Introduction

The objective of model-building was an inflation model suitable for prognosis as well as for simulation. The model serves two purposes. First of all, it is a tool for analysing inflation. Secondly, it is part of the model of Estonian economy, which completes the adjustment loop of the macromodel.

The theoretical background of the inflation model derives from four basic features of Estonian economy. Namely, Estonia is:

1) a small and open economy

2) a transitional economy In the conventional sense, transitional economy means (post)socialist economy which is developing from a centrally planned system into market economy. Estonia seems to have almost completed such a transition. However, Estonia still remains a transitional economy – in the sense of accession to the European Union (transition into EU). The underlying process of the inflation in a transitional economy – whichever meaning of it we use – is price convergence. For Estonia it means the convergence of price level and relative prices of post-socialist economy with the market economies of the European Union.

3) economy under currency board arrangement (CBA) Estonian economy is based on a relatively unique monetary rule – currency board. As for inflation, endogenous money supply, which is characteristic for the currency board, is important. In case of perfect foresight and perfect competition, the monetary approach to the balance of payments is applicable under the CBA. Therefore, money supply is not a factor of the inflation because causality runs quite the opposite. However, there is empirical evidence of the validity of this causality also in more realistic settings – when giving up perfect foresight and markets.

4) market economy The theoretical set-up of Phillips Curve (PC) used in our modelling exercise is somewhat obsolete. We use a model where the GDP gap and the PC are estimated separately. Therefore the supply shocks are only presented as the change in prices. The GDP gap (or the long run (equilibrium) production) does not depend on the supply shocks, although in reality it is hardly so.

The base model of Estonian inflation is a combination of all above-mentioned models.

When estimating the model, inflation was separated into:

- underlying inflation which is a long-run and equilibrium process;
- inflation deviations from the equilibrium which are caused by the deviations of inflation factors from their equilibrium.

The model has been tested on the basis of the following criteria:

1. The equations had to be reasonably interpreted, provide valid statistics and correct results in ex post simulations.
2. The model had to provide acceptable results in the simulation of endogenous and exogenous shocks.

3. Ex ante forecast of the model had to be acceptable.

The underlying inflation, which reflects the convergence, is determined as a trend. The latter was specified as a time function, ARMA process, moving average or HP filter, whereas the best result was obtained with time function. The constant 1.003 of the function was predetermined and it can be interpreted as the quarterly ratio of the inflation which our inflation is expected to reach when the convergence is complete.

The model shows that the short-run dynamics of the inflation is determined by three main factors – supply-demand situation, exchange rate of the dollar (which is approximation for foreign prices), and administrative action for correcting (or liberalising) regulated prices.

The structure of the model is rather simple. The relationships between indicators are nothing but the transmission of impact. The importance of adjustment processes is not considerable. The lack of internal adjustment mechanisms for the inflation model is obvious. The inflation model itself is partial and the adaptation circles of the economy reach beyond the range covered by the inflation model.

Producer prices have the key role in transmission. If we were to believe the supply side price formation, such impact corresponds to the intuition. Thus: producers determine their prices either:

a) on the basis of (imported) input prices (the change of imported input prices is reflected in the change of the exchange rate of the dollar)
b) on the basis of the demand (this is reflected in the GDP gap).

Producer price is the direct basis for export prices and through transmission also for prices in domestic market.

1. Theoretical background

1.1 Transitional economy

In the conventional sense, *transitional economy* means (post)socialist economy which is developing from a centrally planned system into market economy. Estonia seems to have almost completed such a transition. However, Estonia still remains a transitional economy – in the sense of its accession to the European Union.

The underlying process of the inflation in a transitional economy – whichever meaning of it we use – is price convergence. In transition to market economy, convergence means the approximation of the price level and relative prices of post-socialist economy with the market economy; in the accession to the EU, convergence means approximation with the economies of the EU.

