STONE & STONE PRODU
284	18	10	36	7	3291	ABRASIVE PRODUCTS
285	18	10	36	7	3292	ASBESTOS PRODUCTS
286	18	10	36	7	3293	GASKETS, PACK&SEAL DEVICES
287	18	10	36	7	3295	MINERALS, GROUND OR TREATED
288	18	10	36	7	3296	MINERAL WOOL
289	18	10	36	7	3297	NONCLAY REFRACTORIES
290	18	10	36	7	3299	NONMETAL MINERAL PROD,NEC
291	19	11	37	1	3312	BLAST FURNACES & STEEL MILLS
292	19	11	37	1	3313	ELECTROMETALLURGICAL PRODUCTS
293	19	11	37	1	3315	STEEL WIRE & RELATED PRODUCTS
294	0	11	37	1	3316	COLD FINISHING OF STEEL SHAPES
295	0	11	37	1	3317	STEEL PIPE & TUBES
296	19	11	37	1	3320	IRON & STEEL FOUNDRIES
297	19	11	37	1	3462	IRON & STEEL FORGINGS
298	19	11	37	1	3398	METAL HEAT TREATING

540	55	BEACS	BEA77	P&E	1977 SIC	
299	19	11	37	1	3399	PRIMARY METAL PROD, NEC
300	20	11	38	1	3331	PRIMARY COPPER
301	20	11	38	1	3332	PRIMARY LEAD
302	20	11	38	1	3333	PRIMARY ZINC
303	20	11	38	1	3334 28195	PRIMARY ALUMINUM
304	20	11	38	1	3339	PRIMARY NF METALS, NEC
305	0	11	38	1	3341	SECONDARY NONFERROUS METALS NEC
306	20	11	38	1	3351	COPPER ROLLING & DRAWING
307	20	11	38	1	3353 3354 3355	ALUMINUM ROLLING & DRAWING
308	20	11	38	1	3356	NONFERROUS ROLL & DRAW, NEC
309	20	11	38	1	3357	NF WIRE DRAWING&INSULATING
310	20	11	38	1	3361	ALUMINUM CASTINGS
311	20	11	38	1	3362	BRASS, BRONZE, COPPER CASTINGS
312	20	11	38	1	3369	NONFERROUS CASTINGS, NEC
313	20	12	38	1	3463	NONFERROUS FORGINGS
314	21	12	39	2	3411	METAL CANS
315	21	12	39	2	3412	METAL BARRELS, DRUMS, PAILS
316	21	12	40	2	3431	METAL SANITARY WARE
317	21	12	40	2	3432	PLUMBING FIXTURES, ETC
318	21	12	40	2	3433	HEATING EQUIP, EXC ELEC
319	21	12	40	2	3441	FABRICATED STRUCTURAL METAL
320	21	12	40	2	3442	METAL DOORS, SASH, TRIM
321	21	12	40	2	3443	BOILER SHOPS
322	21	12	40	2	3444	SHEET METAL WORK
323	21	12	40	2	3446	ARCHITECTURAL METAL WORK
324	21	12	40	2	3448	PREFAB METAL BUILDINGS
325	21	12	40	2	3449	MISCELLANEOUS METAL WORK
326	21	12	41	2	3450	SCREW MACH PRODUCTS
327	21	12	41	2	3465	AUTO STAMPINGS
328	21	12	41	2	3466	CROWNS & CLOSURES
329	21	12	41	2	3469	METAL STAMPINGS, N.E.C.
330	21	12	42	2	3421	CUTLERY
331	21	12	42	2	3423	HAND & EDGE TOOLS, NEC
332	21	12	42	2	3425	HAND SAWS & SAW BLADES
333	21	12	42	2	3429	HARDWARE, N.E.C.
334	21	12	42	2	3471	PLATING & POLISHING
335	21	12	42	2	3479	METAL COATING & ALLIED SERVICES
336	21	12	42	2	3495 3496	MISC FAB WIRE PRODUCTS
337	21	12	42	2	3493	STEEL SPRINGS, EXC WIRE
338	21	12	42	2	3494 3498	PIPE, VALVES, PIPE FITTIN
339	21	12	42	2	3497	METAL FOIL & LEAF
340	21	12	42	2	3499	FABRICATED METAL PROD, NEC
341	22	13	43	4	3511	TURBINES & TURBINE GENERATOR SETS
342	22	13	43	4	3519	INTERNAL COMBUST ENGINES, NEC
343	23	13	44	4	3523	FARM MACHINERY & EQUIP.
344	23	13	44	4	3524	LAWN & GARDEN EQUIP.
345	28	13	45	4	3531	CONSTRUCTION MACH & EQUIP
346	28	13	45	4	3532	MINING MACH, EXC OIL FIELD

