Michal Przybylinski

Chair of Theory and Analyses of Economic Systems

University of Lodz, Poland

41 Rewolucji 1905r str.

90-214 Lodz

e-mail: micprz@uni.lodz.pl

Import share equations for IMPEC[1]

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1. Introduction

Import equations in the Polish model IMPEC, like in most of INFORUM models, explain the ratio of import to total output. That is why, the product classification of import data must be the same as in the model, that means NACE. We can not use SITC or Polish CN data on imports simply because they don't fit to the data on output. At the moment our data set, in 57 NACE classification, covers 5 years only, and these data are expressed only in current prices, with no information about price deflators. The most detailed time series we can collect now are10 categories according to NACE. The data cover the period 1984-2001.

The previous version of import share equations[2] was very modest, as the commodities were divided into three groups only.

Practically, there is no information available on import of services. It might be calculated by subtracting commodity import from import in National Accounts, but even this operation is inprecise – sometimes we get negative values.

2. Transition curve

Looking at the graphs showing the import share in total output (fig. 1-11) we can see a general rule: comparing with the '80s, these shares measured both in constant and current prices have risen dramatically. The opening of the Polish foreign trade started in 1990, although some steps towards it can be seen in late eighties. Soon after the fall of the centrally planned economy and COMECON, regulations in Polish foreign trade gradually changed towards the future joining the EU. Until 2001 the volume, as well as value calculated in USD, of commodity imports increased more than five times comparing to 1990. According to National Accounts, the volume of imports of goods and services increased over four times.

Similar tendencies are shown in export, but the rise is not so high. The changes in relative prices of export has been more dynamic, so we can see that the share of export in GDP has risen significantly in the nineties only if we calculate it in constant prices. This share in current prices seems rather stable.

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[2] Przybyliński M., [1998], Including FDI into Foreign Trade Equations. The Case of Poland, VI INFORUM World Conference, El Escorial, Madrid, September 1998

Apart from the changes in regulations towards free market and the opening of the economy, there is probably another tendency hidden here, which has more universal roots. This is the global tendency to increase the trade turnover caused by more effective means of communications and transportation etc. All these reasons make the import shares grow very quickly.

For all commodities, the import share reached 0.28 in 2001 starting from less than 0.1 in 1990. After eleven years, transition process seems to be over for agricultural products, other non metallic products, and other commodities. Import shares for other categories are still growing. It is hard to decompose this growth according to the reasons mentioned above, but altogether these tendencies shape the import shares time series into logistic time trend functions:

$$y = d + \frac{a - d}{1 + be^{-ct}} \tag{1}$$

where the initial value, $d+(a-d)/(1+b)$ is the share of imports typical of the old style economy and the saturation level a is the share typical of a free market economy.

As it can be seen, in some cases dummy variables were introduced, especially for 1990 and 1991, when the market changed its rules and sometimes we witnessed price revolutions. Introduction of such variables changes the shape of the trend function and sometimes we have alternatives like on Fig. 9, but the concept of logistic function seems to be right. The same applies to the shares measured in current prices, shown in the middle column of graphs. There is one exception – products of mining quarrying, fuels and energy, where we can see that the share in current prices, after some perturbations, came back to the level of 1985. In the right column of graphs there are ratios of import prices to domestic prices (index, which value in 2000 is 1). There is no common tendency here. In five cases (which is exactly a half) we may say that the price ratios after long and dramatic journey came back more or less to their initial levels. For mining and other non-metallic products these ratios went down, and for metals, machinery and textiles they went up. These three cases show, that there exist reasons for opening the economy which are so strong, that even unfavourable changes in prices don't copensate them.

Looking at the graphs we can see different speed of transition processes. In some cases the transition seem to be over (agriculture, other non metalic mineral products) in some ther cases it looks like it would continue for some years (food products). Generally we can say, that the main wave of changes is behind us.

Fig. 1-11. Share of import in total output.

From left to right: 1) constant prices of 2000 2) current prices 3) price ratio, 2000=1