Price convergence is derived from the purchasing power parity (PPP). The validity of PPP (in the absolute or relative sense) is subject to long-lasting debates.[1] It is noteworthy that the generally negative reaction to the validity of PPP which was dominant earlier has given ground to a more lenient attitude[2]. However, it seems that regardless of the doubts concerning universal validity of PPP, within the context of transitional economies, the hypothesis of PPP is adequate to describe the changes in prices. Therefore such hypothesis serves as a reasonable starting point in building an inflation model for the transitional economy.

According to Koen and De Masi (1997), there are ten stylized facts to characterise the form and dynamics of price convergence. With regard to Estonia, the following should be emphasised: economic development and opening of the economy, the process of overall liberalisation in the economy (incl. price deregulation), the capitalisation of economy and emission of the *kroon* under its real value.

During a transition, the role and relevance of convergence factors changes. The factors which were important during the first stage of the transition do not necessarily retain its weight later. In that sense, liberalisation is characteristic. Hernandes and Cata (1999) point out that:

a) in the earlier stages of the transition, inflation is proportionally dependent on the scope of liberalisation (especially in countries where liberalisation takes a more radical form);
b) in the middle perspective, the relationship between inflation and liberalisation becomes inversely proportional.

The change in the impact is also characteristic of other factors, and it is a serious problem how to include it in the inflation model. In our model, we tried to solve it by presenting inflation in two phases: separate consideration is given to the underlying inflation and to the dynamic component of inflation.

[1] The new wave in PPP analysis deals with the stationarity and cointegration of data (see for instance Kugler (1999)).
[2] For instance, Papell's (1998) and (1997) and Nagayasu's (1998) empirical studies do not deny the validity of long-term PPP.

As mentioned before, convergence means harmonization of price level and of relative prices. In order to simplify the model, the harmonization of the price level is taken as external convergence and the harmonization of relative prices as internal convergence. External convergence takes place in the tradable sector. Internal convergence is the convergence of the nontradable sector price level with that of the tradable sector. Such simplifications are important in empirical model building because they allow for a separate estimation of inflation equations for the tradable and nontradable sector within the same theoretical framework.

In our plain approach external convergence covers three indicators: inflation, price level and income level. The duration of convergence is determined by the following conditions:

°1. Inflation convergence ends with price level convergence;

°2. Price level convergence ends with income level convergence;

°3. Inflation convergence ends with income convergence (derives from °1 and °2).[3]

The length of internal convergence is limited to the convergence of the nontradable sector price level with the tradable sector. The forms of internal convergence include cost-recovery, liberalisation of prices, administrative increase in the prices and tariffs of services, etc. It is widely assumed[4] that internal convergence is related to the Samuelson-Balassa process[5]. Therefore, in estimating Estonia's inflation model, we tried to specify internal convergence in the Samuelson-Balassa framework.

1.2 Small and open economy

For a small and open economy, the international transmission of inflation is of utmost importance. The transmission is realised as a result of the following shifts:

1. increase of external demand;
2. change in the prices of imported production inputs;
3. change in the prices of imported substitutes[6];
4. revaluation/devaluation of home currency (or its real apreciation/depreciation);
5. decline in foreign interest rates which is followed by capital inflow;
6. the Samuleson-Balassa process.

When estimating the model, the first three aspects - as relevant for the inflation in Estonia - were used explicitly.

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[3] Or as put in EU accession terms – nominal and real convergence will end at the same time.

[4] Yet there are opponents to that opinion. The validity of the Samuelson-Balassa process in transitional economy has been questioned for instance by Ito, Isard and Symansky ((1999), p. 126). For discussion of the validity of the Samuelson-Balassa process, see also Devereux (1999).

[5] For Estonia, this is said to hold true by Võrk (1998) and Raim (1999).

[6] Clauses 2 and 3 are most probably connected with the notion of the pricing to market, see Krugman (1987), Faruqee (1995), Kadiyali (1997), for Estonia: Sepp (1999).