540	55	BEACS	BEA77	P&E	1977 SIC		
347	28	13	45	4	3533		OIL FIELD MACHINERY
348	28	13	46	4	3534		ELEVATORS & MOVING STAIRWAYS
349	28	13	46	4	3535		CONVEYERS & CONVEYING EQ
350	28	13	46	4	3536		HOIST, CRANES, & MONORAILS
351	28	13	46	4	3537		INDL TRUCKS & TRACTORS
352	25	13	47	4	3541		MACH TOOLS, METAL CUTTING
353	25	13	47	4	3542		MACH TOOLS, METAL FORMING
354	25	13	47	4	3544	3545	SPEC DIES, TOOLS, MACH TOOL ACCESSORIES
355	25	13	47	4	3546		POWER DRIVEN HAND TOOLS
356	25	13	47	4	3547		ROLLING MILL MACHINERY
357	25	13	47	4	3549		METALWORKING MACHINES, NEC
358	27	13	48	4	3551		FOOD PRODUCTS MACHINERY
359	27	13	48	4	3552		TEXTILE MACHINERY
360	27	13	48	4	3553		WOODWORKING MACHINERY
361	27	13	48	4	3554		PAPER INDUSTRIES MACHINERY
362	27	13	48	4	3555		PRINTING TRADES MACHINERY
363	27	13	48	4	3559		SPECIAL INDL MACH, NEC
364	28	13	49	4	3561	3563	PUMPS & COMPRESSORS
365	28	13	49	4	3562		BALL & ROLLER BEARINGS
366	28	13	49	4	3564		BLOWERS & FANS
367	28	13	49	4	3565		INDUSTRIAL PATTERNS
368	28	13	49	4	3566	3568	POWER TRANSMISSION EQUIPMENT
369	28	13	49	4	3567		INDL FURNACES & OVENS
370	28	13	49	4	3569		GENL INDL MACH, NEC
371	28	13	50	4	3592		CARBURETORS, PISTONS, RINGS, VALVES
372	28	13	50	4	3599		NON-ELEC MACHINERY, NEC
373	29	13	51	3	3573		ELECTRONIC COMPUTING EQ
374	29	13	51	3	3574		CALC & ACCOUNTING MACH
375	29	13	51	3	3576		SCALES & BALANCES
376	29	13	51	3	3579	3572	OFFICE MACH, NEC INCL TYPEWRITERS
377	30	13	52	4	3581		AUTOMATIC MERCHANDIS MACH
378	30	13	52	4	3582		COMMERCIAL LAUNDRY EQUIP
379	30	13	52	4	3585		REFRIG & HEATING EQUIPMENT
380	30	13	52	4	3586		MEASUR & DISPENS PUMPS
381	30	13	52	4	3589		SERVICE IND MACH, NEC
382	32	14	53	3	3825		INSTRUM TO MEASURE ELECTRICITY
383	32	14	53	3	3612		TRANSFORMERS
384	32	14	53	3	3613		SWITCHGEAR&SWITCHBOARD APPARATUS
385	32	14	53	3	3621		MOTORS & GENERATORS
386	32	14	53	3	3622		INDUSTRIAL CONTROLS
387	32	14	53	3	3623		WELDING APPARTUS, ELECT
388	32	14	53	3	3624		CARBON & GRAPHITE PRODU
389	32	14	53	3	3629		ELEC INDL APPARATUS, NE
390	33	14	54	3	3631		HOUSEHOLD COOKING EQUIP
391	33	14	54	3	3632		HHLD REFRIG, FREEZERS
392	33	14	54	3	3633		HOUSEHOLD LAUNDRY EQUIP
393	33	14	54	3	3634		ELEC HOUSEWARES & FANS
394	33	14	54	3	3635		HHLD VACUUM CLEANERS

540	55	BEACS	BEA77	P&E	1977 SIC	
395	33	14	54	3	3636	SEWING MACHINES
396	33	14	54	3	3639	HOUSEHOLD APPLIANCES, NEC
397	34	14	55	3	3641	ELECTRIC LAMPS
398	34	14	55	3	3645 to 3648	LIGHTING FIXTURES & EQUIP
399	34	14	55	3	3643 3644	WIRING DEVICES
400	35	14	56	3	3651	RADIO & TV RECEIVING SETS
401	35	14	56	3	3652	PHONOGRAPH RECORDS & TAPES
402	31	14	56	3	3661	TELEPHONE & TELEGRAPH APPARATUS
403	31	14	56	3	3662	RADIO & TV COMMUNIC EQUIP
404	31	14	57	3	3671 3672 3673	ELECTRON TUBES
405	31	14	57	3	3674	SEMICONDUCTORS & RELATED DEVICES
406	31	14	57	3	3675 to 3679	ELECTRONIC COMPONENTS, NEC
407	34	14	58	3	3691	STORAGE BATTERIES
408	34	14	58	3	3692	PRIMARY BATTERIES, DRY&WET
409	34	14	58	3	3693	X-RAY APPARATUS & TUBES
410	34	14	58	3	3694	ENGINE ELECTRICAL EQUIP
411	34	14	58	3	3699	ELECTRICAL EQUIPMENT, NEC
412	36	15	59	5	3713	TRUCK & BUS BODIES
413	36	15	59	5	3715	TRUCK TRAILERS
414	36	15	59	5	3711	MOTOR VEHICLES & CAR BODIES
415	36	15	59	5	3714	MOTOR VEHICLE PTS&ACCESSORIES
416	37	16	60	6	3721	AIRCRAFT
417	37	16	60	6	3724 3764	AIRCRAFT, MISSILE ENGINES
418	37	16	60	6	3728 3769	AIRCRAFT, MISSILE EQ, NEC
419	38	16	61	4	3731	SHIP BUILDING & REPAIRING
420	38	16	61	4	3732	BOAT BUILDING & REPAIRING
421	39	16	61	4	3740	RAILROAD EQUIPMENT
422	39	16	61	4	3750	MOTORCYCLES, BICYLES, &PT
423	39	16	61	4	3792	TRAVEL TRAILERS & CAMPERS
424	16	16	61	8	2451	MOBILE HOMES
425	36	16	61	5	3716	MOTOR HOMES (FORMERLY WITH TRUCK BODIES)
426	39	16	61	4	3799	TRANSPORTATION EQUIP, NEC
427	40	17	62	8	3811	ENGINEER & SCI INSTRUMENTS
428	40	17	62	8	3823 3824 3829	MECHANICAL MEASURING DEVICES
429	40	17	62	8	3822	AUTOMAT TEMPERATURE CON
430	40	17	62	8	3841	SURG & MED INSTRUMENTS
431	40	17	62	8	3842	SURG APPLIANCES & SUPPLIES
432	40	17	62	8	3843	DENTAL EQUIP & SUPPLIES
433	40	17	62	8	3870	WATCHES, CLOCKS, & PART
434	40	17	63	8	3830	LENSES, OPTICAL INSTRUMENTS
435	40	17	63	8	3850	OPHTHALMIC GOODS
436	40	17	63	8	3860	PHOTOGRAPHIC EQUIP&SUPPLIES
437	41	18	64	8	3911	JEWELRY, PRECIOUS METAL
438	41	18	64	8	3915	JEWELERS MATL&LAPIDARY WORK
439	41	18	64	8	3914	SILVERWARE & PLATED WARE
440	41	18	64	8	3961	COSTUME JEWELRY
441	41	18	64	8	3930	MUSICAL INSTRUMENTS
442	41	18	64	8	3944	GAMES, TOYS, KIDS' VEHICLES