1. All commodities
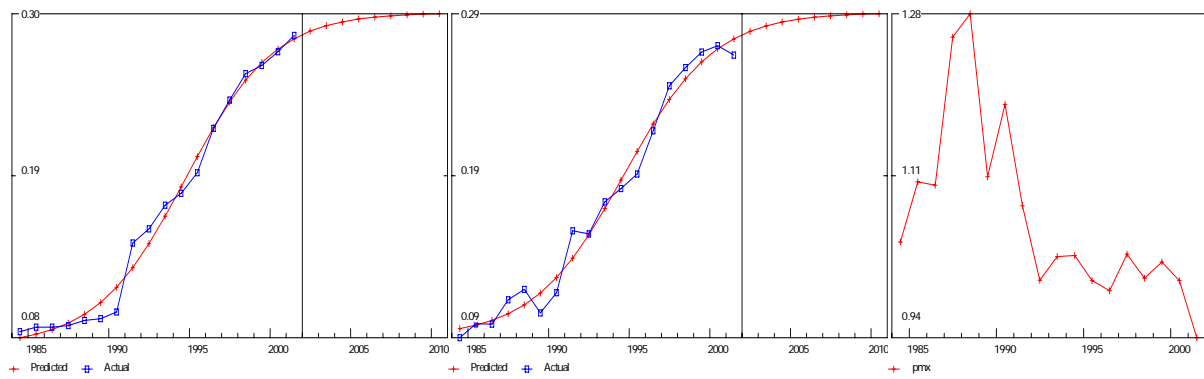
2. Products of agriculture, hunting, forestry and fishing
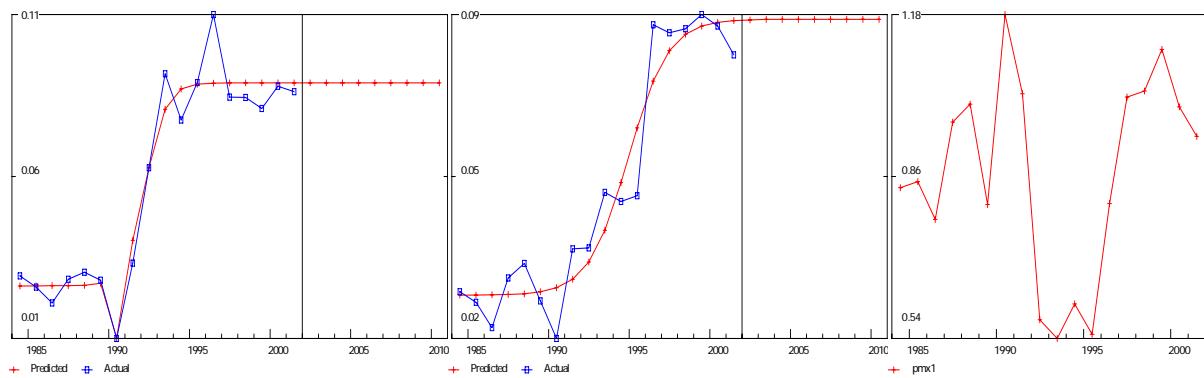
3. Products of mining, quarrying, fuels and energy
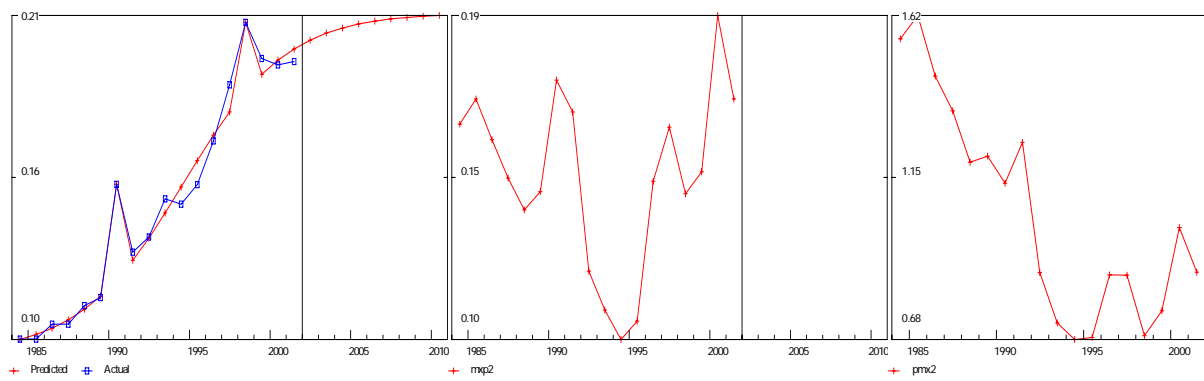
4. Basic metals and fabricated metal products
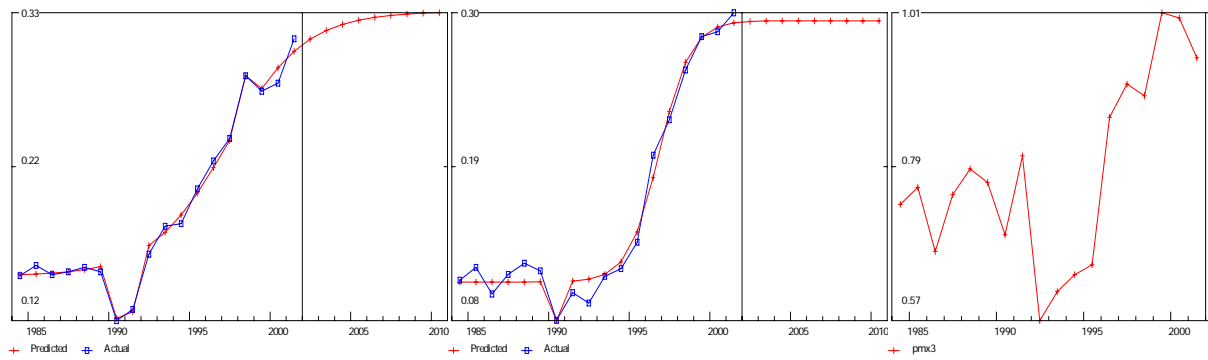