1.3 Currency Board Arrangement (CBA)

Since Estonian economy is based on a rather exceptional monetary rule – currency board, it can be expected that when modelling economic processes such specific framework needs to be taken into account.

As for inflation, endogenous money supply, which is characteristic of the CBA, is significant. In case of perfect foresight and perfect competition, the flow-chart known from the monetary approach to the balance of payments applies here: inflation → demand for money → money supply → change in foreign reserves, or as in the conventional formulation R = g(P,Y,I m,D).[7] Therefore money supply is not a factor of the inflation but vice versa.[8]

However, there is evidence of the validity of this causality also in more realistic settings – when we put aside the perfect foresight and markets. Empirical studies show that CBA has been successful in curbing inflation.[9] If we assume that endogenous (and demand-driven) money supply excludes excessive money and inflation pressure, the relatively low inflation that is characteristic of currency boards is also an indirect proof of endogenous money supply.

We arrived at the same result (or endogenity of money supply) when making a provisional analysis of Estonian data. We examined the short-term relationship of money supply and inflation using CPI and M1 supply first differences (as both time-series were integrated in order 1). Granger causality tests show that inflation affects money supply with the lags of 3 and 4 quarters.

The latter claim has straight outcome to model-building. In the case of endogenity it is not reasonable to include money supply in the equation of inflation as an explanatory variable.

The CBA and endogenous money supply do have an obvious connection to inflation expectations as well. In the case of a CBA, the component, which derives from the discretionary monetary policy of the conventional central bank, is not included in the expectations of agents.[10] Thus we can say that the discretion of the monetary authority and its (presumable) inflationary effect do not matter under the CBA. As a result of this, the CBA enjoys a higher degree of confidence and modest expectations of inflation.

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[7] Blejer and Frenkel (1992, p. 725).

[8] We abstract here endogenous money supply from the external components – for instance, capital inflow which is caused by external factors.

[9] Ghosh, Gulde and Wolf (1998) indicate that in the case of a CBA the inflation is ~4% smaller as compared to other fixed exchange rate regimes. The advantage of the CBA in curbing inflation in comparison to other monetary rules is also emphasised by McCarthy and Zanalda (1996) in their empirical research.

[10] The separation of the expectations of economic agents into two components: inflation expectations and expectations regarding the behaviour of the central bank, and the impact of such expectations is described by Tarka and Mayes (1999).

1.4 Models of inflation of market economy

The typical inflation models of (closed) market economy include the Okun law and Phillips curve (*PC*), more often, however, a specification which associates both of them.[11] The latter form– though with some changes, which we will explain next – was taken as the basis when building Estonia's model of inflation.

In a sense, the theoretical set-up of PC, which was the basis for our model, is somewhat obsolete. Modern inflation models are estimated as a system where both the equations for the GDP gap and the PC are determined simultaneously.[12] Meanwhile in the current set-up the PC is specified not only as an effect of expectations and demand factors (the GDP gap), but also as a function of the supply factors. We, however, came up with a model in which the GDP gap and the PC are estimated separately. Therefore the supply shocks are influential only in the change of prices.

If we leave aside the expectations, which are irrelevant for the present aspect, inflation according to the conventional PC can be expressed as a function of the GDP gap and other factors (for instance foreign inflation π^x): $\pi = \alpha + \beta1^* \text{ gap} + \beta2^* \pi^x$. The parameter α can be interpreted as a kind of *equilibrium* inflation which is constant. The constancy of the *equilibrium* inflation applies in the case of developed market economies of considerable stability. In transitional economies, the *equilibrium* is much more dynamic. Transitional economies are typified by price convergence which has different intensity in time. To present the *equilibrium* inflation as a time function [f(t)], we get the following equation $\pi = f(t) + \beta1^* \text{ gap} + \beta2^* \pi^x$.

Unfortunately, we failed in the model-building to find the f(t) only on the basis of statistical criteria. The determination of f(t) has to involve the expert judgements as well. As the judgements are essential, there were two stages in estimating the model:

1. first of all, the f(t) was derived,
2. and thereafter the short-term component of inflation (π - f(t)) was calculated and the equation $\pi - f(t) = \beta1^* \text{ gap} + \beta2^* \pi^x$ was estimated.