540	55	BEACS	BEA77	P&E	1977 SIC	
443	41	18	64	8	3942	DOLLS
444	41	18	64	8	3949	SPORT & ATHLETIC GOODS, NEC
445	41	18	64	8	3951	PENS & MECHANICAL PENCILS
446	41	18	64	8	3952	LEAD PENCILS & ART GOOD
447	41	18	64	8	3953	MARKING DEVICES
448	41	18	64	8	3955	CARBON PAPER & INK RIBB
449	41	18	64	8	3962	ARTIFICIAL TREES & FLOWERS
450	41	18	64	8	3963	BUTTONS
451	41	18	64	8	3964	NEEDLES, PINS, & FASTENERS
452	41	18	64	8	3991	BROOMS & BRUSHES
453	41	18	64	8	3996	HARD SURFACE FLOOR COVERING
454	41	18	64	8	3995	BURIAL CASKETS & VAULTS
455	41	18	64	8	3993	SIGNS & ADVERTIS DISPLA
456	41	18	64	8	3999	MANUFACTURING, N.E.C.
457	42	29	65	17	4000 4740 4789	RAILROADS & RELATED SER
458	44	30	65	19	4100	HWY PASSENGER TRANSIT
459	44	31	65	19	4200 4789	TRUCKING & WAREHOUSING
460	44	32	65	19	4400	WATER TRANSPORTATION
461	43	33	65	18	4500	AIR TRANSPORTATION
462	44	34	65	19	4600	PIPELINES, EXC NATURAL G
463	44	35	65	19	4710 4723 4780	TRANSPORTATION SERVICES, NEC
464	44	35	65	19	4722	ARRANGEMENT OF PASSENGER TRANSPORTATION
465	45	36	66	25	4800 -483	COMMUNIC, EXC RADIO & TV
466	45	37	67	25	4830	RADIO & TV BROADCASTING
467	46	38	68	20	4910 4930	ELECTRIC UTILITIES
468	47	39	68	21	4920 4930	GAS UTILITIES
469	47	40	68	21	4940 4952	WATER SUPPLY & SEWERAGE SYSTEMS
470	47	40	68	21	4950-4952 4960,70	SANITARY SERVICES, IRRIGATION SYSTEMS
471	48	41	69	22	5000 5100	WHOLESALE TRADE
472	48	42	69	22	5200 to 5900	RETAIL TRADE (also 7396 8042)
473	49	43	70	23	6000	BANKING
474	49	44/49	70	23	6100 6700-6732	CREDIT AGENCIES
475	49	45	70	23	6200	SECURITY & COMMODITY BROKERS
476	49	46	70	23	6300	INSURANCE CARRIERS
477	49	47	70	23	6400	INSURANCE AGENTS & BROKERS
478	0	48	71	0		OWNER-OCCUPIED DWELLING
479	50	48	71	23	6500 6600 1531	REAL ESTATE
480	51	50	72	24	7000 PART	HOTELS & LODGING PLACES EXCL DINING
481	51	51	72	24	7210 7250	LAUNDRY, CLEANING, SHOE REPAIR SERVICES
482	51	51	72	24	7260	FUNERAL SERVICES
483	51	51	72	24	7220 7290	PHOTO STUDIOS & OTH MISC PERSONAL SERV
484	51	54	72	24	7620	ELECTRICAL REPAIR SHOPS
485	51	54	72	24	7630 7640	WATCH, CLOCK, JEWELRY, FURNITURE REPAIR
486	51	51	72	24	7230 7240	BEAUTY & BARBER SHOPS
487	52	54	73	24	7690	MISC REPAIR SHOPS
488	52	52	73	24	7340	SERVICES TO DWELLINGS & BLDGS
489	52	52	73	24	7360	PERSONNEL SUPPLY SERVICES

540	55	BEACS	BEA77	P&E	1977 SIC	
490	52	52	73	24	7370	COMPUTER & DATA PROCESSING SERVICES
491	52	52	73	24	7391 7392 7397	MANAG & CONSULTING SERVICES, TESTING & RESEARCH LABS
492	52	52	73	24	7393	DETECTIVE & PROTECTIVE SERVICES
493	52	52	73	24	7394	EQUIPMENT RENTAL & LEASING SERVICES
494	52	52	73	24	7332 7333 7395	PHOTOFINISHING LABS, PHOTOCOPY, COMMERCIAL PHOTOGRAPHY
495	52	52	73	24	7320 7331 7339 7350 7399	OTHER BUSINESS SERVICES
496	52	52	73	24	7310	ADVERTISING
497	52	58	73	24	8110	LEGAL SERVICES
498	52	60	73	24	8911	ENGINEERING, ARCHITECTURAL, SURVEYING SERVICES
499	52	60	73	24	8930 8990	MISC PROF SERV NEC, INCL ACCOUNTING, AUDITING, BOOKKEEPING
500	48	53	74	22	5800 7000 PART	EATING & DRINKING PLACE
501	53	53	75	24	7510	AUTO RENTAL & LEASING
502	53	53	75	24	7530 7549	AUTO REPAIR & SERVICES
503	53	53	75	24	7520 7542	AUTO PARKING, CAR WASHES
504	54	55	76	24	7800	MOTION PICTURES
505	54	56	76	24	7920	THEATRICAL PRODUCERS, BANDS, ENTERTAINERS
506	54	56	76	24	7930	BOWLING ALLEYS, BILLIARD & POOL ESTAB
507	54	56	76	24	7941	COMMERCIAL SPORTS, EXC RACING
508	54	56	76	24	7948	RACING
509	54	56	76	24	7997	MEMBERSHIP SPORTS & RECREATION CLUBS
510	54	56	76	24	7910 7990-7997	OTH AMUSEMENT & RECREATION
511	55	57	77	24	8010 8020 8030 8041	DOCTORS & DENTISTS
512	55	57	77	24	8060	HOSPITALS
513	55	57	77	24	8050	NURSING & PERSONAL CARE FACILITIES
514	55	57	77	24	0740 8049 8070 8080 8090	OTH MEDICAL & HEALTH SERVICES EXCL NURSING HOMES
515	55	59	77	24	8210	ELEMENTARY & SECONDARY SCHOOLS
516	55	59	77	24	8220	COLLEGES, UNIVERSITIES, PROFESSIONAL SCHOOLS
517	55	59	77	24	8200-8210-8220	LIBRARIES, CORRESP & VOCAT SCH, EDUC SERVICES NEC
518	55	60	77	24	8610 8620	BUSINESS ASSOC & PROF MEMBERSHIP ORG
519	55	60	77	24	8630 8640	LABOR ORGANIZ & CIVIL, SOCIAL, FRATERNAL ORG
520	55	60	77	24	8660	RELIGIOUS ORGANIZATIONS
521	55	60	77	24	8400 8650 8690 8922 6732	OTH MEMBERSHIP ORGANIZATIONS
522	55	60	77	24	8331	JOB TRAINING & RELATED SERVICES
523	55	60	77	24	8351	CHILD DAY CARE SERVICES
524	55	60	77	24	8361	RESIDENTIAL CARE
525	55	60	77	24	8321 8399	SOCIAL SERVICES, NEC