5. Machinery and equipment incl. electrical, optical and transport equipment
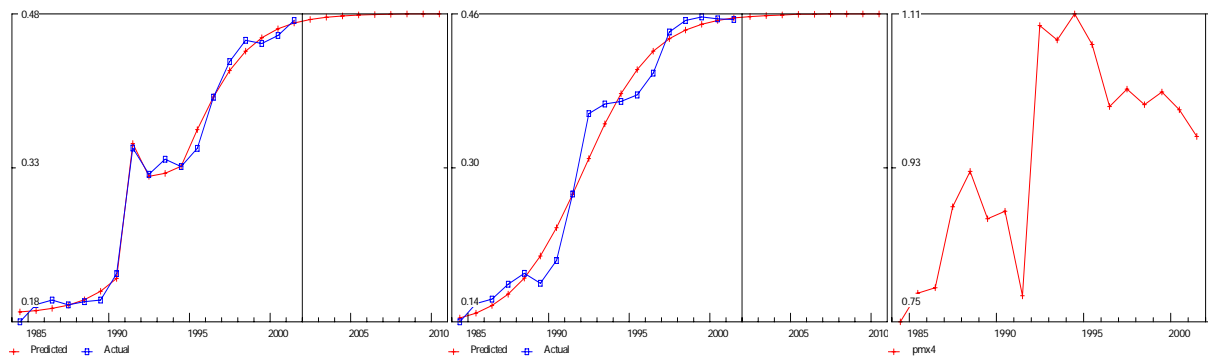
6. Chemical, rubber and plastic products
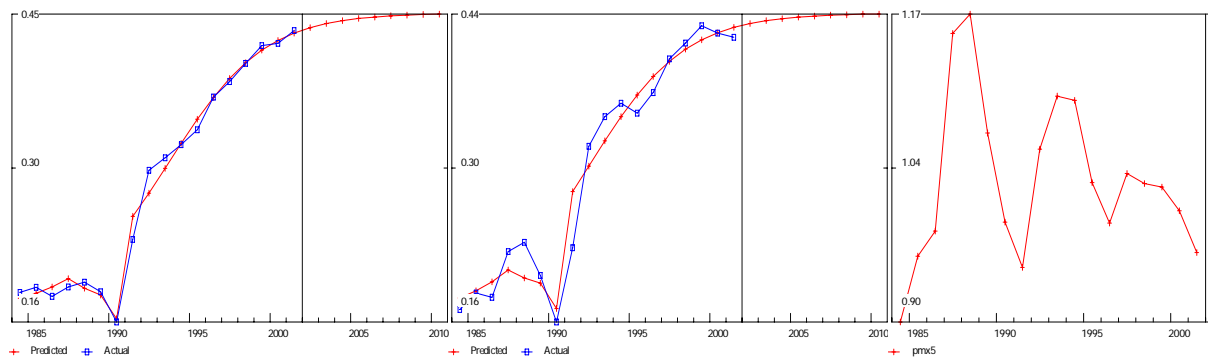
7. Other non-metallic mineral products
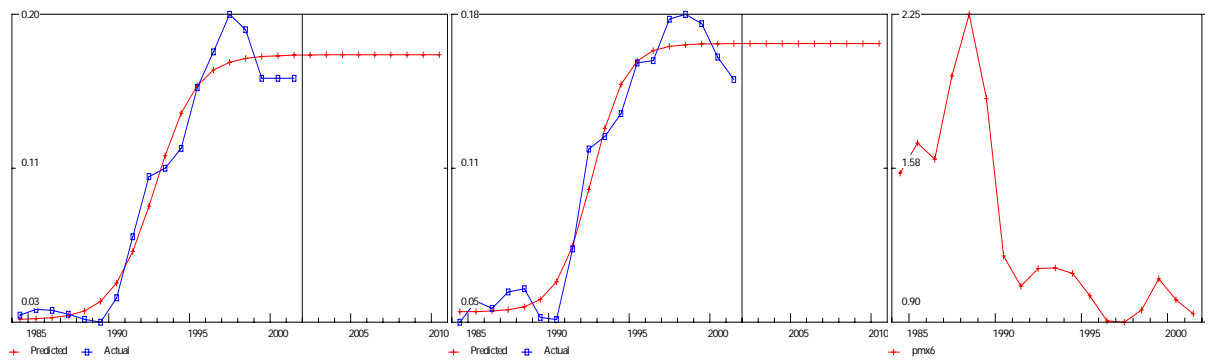
8. Wood, wood products, pulp, paper, paper products, recorded media, printing services