Let us now add the expectations (π^e): $\pi = f(t) + \beta1^* \text{ gap} + \beta2^* \pi^x + \beta3^* \pi^e$. The economic literature gives the PC which contains expectations in two principal ways – as the old and as the new PC. Distinctive for the new PC are forward-looking expectations, also with regard to future flow of marginal costs.[13] The old PC shows the inflation essentially backward-looking as dependent on the lagged GDP gap etc.

Since both price-setting models are used in practise, it is advisable to combine the forward and backward-looking expectations in building an empirical model. It becomes possible when the old and new PC are combined; the corresponding combination is known as the hybrid PC (see Gali and Getler (1999) p. 7).

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[11] For instance Berg and Lundkvist (1997), Laxton, Isard, Faruqee, Prasad and Turtelboom (1998). A good overview is provided in the edition Bank of England (1999).
[12] The system estimates of potential output and NAIRU, see Apel and Jansson (1998), Apel and Jansson (1999).
[13] For derivation see Gali-Getler (1999), p. 3-6.

When building the Estonian inflation model, the hybrid PC was considered but not applied. Actually only the old PC has been estimated. This was due to the fact that we were not able to quantify the component of the new PC. The reasons included lack of information, presumable change in the pattern of behaviour, as well as past failures in applying forward-looking expectations.[14]

2. Underlying Inflation[15]

As we stated above the price convergence is the underlying process of inflation.

First of all we attempted to estimate price convergence as a function of the real convergence.[16] So we tried the equation for tradables inflation as function of time and GDP (per capita). Unfortunately the outcome was unsatisfactory not only according to statistical criteria but also considering the intuition as well.

When estimating the internal convergence, the Samuelson-Balassa process was taken as the starting point. The nontradables inflation was specified as a function of different combinations of wages and productivities in the open and sheltered sectors.

The results of these exercises were unsatisfactory as well for the reasons mentioned above.

Both failures led us to the conclusion that it was impractical to estimate the underlying inflation as a function of fundamentals. Instead we determined the underlying inflation as a trend, which has been specified as the function of time, ARMA process, moving average or HP filter.

Although at first sight the use of a trend might seem artificial, it need not be so.[17] An adequate trend reflects the long-term (state) path of the variable. In the real world, the latter corresponds to the long-term (equilibrium) trajectories of other indicators. Consequently, the well-estimated trend is consistent with the long-term features of the economy under consideration.

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[14] Unfortunately it is of little help indeed, as according to Gali and Getler (1999, p. 15-16), it is the future-oriented behaviour which dominates in price formation.

[15] The variables of the model (including those which were used in the model-building but became irrelevant in the final version) are listed in Appendix 1. The data-sources are provided in Appendix 2.

[16] See Sepp (1996) for the set-up of the problem.

[17] The specification of a long-term underlying process as a formal function (HP or Kalman filter, trend, moving average, etc.) and explication of a short-term component by detrending is a recognised method, especially in the models of real business cycle (see Kydland and Prescott (1990), Niemera and Klein (1994)). Such detrending is also widely used in inflation modelling, particularly within the context of the Phillips curve (see Gali and Getler (1999), p. 6).

2.1 Time Function

The original four quarters' price indices[18] were transformed by formula $\sqrt[4]{\text{four - quarter price index}}-1$. On the basis of a visual judgement and in accordance with the assumptions about the path of convergence, the long-run function for the transformed price index was specified as $0{,}003+\frac{c1}{t^{c2}}$. The constant 0.003 of the function was predetermined (i.e. $0.003 \approx \sqrt[4]{1{,}012}-1$ and 1,012 is the average weighted yearly inflation of Estonia's EU trade partners[19], afterwards referred to as EU inflation, within the period of 1994q4 – 1999q2). The trend is approaching it when *t* tend, to infinity (if c2>0). The constant can be interpreted as the ratio of the inflation which our inflation is expected to reach when the convergence is completed. A summary of the results of estimating trend equations is given in table 2.1 and figure 2.1.