INFORUM 55-order Sector Titles for Investment

1 Agricultural, Forestry and Fisheries
2 Crude Petroleum and Natural Gas
3 Mining
4 Construction
5 Food and Tobacco
6 Textiles
7 Knitting and Hosiery
8 Apparel and Household Textiles
9 Paper
10 Printing and Publishing
11 Agricultural Fertilizers
12 Other Chemicals
13 Petroleum Refining and Fuel Oil
14 Rubber and Plastic Products
15 Footwear and Leather
16 Lumber
17 Furniture
18 Stone, Clay and Glass
19 Iron and Steel
20 Non-Ferrous Metals
21 Metal Products
22 Engines and Turbines
23 Agricultural Machinery
25 Metalworking Machinery
27 Special Industry Machinery
28 Miscellaneous Non-Electrical Machinery
29 Computers and Other Office Machinery
30 Service Industry Machinery
31 Communications Machinery
32 Heavy Electrical Machinery
33 Household Appliances
34 Electrical Lighting and Wiring Equipment
35 Radio, TV, and Phonographs
36 Motor Vehicles
37 Aerospace
38 Ships and Boats
39 Other Transportation Equipment
40 Instruments
41 Miscellaneous Manufacturing
42 Railroads
43 Air Transport
44 Trucking and Other Transport
45 Communications Services
46 Electric Utilities
47 Gas, Water and Sanitation
48 Wholesale and Retail Trade
49 Finance and Insurance
50 Real Estate
51 Hotels and Repairs Minus Auto Repair
52 Business Services

53 Auto Repair
54 Movies and Amusements
55 Medical, Educational Services and NPO
56 Personal Autos
57 Sales of Used Equipment

Sector Titles for BEA Capital Stock Study

1 Farms (01, 02)
2 Agricultural Services, Forestry and Fisheries (07, 08, 09)
3 Metal Mining (10)
4 Coal Mining (11, 12)
5 Oil and Gas Extraction (13)
6 Nonmetallic Minerals, Except Fuels (14)
7 Construction (15, 16, 17)
8 Lumber and Wood Products (24)
9 Furniture and Fixtures (25)
10 Stone, Clay and Glass Products (32)
11 Primary Metal Industries (33)
12 Fabricated Metal Products (34)
13 Machinery, Except Electrical (35)
14 Electric and Electronic Equipment (36)
15 Motor Vehicles and Equipment (371)
16 Other Transportation Equipment (37 -371)
17 Instruments and Related Products (38)
18 Miscellaneous Manufacturing Industries (39)
19 Food and Kindred Products (20)
20 Tobacco Manufactures (21)
21 Textile Mill Products (22)
22 Apparel and Other Textile Products (23)
23 Paper and Allied Products (26)
24 Printing and Publishing (27)
25 Chemicals and Allied Products (28)
26 Petroleum and Coal Products (29)
27 Rubber and Miscellaneous Plastic Products (30)
28 Leather and Leather Products (31)
29 Railroad Transportation (40)
30 Local and Interurban Passenger Transit (41)
31 Trucking and Warehousing (42)
32 Water Transportation (44)
33 Air Transportation (45)
34 Pipelines, Except Natural Gas (46)
35 Transportation Services (47)
36 Telephone and Telegraph (481, 482, 489)
37 Radio and television Broadcasting (483)
38 Electric Services (491, pt. 493)
39 Gas Services (492, pt. 493)
40 Sanitary Services (494, 495, 496, 497)
41 Wholesale Trade (50, 51)

42 Retail Trade (52-59)
43 Banking (60)
44 Credit Agencies Other Than Banks (61)
45 Security, Commodity Brokers and Services (62)
46 Insurance Carriers (63)
47 Insurance Agents, Brokers and Services (64)
48 Real Estate (65, 66)
49 Holding and Other Investment Companies (67)
50 Hotels and Other Lodging Places (70)
51 Personal Services (72)
52 Business Services (73)
53 Auto Repair, Services, and Garages (75)
54 Miscellaneous Repair Services (76)
55 Motion Pictures (78)
56 Amusement and Recreation Services (79)
57 Health Services (80)
58 Legal Services (81)
59 Educational Services (82)
60 Other (83, 84, 86, 89)