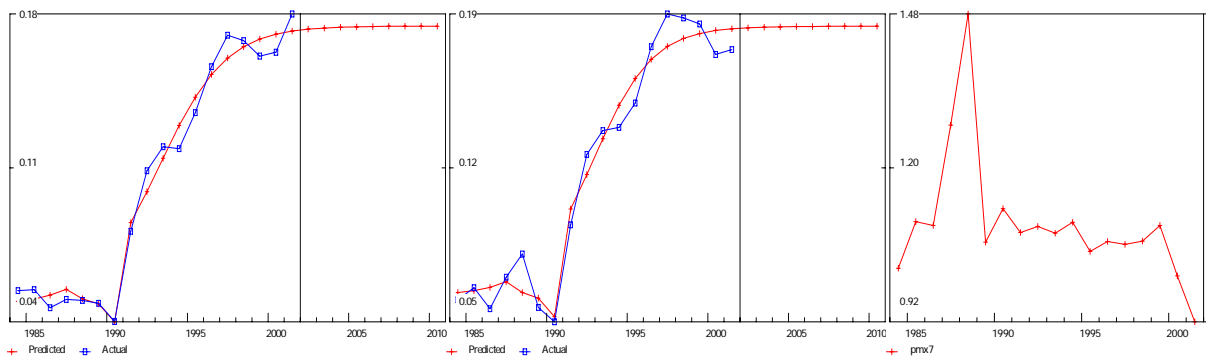
9. Textiles, textile products and wearing apparel,leather and leather products
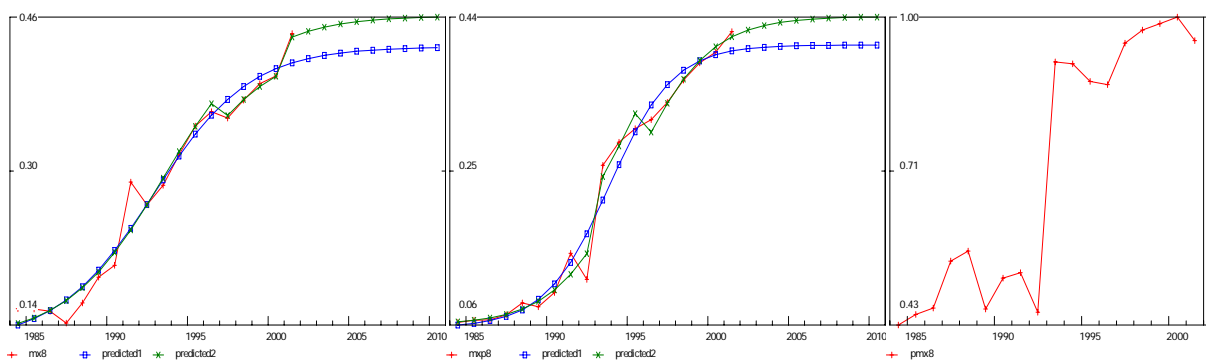
10. Food products, beverages and tobacco
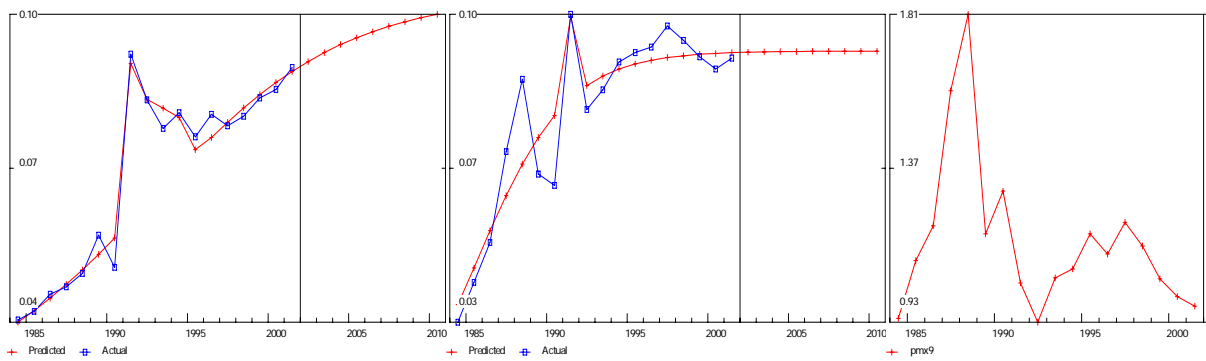
11. Other commodities
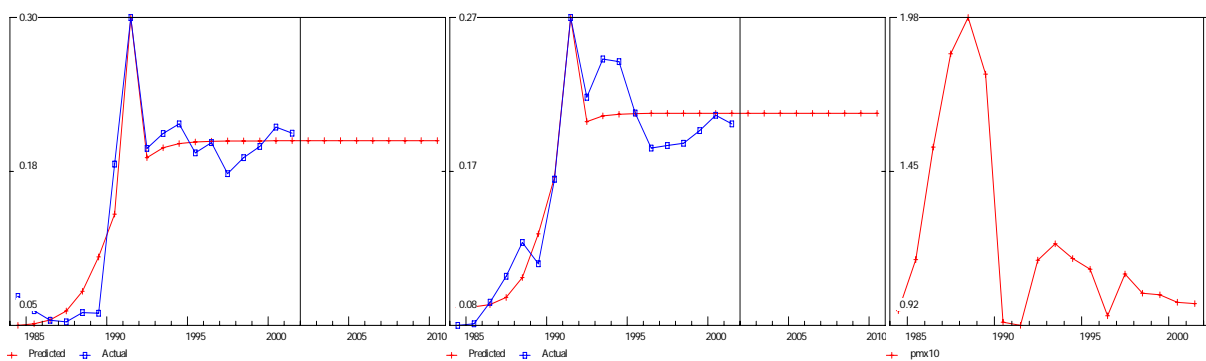
3. The equations