T a b l e 2.1
Parameters of time functions

Price index	Acronym	*C1*	*C2*	Period of estimation
Tradables	*CPI_TR_LR*	67.76	2.4	94:01 - 99:02
Nontradables	*CPI_NT_LR*	407.74	2.7	94:02 - 99:02
Producer prices	*PPI_LR*	4494.97	3.7	94:04 - 99:02
Import deflator	*DEF_M_LR*	466.90	3.0	94:01 - 99:02
Export deflator	*DEF_X_LR*	2477.53	3.5	94:03 - 99:02
GDP deflator	*DEF_GDP_LR*	71.51	2.3	94:02 - 99:02

Jarque-Bera test shows that there is high probability that *RES_CPI_NT* has not been distributed normally (see table 2.2). The closest series to the normal distribution is *RES_CPI_TR*. The series of all other residuals also (somewhat) resemble the normal distribution.

T a b l e 2.2
Descriptive statistics of the residuals of the time functions

	RES_CP_NT	RES_CPI_TR	RES_PPI	RES_DEF_M	RES_DEF_X	RES_DEF_GDP
Mean	-0.001911	-0.000667	-0.001203	-0.001760	-0.001235	-0.000692
Median	-0.003945	0.000492	0.001172	-0.003291	-0.000384	-0.001818
Maximum	0.030974	0.015852	0.011091	0.011895	0.011434	0.016922
Minimum	-0.018944	-0.015050	-0.016242	-0.017388	-0.019596	-0.016273
Std. Dev.	0.011655	0.008460	0.007415	0.008724	0.008341	0.009663
Skewness	0.962202	0.268675	-0.677445	0.158022	-0.468174	0.036087
Kurtosis	4.267818	2.403326	2.685004	2.025856	2.652588	1.978235
Jarque-Bera	4.646859	0.591034	1.531836	0.961437	0.831204	0.918060
Probability	0.097937	0.744147	0.464907	0.618339	0.659943	0.631896
Observations	21	22	19	22	20	21

[18] The four-quarter indices were used to avoid the problem of seasonal adjustment of quarterly time-series.
[19] Finland, Sweden, Denmark, Germany and the Netherlands.

The residuals are for the most part stationary (see table 2.3). *RES_PPI* and *RES_DEF_X* non-stationarity is the result of the permanent decline of producer prices and export deflator during the period of 1998q2-1999q2.

T a b l e 2.3
Stationarity of Residuals

		Probability (%)	**ADF test protocol in**
RES_CPI_TR	Stationary	5	appendix 3.1
RES_CPI_NT	Stationary	1	appendix 3.2
RES_PPI	Non-stationary		appendix 3.3
RES_DEF_M	Stationary	10	appendix 3.4
RES_DEF_X	Non-stationary		appendix 3.5
RES_DEF_GDP	Stationary	10	appendix 3.6