Sector Titles for BEA Input-Output Categories

1 Livestock and Livestock Products
2 Other Agricultural Products
3 Forestry and Fishery Products
4 Agricultural, Forestry and Fishery Services
5 Iron and Ferroalloy Ores Mining
6 Nonferrous Metal Ores Mining
7 Coal Mining
8 Crude Petroleum and Natural Gas
9 Stone and Clay Mining and Quarrying
10 Chemical and Fertilizer Mineral Mining
11 New Construction
12 Maintenance and Repair Construction
13 Ordnance and Accessories
14 Food and Kindred Products
15 Tobacco Manufactures
16 Broad and Narrow Fabrics, Yarn and Thread Mills
17 Miscellaneous Textile Goods and Floor Coverings
18 Apparel
19 Miscellaneous Fabricated Textile Products
20 Lumber and Wood Products, Except Containers
21 Wood Containers
22 Household Furniture
23 Other Furniture and Fixtures
24 Paper and Allied Products, Except Containers
25 Paperboard Containers and Boxes
26 Printing and Publishing
27 Chemical and Selected Chemical Products
28 Plastics and Synthetic Materials

29 Drugs, Cleaning and Toilet Preparations
30 Paints and Allied Products
31 Petroleum and Refining and Related Industries
32 Rubber and Miscellaneous Plastics Products
33 Leather Tanning and Finishing
34 Footwear and Other Leather Products
35 Glass and Glass Products
36 Stone and Clay Products
37 Primary Iron and Steel Manufacturing
38 Primary Nonferrous Metals Manufacturing
39 Metal Containers
40 Heating, Plumbing, and Fabricated Structural Metal Products
41 Screw Machine Products and Stampings
42 Other Fabricated Metal Products
43 Engines and Turbines
44 Farm and Garden Machinery
45 Construction and Mining Machinery
46 Materials Handling Machinery and Equipment
47 Metalworking Machinery and Equipment
48 Special Industry Machinery and Equipment
49 General Industrial Machinery and Equipment
50 Miscellaneous Machinery, Except Electrical
51 Office, Computing, and Accounting Machines
52 Service Industry Machines
53 Electric Industrial Equipment and Apparatus
54 Household Appliances
55 Electric Lighting and Wiring Equipment
56 Radio, TV, and Communication Equipment
57 Electronic Components and Accessories
58 Miscellaneous Electrical Machinery and Supplies
59 Motor Vehicles and Equipment
60 Aircraft and Parts
61 Other Transportation Equipment
62 Scientific and Controlling Instruments
63 Optical, Opthmalmic, and Photographic Equipment
64 Miscellaneous Manufacturing
65 Transportation and Warehousing
66 Communications, Except Radio and TV
67 Radio and TV Broadcasting
68 Electric, Gas, Water, and Sanitary Services
69 Wholesale and Retail Trade
70 Finance and Insurance
71 Real Estate and Rental
72 Hotels; Personal and Repair Services
73 Business Services
74 Eating and Drinking Places
75 Automobile Repair and Services
76 Amusements
77 Health, Educational, and Social Services and Nonprofit Organizations

Sector Titles for Plant and Equipment Survey

1 Primary Metals
2 Fabricated Metals
3 Electrical Machinery
4 Machinery, Except Electrical
5 Motor Vehicles
6 Aircraft
7 Stone, Clay & Glass
8 Other Durables
9 Food, Including Beverage
10 Textiles
11 Paper
12 Chemicals
13 Petroleum
14 Rubber
15 Other Nondurables
16 Mining
17 Railroad
18 Air
19 Other
20 Electric Utilities
21 Gas Utilities & Other
22 Wholesale & Retail Trade
23 Finance and Insurance
24 Personal & Business Services
25 Communication

Table A-3

Summary of Benchmark Points Used on CU$ Gross Investment Data

Sector title	1958	1963	1967	1972	1977
1 Agricultural, Forestry and Fisheries	3307.0	4079.3	5004.4	5749.5	12178.8
2 Crude Petroleum and Natural Gas	627.7	584.2	709.2	704.5	2441.6
3 Mining	683.2	512.1	778.4	1125.7	3312.5
4 Construction	977.6	2780.5	3720.8	6393.3	15141.9
5 Food and Tobacco	741.9	1072.9	1486.2	2311.3	3984.9
6 Textiles	215.9	351.0	568.3	732.2	1058.8
7 Knitting and Hosiery	12.8	21.3	56.1	237.0	170.8
8 Apparel and Household Textiles	99.3	161.7	280.0	498.8	552.8
9 Paper	453.7	694.5	1102.3	1292.3	2948.1
10 Printing and Publishing	296.5	488.7	712.0	1004.4	1643.7
11 Agricultural Fertilizers	45.0	79.3	233.2	144.0	989.7
12 Other Chemicals	790.1	1226.5	1814.2	2513.6	4811.5
13 Petroleum Refining and Fuel Oil	316.4	201.4	345.6	640.4	1444.2
14 Rubber and Plastic Products	166.6	322.0	577.1	890.6	1534.9
15 Footwear and Leather	44.0	44.7	85.4	70.6	96.1
16 Lumber	213.8	280.6	441.6	794.2	1283.1
17 Furniture	76.5	88.4	164.3	236.2	384.9
18 Stone, Clay and Glass	253.6	489.6	583.6	1101.9	1559.9
19 Iron and Steel	789.0	854.5	1374.5	1282.4	3039.6
20 Non-Ferrous Metals	303.9	283.1	476.6	712.5	973.8
21 Metal Products	414.9	583.6	1134.5	1189.5	2292.6
22 Engines and Turbines	31.4	53.1	101.2	164.6	258.6
23 Agricultural Machinery	35.6	55.7	106.0	155.7	272.9
25 Metalworking Machinery	102.7	127.9	280.2	227.9	378.3
27 Special Industry Machinery	78.6	60.4	148.5	153.3	206.4
28 Miscellaneous Non-Electrical Machiner	212.7	274.5	626.2	671.4	1427.6
29 Computers and Other Office Machinery	69.2	112.0	256.5	275.7	682.8
30 Service Industry Machinery	31.4	40.3	105.6	232.6	234.9
31 Communications Machinery	146.3	324.1	684.1	834.8	1404.3
32 Heavy Electrical Machinery	79.6	107.6	294.7	280.8	541.2
33 Household Appliances	31.4	62.9	100.8	161.0	171.1
34 Electrical Lighting and Wiring Equipmn	59.7	92.4	229.9	281.6	536.9
35 Radio, TV, and Phonographs	10.9	29.0	79.0	71.5	129.6
36 Motor Vehicles	286.1	524.1	772.9	2067.6	3376.8
37 Aerospace	144.6	217.2	623.3	320.6	503.7
38 Ships and Boats	10.3	9.9	23.4	136.0	195.4
39 Other Transportation Equipment	6.4	9.6	21.6	94.2	181.1
40 Instruments	96.4	161.2	316.4	478.2	685.9
41 Miscellaneous Manufacturing	111.1	113.4	211.5	294.9	467.5
42 Railroads	441.4	792.5	1671.6	2013.9	4040.5
43 Air Transport	301.7	413.8	2192.3	2357.1	4399.9
44 Trucking and Other Transport	1240.5	1954.8	2997.7	4390.4	6950.2
45 Communications Services	1756.2	2661.5	3876.2	6594.1	10301.2
46 Electric Utilities	1612.7	1561.2	2439.7	4326.3	6913.9