Time trend equations might be used for simple projections but are not enough for making simulations.

The proposed equations have a logit form, which is often used in INFORUM models[3]. It is quite similar to (1), it just assumes that the lower and upper asymptotes are 0 and 1. This assumption is necessary, as the explained variable is a share. The logit form can be estimated with OLS after transformation to:

$$\ln(mx/(1-mx)) = \alpha_0 + \alpha_1 EV_1 + \alpha_2 EV_2 + ... \tag{2}$$

where:

$mx = m/(x+m)$ is the share of import in total output,

m - import in constant prices

x - output in constant prices

EV - explanatory variables.

The first explanatory variable is the price relation between import and domestic goods. The import prices were corrected with duties and other taxes related to imports, so the variables are not exactly the same as can be seen in fig. 1-11 on the right. These variables are present in all equations, because the price ratio, changes in duties and exchange rate are the most often used instruments for simulations. As there was no information about duties in the eighties, estimations were based on the period 1990-2001.

All equations are supported with another variable. In the previous version, the role of the second explanatory variable was played by a measure of foreign direct investment. It was assumed that there were two effects of the FDI here: one was immediate and positive – foreign companies import machines and supplies. In longer term, with some time lags, the FDI make the domestic production more competitive, pushing out imports. Using the new data set it was not possible to separate these two effects, or they appeared insignificant, nevertheless, the new estimates showed that the FDI was rather not a good choice.

So, there are three types of „another variable" proposed:

Total output: $(x+m)$

Changes in total output in the form of chain index: $(x_t + m_t)/(x_{t-1} + m_{t-1})$

Time trend: $\ln(t)$ or $t^{\beta}, 0 < \beta < 1$

There are two reasons for introduction of total output or changes in total output as an explanatory variable:

1) in short term import is more elastic for changes in demand than domestic production. Domestic producers are often not able to quickly reflect an increase in demand. In the nineties (especially the first half) there was a problem of the structure of potential production, which didn't match well to the demand. In other words, producers were

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[3] Barnabani M., [1993], Logit Model Applied to Import Market Shares: The Italian Case, 1st World INFORUM Conference, Rennes

Wu H., Pan S., [1998], Import-Export Equations for Mudan Model, 6th World INFORUM Conference, El Escorial, Madrid

able to produce enough goods, but not exactly of the kind people would have bought. This problem has more long-term character in the case of mining products and fuels. In this equation (and only in this equation) total output was used instead of its chain index.

2) in long term it may reflect the effect of scale and intra industry trade, but this is rather weak hypothesis.

All estimations were made using G7 software (see www.InforumWeb.umd.edu).

Results of estimation of import share equations

Symbols: *m* - import
x - output
$$mx = m/(x+m)$$
$$tmx = \ln(mx/(1-mx))$$
pdmx - price ratio: import price deflator (including duties and other import taxes) divided by the price deflator of domestic production

Note: Figures show import share (*mx*) not the transformed variable *tmx*

```
:                              All commodities
  SEE   =         0.09 RSQ   = 0.9443 RHO =  -0.03 Obser   =    12 from 1990.000
  SEE+1 =         0.09 RBSQ  = 0.9320 DW  =   2.05 DoFree  =     9 to   2001.000
  MAPE  =         6.05
Variable name        Reg-Coef Mexval  Elas   NorRes   Mean   Beta  t-value  F-Stat
0 tmx                - - - - - - - - - - - - - - - - -1.40 - - - - - - - - - - -
1 intercept           1.24315   20.1  -0.89   17.96   1.00           1.994
2 pmdx                -3.18635  240.1   2.51    1.62   1.10 -0.860  -9.753   76.33
3 (x+m)/(x[1]+m[1])    0.84144   27.2  -0.62    1.00   1.04  0.208   2.357    5.55

:              Products of agriculture, hunting, forestry and fishing
  SEE   =         0.14 RSQ   = 0.9386 RHO =   0.05 Obser   =    12 from 1990.000
  SEE+1 =         0.14 RBSQ  = 0.9249 DW  =   1.89 DoFree  =     9 to   2001.000
  MAPE  =         4.76
Variable name        Reg-Coef Mexval  Elas   NorRes   Mean   Beta  t-value  F-Stat
0 tmx1               - - - - - - - - - - - - - - - - -2.64 - - - - - - - - - - -
1 intercept          -2.56773  253.5   0.97   16.28   1.00          -10.173
2 pmdx1              -1.10003  106.0   0.39    8.87   0.93 -0.466  -5.404   68.75
3 @log(t)             0.57502  197.9  -0.36    1.00   1.67  0.726   8.417   70.85
```