Sector title	1958	1963	1967	1972	1977
47 Gas, Water and Sanitation	676.8	337.0	479.6	708.7	2956.8
48 Wholesale and Retail Trade	3462.1	4789.9	6399.7	9160.1	19307.9
49 Finance and Insurance	738.7	680.5	1397.1	2436.9	3987.1
50 Real Estate	402.4	1207.5	653.3	3108.4	5543.5
51 Hotels and Repairs Minus Auto Repair	862.4	877.5	1260.3	2343.1	2417.6
52 Business Services	597.3	648.8	1588.5	2949.2	5084.6
53 Auto Repair	423.3	613.5	1436.5	1409.3	3479.7
54 Movies and Amusements	315.4	559.7	517.8	1057.3	1495.3
55 Medical, Educational Services and NPO	1033.2	1768.6	3157.9	3825.0	7809.5
TOTAL	26237.	36442.	56698.	83207.	158186.
NIPA CONTROLS	26238.	36442.	56698.	83207.	158187.
TOTAL BEFORE SCALING	25040.	34493.	55178.	78060.	158067.
SCALING FACTORS USED	1.0478	1.0565	1.0275	1.0659	1.0008

Table A-4

Comparison of INFORUM and NIPA PDE Totals: 1959 - 1984

	INFORUM	NIPA
1959	59361.2	52968.0
1960	61278.9	54533.0
1961	58477.7	53038.0
1962	65132.7	57882.0
1963	69712.4	62648.0
1964	76953.3	69870.0
1965	89196.8	82593.0
1966	101236.8	93128.0
1967	102561.6	92175.0
1968	109437.2	96784.0
1969	114260.6	104121.0
1970	106556.4	102508.0
1971	108178.8	101819.0
1972	121864.7	113308.0
1973	138220.4	133956.0
1974	133116.6	135675.0
1975	119721.6	121745.0
1976	129083.4	127683.0
1977	149819.9	149700.0
1978	163489.0	175694.0
1979	172161.9	191883.0
1980	162039.1	190073.0
1981	167173.1	202854.0
1982	158595.7	190924.0
1983	167788.1	213891.0
1984	198684.5	270938.0

Appendix B

THE DERIVATION OF CAPITAL STOCKS AND REPLACEMENT INVESTMENT

This appendix describes formally some of the measures of capital stock and replacement investment used in the various investment models presented in this work. The more formal representation presented in the first part of this appendix is equivalent to the more intuitive notion of "buckets" developed at the end of the appendix. In other words, a single bucket system is equivalent to a first-order Pascal lag; a two-bucket system is equivalent to the second-order Pascal lag, etc. We will begin by analyzing measures of replacement investment, and then continue with measures of the capital stock.

Let d_i be the fraction of productive capacity of a capital good which is lost in the *i*'th period after its acquisition. Depreciation in period *t*, assuming $d_0 = 0$, is given by:

$$\text{(B-1)} \qquad R_t = \sum_{i=1}^{t} d_i \; I_{t-1}$$

where i_t is real gross investment in period *t* and $\sum d_i = 1$. In the case of geometric decay, the rate of decay is simply a function of the inverse of the average life of capital equipment. In this case:

$$\text{(B-2)} \qquad d_i = \lambda^{i-1}(1-\lambda)$$

where λ is the rate of retention, and so (1-λ) is the *rate of depreciation.* If the depreciation pattern is geometric, and the average service life is given by L^*, then the average service life should be equal to the mean of the geometric distribution:

(B-3) $$L^* = \lambda/(1-\lambda)$$

This implies that the *rate of depreciation* equals:

(B-4) $$1-\lambda = 1/(1+L^*)$$

If we assume the geometric pattern, then capital stock may be simply computed by the following equation:

(B-5) $$K_t = I_t + \lambda K_{t-1}$$

The depreciation, or replacement of capital is then given by:

(B-6) $$R_t = D_t = (1-\lambda)K_{t-1}$$

The geometric decay pattern is simply a Pascal lag distribution of degree one. Depreciation can in general follow a Pascal lag of any positive degree *r*:

(B-7) $$R_t = [(1-\lambda)^r/(1-\lambda L)^r]\ I_t$$

where L is the *lag operator*, and λ is picked in a way which is consistent with the average service life. The case in which $r = 2$ can be equivalently represented by a "bucket" scheme. Construct two fictitious classes of capital:

(B-8a) $$B_1(t) = I_t + \lambda\ B_1(t-1)$$

(B-8b) $$B_2(t) = (1-\lambda)\ B_1(t) + \lambda\ B_2(t-1)$$

The *rate of retention* λ is determined by the average service life. Consider the quantity "spilled" from the second bucket, B_2:

(B-9) $$R_t = (1-\lambda)\ B_2(t-1)$$

It can be shown that R_t is identical to the second degree Pascal lag on gross investment. We can reconstruct the d_i's from equation (B-1). Solving (B-8a) recursively in terms of *I* we get:

$$\text{(B-10)} \quad B_1(t) = \sum_{i=0}^{t} \lambda^i I_{t-i}$$
$$= \sum_{i=0}^{t} (\lambda L)^i I_t$$
$$= [1/(1-\lambda L)]\ I_t$$

Similarly for (B-8b):

$$\text{(B-11)} \quad B_2(t) = (1-\lambda) \sum_{i=0}^{t} \lambda^i B_1(t-i)$$
$$= (1-\lambda) \sum_{i=0}^{t} (\lambda L)^i B_1(t)$$
$$= [(1-\lambda)/(1-\lambda L)]\ B_1(t)$$

The expression for replacement investment is given by:

$$\text{(B-12)} \quad R_t = (1-\lambda)\ B_2(t-1)$$
$$= (1-\lambda)\ [(1-\lambda)/(1-\lambda L)]\ B_1(t-1)$$
$$= [(1-\lambda)^2/(1-\lambda L)^2]\ I_{t-1}$$

Thus, equation (B-12) shows that the depreciation pattern generated by equation (B-11) follows a second order Pascal distribution. The second degree Pascal distribution suggests that the annual loss in productive capacity is small early in the useful life of equipment. Again, the retention rate λ is chosen so that the mean of the distribution equals the average service life of capital:

$$L^* = 2\lambda/(1-\lambda)$$

Therefore the spill rate is given by:

$$\text{(B-13)} \quad 1-\lambda = 2/(2 + L^*)$$

The Capital Stock

The capital stock is defined as the sum of all investments over time minus the sum of all depreciations:

$$\text{(B-14)} \qquad K_t = \sum [I_{t-1} - (1-\lambda)\ B_2(t-i-1)]$$

Taking the sum of the two buckets:

$$\text{(B-15)} \qquad B_1(t) + B_2(t) = \sum_{i=0}^{t} \Big[I_{t-1} - (1-\lambda)\ B_1(t-i-1)]$$
$$+ (1-\lambda)\ B_1(t-i) - (1-\lambda)\ B_2(t-i-1) \Big]$$
$$= (1-\lambda)\ B_1(t) + \sum_{i=0}^{t} \Big[I_{t-i} - (1-\lambda)\ B_2(t-i-1) \Big]$$
$$= (1-\lambda)\ B_1(t) + K_t$$

Therefore, capital may be expressed as a linear function of the two classes of capital at time t:

$$\text{(B-16)} \qquad K_t = \lambda\ B_1(t) + B_2(t)$$

So much for 1st and 2nd order Pascal lag distributions. A more general specification is to represent depreciation as a convex combination of Pascal lags of the 1st, 2nd and 3rd orders. In this case, depreciation is given by:

$$\text{(B-17)} \qquad R_t = \sum_{j=1}^{3} w_j\ (1-\lambda_j)^j/(1-\lambda_j L)^j\ I_{t-1}$$

where

$$\sum_{=1}^{3} w_j = 1; \qquad \lambda_j = L^*/(L^* + j); \qquad \text{and } 0 \le w_j \le 1 \text{ for } j = 1,2,3$$

With this definition of replacement, the d_i's in (B-1) are redifined to be a weighted average of the d_i's which correspond to Pascal lags of one, two or three degrees. Now let B_{ij} be the i'th class of capital (i'th bucket) for the j'th depreciation pattern, j = 1,2,3. Let λ_j be the retention rate resulting flom the assumed service life of the j'th depreciation patern, as defined above. Then we have:

$$
\text{(B-18)} \qquad B_{ij}(t) = \begin{cases} 0 \text{ for } i > j \\ (1-\lambda_j)\ B_{i,j-1}(t) + \lambda_j B_{ij}(t-1) \quad \text{for } i \le j \\ I_t + \lambda_j\ B_{ij}(t-1) \quad \text{for } i = 1 \end{cases}
$$

Depreciation D_j, and the capital stock K_j resulting from the j'th depreciation pattern are given by:

$$
\text{(B-19)} \qquad D_j(t) = (1-\lambda_j)\ B_{jj}(t-1)
$$

$$
\text{(B-20)} \qquad K_j = B_{jj}(t) + \sum_{i=1}^{j-1} \lambda_j\ B_{ij}
$$

Then depreciation, and therefore replacement is defined as:

$$
\text{(B-21)} \qquad R_t = \sum_{j=1}^{3} w_j\ D_j(t)
$$

where $\sum w_j = 1$; and $0 \le w_j \le 1$

This expression may be substituted into an equation for gross investment, and thus the w's can be estimated. Capital stock is given by a weighted average of the measures of capital stock resulting from the three depreciation patterns:

$$
\begin{aligned}
\text{(B-22)} \qquad K_t &= \sum_{i=0}^{t} [I_{t-i} - \sum w_j\ D_j(t-i)\ ] \\
&= \sum_{i=0}^{t} [\ \sum_{j=1}^{3} w_j\ I_{t-i} - w_j\ D_j(t-1)] \\
&= \sum_{j=1}^{3} w_j\ K_j(t)
\end{aligned}
$$

Appendix C

The Concept of User Cost

The 'price' of capital used in most of the models in this study is the concept of the user cost or rental cost of capital. Unlike the prices of other inputs, the user cost is not directly measurable through survey information, but rather is an imputation involving concepts such as the opportunity cost of capital (rate of return), depreciation, and the price index of capital goods. Elements of the tax law, such as the corporate tax rate, the investment tax credit, and the treatment of depreciation for tax purposes are also figured into the calculation of the user cost, since they affect the rate of return received by investors.

User cost is defined as the cost of using a certain quantity of capital for a given period of time. In this study the concept is used to refer to the cost of using a dollar's worth of capital (in 1977 constant dollars) for one year. Although the economically relevant concept is that of the marginal user cost, something more akin to an average user cost is actually measured. With competitive markets and no taxes, user cost could be written:

$$\text{(C.1)} \qquad c = p\ (r + \delta)$$

where c is user cost, p is a price index of capital goods equal to

1.0 in 1977, r is the opportunity cost of capital or desired rate of return, and δ is the depreciation rate. The price index p is included because we want to measure the cost of a constant dollars worth of capital, and this increases as prices increase. The depreciation parameter δ is included to measure the cost of replacement investment expenditures necessary to maintain this quantity of capital stock intact. Ideally this depreciation parameter should be consistent with the rate of depreciation used to measure the capital stock. The opportunity cost of capital r is the rate of return or discount rate necessary to equate the expected future stream of capital income to the present market value of the firm. It can also be considered as the opportunity cost of drawing resources from other uses. A true measure of r would take into account the fact that much of investment is debt financed, so it would be constructed as a weighted average of the cost of equity and the cost of debt.

If we introduce a corporate tax rate T and allow no tax credits or deductions of depreciation cost from profits, then the rental cost of capital must rise by $(1/(1-T))$ in order to yield the same rate of return to investors. This yields:

$$\text{(C.2)} \qquad c = p(r + \delta) \frac{1}{1 - T}$$

However, if firms are allowed to deduct accounting depreciation from profits before paying taxes, then this acts as an offset to the value in the numerator of (C.2). To measure the value of this offset, consider the discounted present value of depreciation deductions Z. This is defined as the sum of the present value of all future depreciation deductions, discounted at an appropriate rate. It is dependent on the accounting technique used to measure depreciation for tax purposes, as well as the discount rate used. Since the savings in taxes is Z multiplied by the corporate tax rate T, user cost becomes:

$$c = p(r + \delta) \frac{(1-TZ)}{(1-T)} \qquad \text{(C.3)}$$

If all investment were written off as a current expense, then Z would equal unity, and the corporate tax rate would have no effect in the above formula.

If an investment tax credit is granted to firms as an offset to taxes at a percentage C on the value of new investments, the after-tax cost of capital becomes:

$$c = p(r + \delta) \frac{(1-TZ-C)}{(1-T)} \qquad \text{(C.4)}$$

Therefore an increase in C reduces the after-tax rental cost.

Most economists would agree that the above formula is a good starting point for the measurement of the cost of capital. However, there is no consensus on the measure of the concepts p, r, δ, T, Z and C.

In this study, p was measured by the equipment investment deflator for each industry. This is an implicit deflator that is derived while deriving equipment investment data in both 77$ and in current dollars.[77] The opportunity cost of capital *r* is measured as the corporate triple-A bond rate, minus the rate of change in the aggregate GNP deflator. No attempt was made in this study to model the cost of debt in the opportunity cost. Although this probably leads to a mis-measurement of the *true* user cost of capital, we did not have industry-specific measures of the cost of debt available when constructing this concept.

The calculation of δ relied on the construction of average service lives for each industry. These service lives were constructed as weighted average of individual service lives by roughly 50 types of PDE used in each industry. The weights were taken from a 1977 capital flow matrix, and the service lives by type of equipment were derived from the BLS capital stock study. The variable δ was calculated for each industry as 1/L, where L is the average service life for that industry.[78]

The corporate tax rate *T* was assumed to be the legislated rate. No attempt was made to try to derive an *effective* corporate tax rate for each industry. Likewise, the value of *C*, the investment tax credit, was taken to be the official, legislated percentage.

The calculation of *Z*, the present value of a dollar of

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[77] See Appendix A for a description of this process.

[78] Note that this is actually inconsistent with our measurement of the capital stock in the two-bucket schemes. However, since δ does not change from year to year, this results in a bias in the *level* of the measured user cost, not in its year to year *change*.

depreciation, varies by industry, according to the mixture of depreciation methods used (straight-line, declining balance, double declining balance, etc.). Weights for each industry from 1955 to 1981 were obtained from an unpublished paper by Thomas Vasquez at the Department of the Treasury. These weights were used to construct a weighted average of Z for each industry, based on tax lives that were also separately constructed for each industry. These tax lives were constructed as weighted averages of allowed tax lives by type of equipment, weighted by the column coefficients of a 1977 capital flow matrix. These legislated tax lives change as investment tax policy changes. The two most recent changes were in 1981 and 1986.

Appendix D

Other Data

<u>Employment</u> - This data is from unpublished worksheets furnished by the Bureau of Labor Statistics (BLS) on total hours worked and average weekly hours. Since this data is available at a level of detail of about 200 sectors, it was aggregated to the 55 sector level. Where employment equations were estimated in this study, the dependent variable was total hours worked in each industry. In the forecasting model, total hours was forecasted and then converted to employment by means of an equation forecasting average annual hours (average weekly hours times 52).

<u>Wage Rates</u> - This data is also based upon unpublished worksheets provided to INFORUM by the Bureau of Labor Statistics.

<u>Energy</u> - Data on quantities and prices of energy purchased by industry for 15 energy categories and 4 functional uses was obtained from a condensed version of the *National Energy Accounts* (NEA), furnished to us by Battelle Pacific Labs. This data was supplied at roughly the 85 industry level, in current and constant dollars, and contained data from 1958 to 1981 inclusive. For the purposes of this study, this data was aggregated to the level of total energy

purchases by industry at the 55 industry level. The data was extended beyond 1981 and before 1958 using data from the *Annual Survey of Manufactures* for manufacturing, and by changes in output for the non-manufacturing sectors. The series used in the regressions in this study was total energy purchases in 77$. Aggregate energy prices at the industry level were obtained by dividing the aggregate current dollar value for each industry by the aggregate constant dollar value.

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