All commodities

Products of agriculture, hunting, forestry and fishing
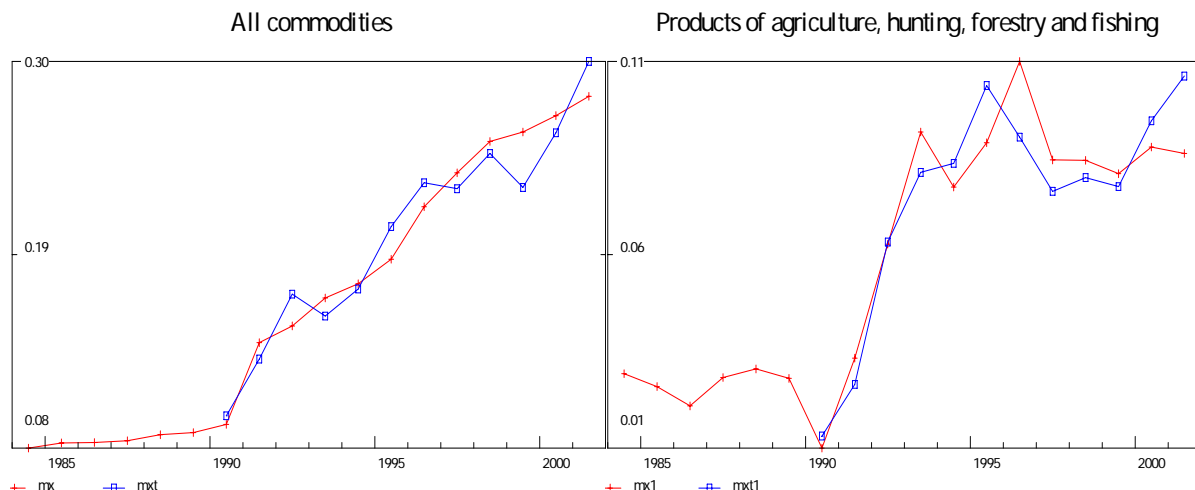
```
:                Products of mining, quarrying, fuels and energy
   SEE    =       0.09 RSQ   = 0.7455 RHO =   0.16 Obser  =   12 from 1990.000
   SEE+1  =       0.09 RBSQ  = 0.6890 DW  =   1.68 DoFree =    9 to    2001.000
   MAPE   =       4.96
Variable name        Reg-Coef  Mexval   Elas   NorRes    Mean    Beta   t-value  F-Stat
0 tmx2                - - - - - - - - - - - - - - - -1.61 - - - - - - - - - -
1 intercept          -4.04615   149.2   2.51    3.93     1.00           -6.847
2 pmdx2              -0.54767    54.1   0.29    3.44     0.86  -0.625   -3.516   13.18
3 (x2+m2)             0.00002    85.4  -1.80    1.00 122037.10  0.833    4.685   21.95

:                Basic metals and fabricated metal products
   SEE    =       0.05 RSQ   = 0.9817 RHO =   0.04 Obser  =   12 from 1990.000
   SEE+1  =       0.05 RBSQ  = 0.9776 DW  =   1.92 DoFree =    9 to    2001.000
   MAPE   =       3.59
Variable name        Reg-Coef  Mexval   Elas   NorRes   Mean    Beta   t-value  F-Stat
0 tmx3                - - - - - - - - - - - - - - - -1.32 - - - - - - - - - -
1 intercept          -2.23273   729.0   1.70   54.59    1.00          -24.688
2 pmdx3              -0.25954    13.4   0.15   29.74    0.78  -0.106   -1.606  241.14
3 @pow(t,.63)         0.35798   445.3  -0.85    1.00    3.12   1.066   16.082  258.64
```
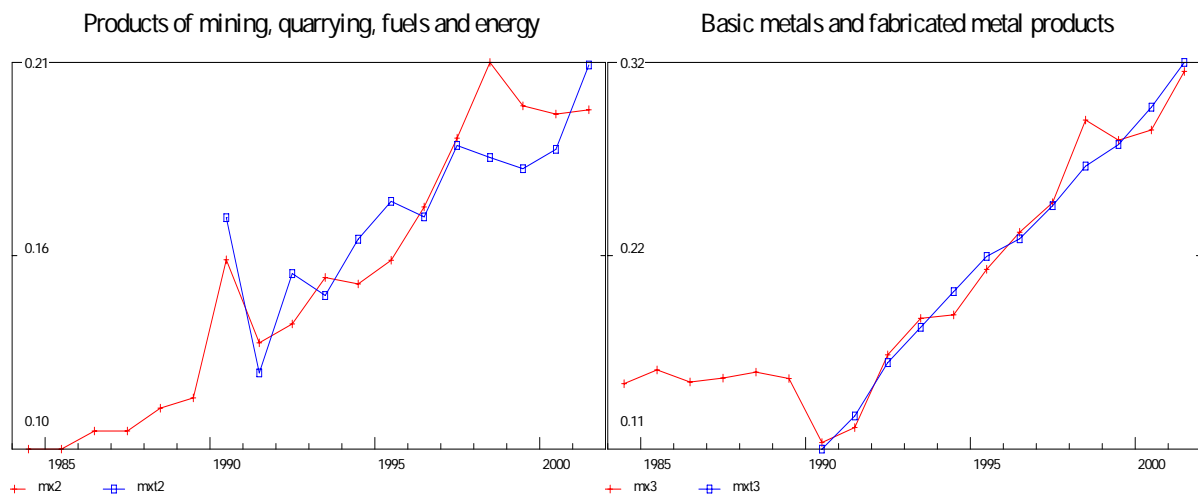
Products of mining, quarrying, fuels and energy   Basic metals and fabricated metal products


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:                Machinery and equipment incl. electrical, optical...
   SEE    =       0.07 RSQ   = 0.9528 RHO =   0.36 Obser  =   12 from 1990.000
   SEE+1  =       0.07 RBSQ  = 0.9423 DW  =   1.29 DoFree =    9 to    2001.000
   MAPE   =      14.32
Variable name        Reg-Coef  Mexval   Elas   NorRes   Mean    Beta   t-value  F-Stat
0 tmx4                - - - - - - - - - - - - - - - 0.50 - - - - - - - - - -
1 intercept          -0.56307    56.8   1.12   21.20    1.00           -3.623
2 pmdx4              -0.62525    70.5   1.31   21.16    1.05  -0.311   -4.141   90.88
3 @log(t)             0.43238   360.0  -1.43    1.00    1.67   1.012   13.470  181.45

:                 Chemical, rubber and plastic products
   SEE    =       0.16 RSQ   = 0.8274 RHO =   0.35 Obser  =   12 from 1990.000
   SEE+1  =       0.16 RBSQ  = 0.7890 DW  =   1.29 DoFree =    9 to    2001.000
   MAPE   =      30.06
Variable name            Reg-Coef  Mexval   Elas   NorRes   Mean    Beta   t-value F-Stat
0 tmx5                    - - - - - - - - - - - - - - - -0.67 - - - - - - - - - -
1 intercept              -1.57788    42.9   2.34    5.79   1.00           -3.062
2 pmdx5                  -1.42900    92.3   2.52    4.31   1.19  -0.706   -4.927   21.57
3 (x5+m5)/(x5[1]+m5[1])   2.39433   107.5  -3.86    1.00   1.09   0.781    5.455   29.75
```

Machinery and equipment incl. electrical, optical...

mx4   mxt4

Chemical, rubber and plastic products

mx5   mxt5
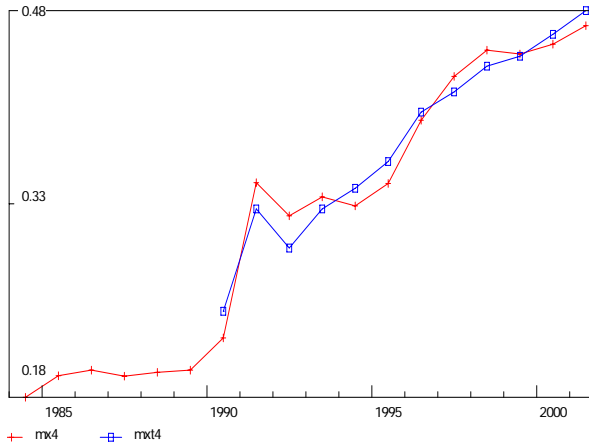
```
:                Other non-metallic mineral products
  SEE   =        0.20 RSQ   = 0.8418 RHO =  -0.05 Obser  =   12 from 1990.000
  SEE+1 =        0.20 RBSQ  = 0.8067 DW  =   2.10 DoFree =    9 to   2001.000
  MAPE  =        8.63
Variable name            Reg-Coef  Mexval  Elas   NorRes  Mean  Beta   t-value  F-Stat
0 tmx6                   - - - - - - - - - - - - - - - -1.89 - - - - - - - - - - -
1 intercept             -2.95655    40.2   1.56     6.32  1.00         -2.947
2 pmdx6                  -1.96550    72.2   1.17     3.18  1.13 -0.572  -4.207   23.95
3 (x6+m6)/(x6[1]+m6[1])  3.07866     78.5  -1.73     1.00  1.07  0.603   4.434   19.66

:           Wood, wood products, pulp, paper, paper products,...
  SEE   =        0.15 RSQ   = 0.8815 RHO =   0.49 Obser  =   12 from 1990.000
  SEE+1 =        0.13 RBSQ  = 0.8552 DW  =   1.02 DoFree =    9 to   2001.000
  MAPE  =        7.57
Variable name            Reg-Coef  Mexval  Elas   NorRes  Mean  Beta   t-value  F-Stat
0 tmx7                   - - - - - - - - - - - - - - - -1.90 - - - - - - - - - - -
1 intercept             -0.34748     1.2   0.18     8.44  1.00         -0.466
2 pmdx7                  -3.46830   127.4   2.05     4.56  1.12 -0.704  -6.127   33.47
3 (x7+m7)/(x7[1]+m7[1])  2.13597   113.5  -1.23     1.00  1.10  0.650   5.659   32.02
```
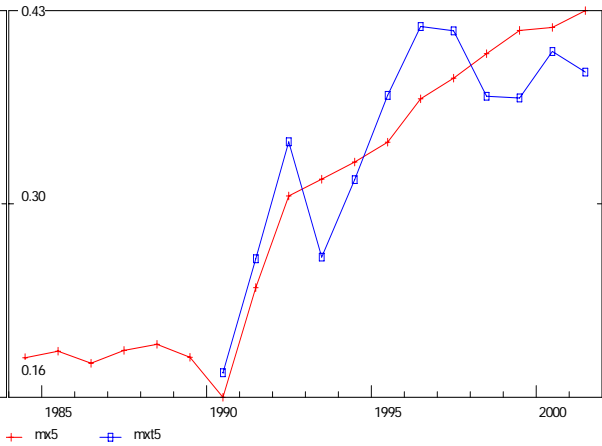
Other non-metallic mineral products
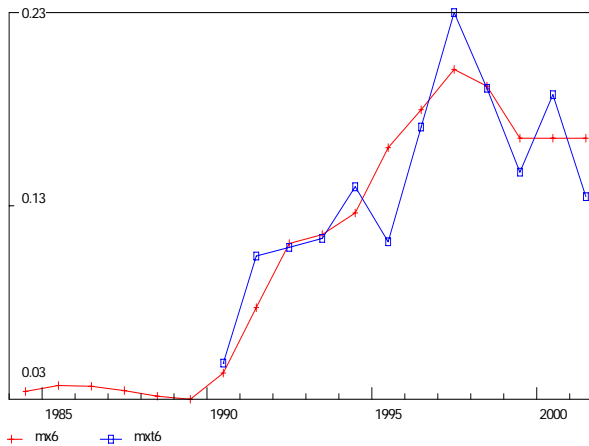
mx6   mxt6

Wood, wood products, pulp, paper, paper products,...

mx7   mxt7
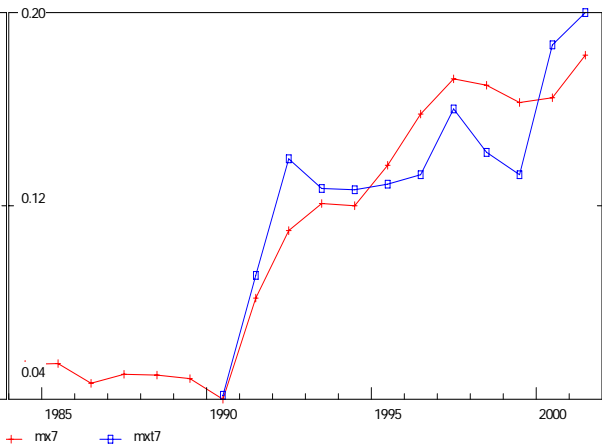
```
:                Textiles, textile products and wearing apparel,...
  SEE   =        0.07 RSQ   = 0.9488 RHO =  -0.38 Obser  =   12 from 1990.000
  SEE+1 =        0.06 RBSQ  = 0.9374 DW  =   2.75 DoFree =    9 to   2001.000
  MAPE  =        8.65
Variable name            Reg-Coef  Mexval  Elas   NorRes  Mean  Beta   t-value  F-Stat
0 tmx8                   - - - - - - - - - - - - - - - - 0.70 - - - - - - - - - - -
1 intercept             -1.13653   205.5   1.63    19.54  1.00         -8.661
2 pmdx8                  -0.42205    21.9   0.54    11.77  0.89 -0.243  -2.091   83.42
3 @log(t)                0.48940   243.1  -1.17     1.00  1.67  1.147   9.847   96.97
```

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:                        Food products, beverages and tobacco
  SEE   =        0.08 RSQ   = 0.8025 RHO =   0.18 Obser   =   12 from 1990.000
  SEE+1 =        0.08 RBSQ  = 0.7587 DW  =   1.63 DoFree  =    9 to    2001.000
  MAPE  =        2.70
Variable name              Reg-Coef  Mexval  Elas   NorRes Mean  Beta   t-value  F-Stat
0 tmx9                     - - - - - - - - - - - - - 2.46 - - - - - - - - - - -
1 intercept               -2.61092   129.3   1.06   5.06  1.00          -6.191
2 pmdx9                    -0.79159    54.3   0.36   2.54  1.11 -0.544   -3.526   18.29
3 (x9+m9)/(x9[1]+m9[1]) 0.99103       59.3  -0.42   1.00  1.04  0.574    3.720   13.84
```

Textiles, textile products and wearing apparel,...   Food products, beverages and tobacco

In many cases relative prices and changes in total output appeared to explain quite a lot of the process described on fig. 1-11 by the transition curves. In other cases, where total output was not significant (or has low Mexval), the time trend was put in the log form, or as a root. Thus, the reasons for transition process were decomposed into two: changes in prices and other reasons. The log trend, which is similar to a root where beta is close to zero, means that the non-price factors raised the share strongly in the beginning of the analyzed period (1990-2001), weakening very quickly. This could be observed for agricultural products, machinery and textiles, and means, that these branches have completed the transition period. Higher value of beta, like 0.63 estimated[4] for metals, suggests, that the transition process in this industry is going to continue (see also fig. 4).

For the category "other commodities" no reasonable equation could be proposed.

The main goal of the calculations showed above was to make the import equations operational. The first, symptomatic version of the equations will serve as the base for long term projections, the second will be used to simulate the reaction of imports on changes in duties, as well as in domestic prices. To do this, these equations will be included into IMPEC with a bridge matrix converting results obtained from 10 equations into 57 branches. Construction of this bridge will probably bring other interesting findings.

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[4] Equations with time trend were first estimated using G7 with *nl* (nonlinear estimation) command. If beta appeared to be under 0.01, the root was replaced with log. Then the equations were estimated using *r* command (OLS) with beta given explicitly.