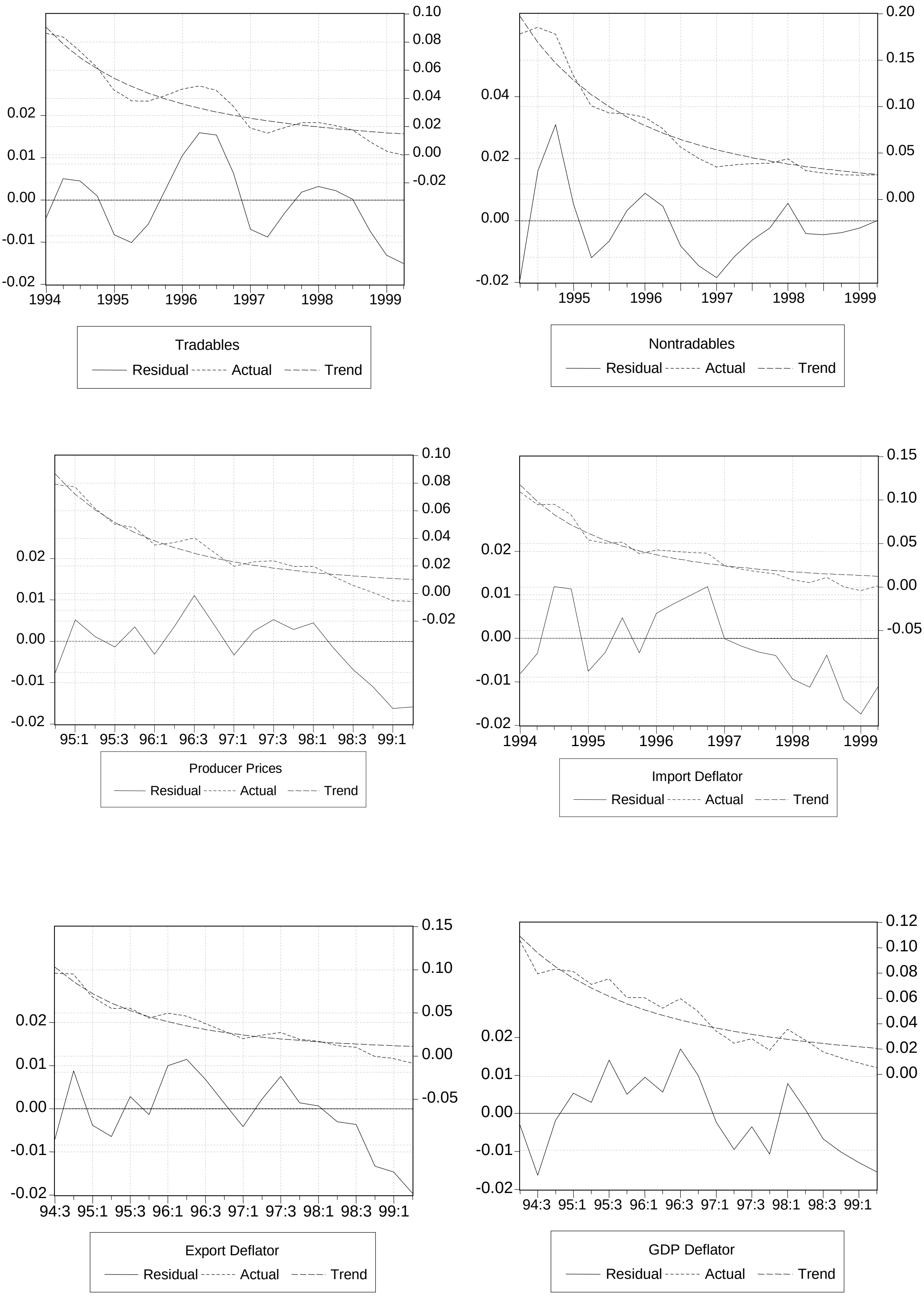

Figure 2.1 Deflators: actual value, trend and deviations from trend

2.2 Internal convergence

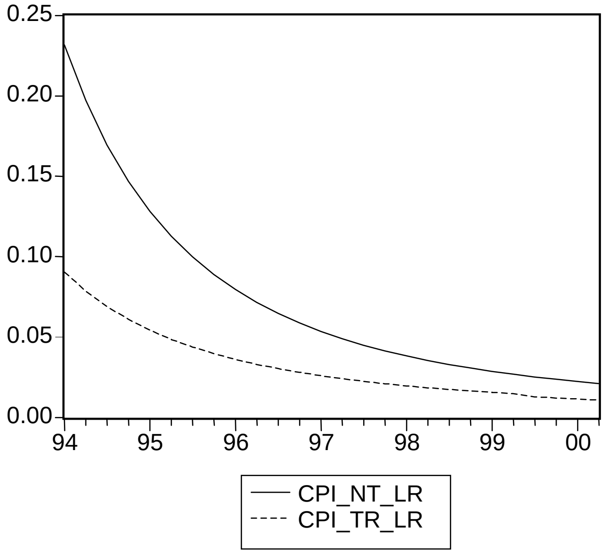

Figure 2.2 Trends of tradables' and nontradables' inflation

Since the trends of the tradables and nontradables (figure 2.2) are both time functions, *CPI_NT_LR* can be derived from *CPI_TR_LR*:

$$CPI\_NT\_LR = 0{,}003 + \frac{407{,}736}{t^{2,7}} \Rightarrow CPI\_NT\_LR - 0{,}003 =$$

$$= \frac{407{,}736}{t^{2,7}} = \frac{67{,}755}{t^{2,4}} \cdot \frac{6{,}02}{t(90:1)^{0,3}} = (CPI\_TR\_LR - 0{,}003) \cdot \frac{6{,}02}{t^{0,3}} \Rightarrow$$

$$\Rightarrow CPI\_NT\_LR = 0{,}003 + (CPI\_TR\_LR - 0{,}003)\frac{6{,}02}{t^{0,3}}$$

As we can see, the underlying inflation of nontradables (*CPI_NT_LR)* is the sum of two components. First of them is the ratio of EU inflation. The second is the product of multiplier $\frac{6{,}02}{t^{0,3}}$ and of the difference of tradables' underlying inflation to compare with the EU inflation.

The multiplier $\frac{6{,}02}{t^{0,3}}$ (figure 2.3) shows how many times the nontradables' inflation difference from the EU inflation is bigger than that of the tradables' inflation. Meanwhile the multiplier could be interpreted as the indicator of internal convergence as the multiplier is approaching to unity when *t* tend, to infinity.

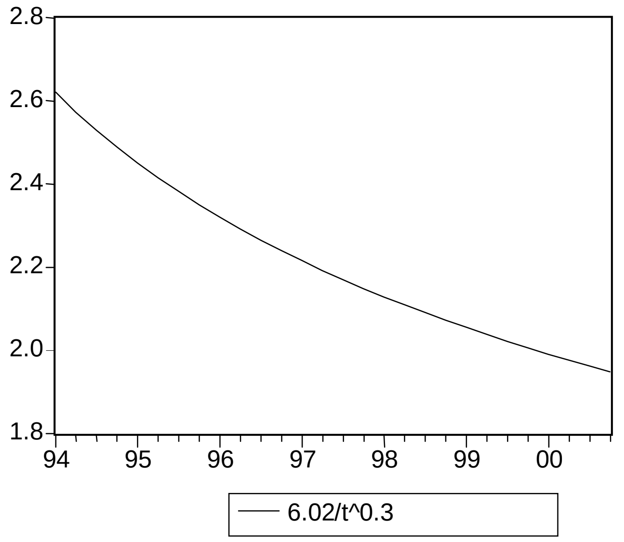

Figure 2.3 The convergence factor of tradables' and nontradables' inflation

2.3 Other methods of the trend estimation

When estimating the trend, we used other methods besides the time function. We experimented with the analytical techniques such as the ARMA model and HP filter, in addition we tried the moving average routine.

At a first look, it might seem that ARMA and the moving average provide better reflection data (see determination coefficients and other indicators of adequacy in Appendices 4.7 – 4.9). Such an advantage is yet deceptive. According to a trend calculated using ARMA, the convergence of inflation is expected to be completed by the end of 1999.

Although the reason for such result – untypically low inflation over the last quarters which is caused by a recession in the business cycle – is obvious, it will not nevertheless make such early end of the convergence more realistic. In fact, the convergence will continue due to the disparity of the purchasing power in the year 2000 and later.

This was the main reason why we gave up the ARMA and similar methods in determination of underlying inflation and preferred the time function. A good picture of the principal advantage of time function in tackling convergence is given in figure 2.4.

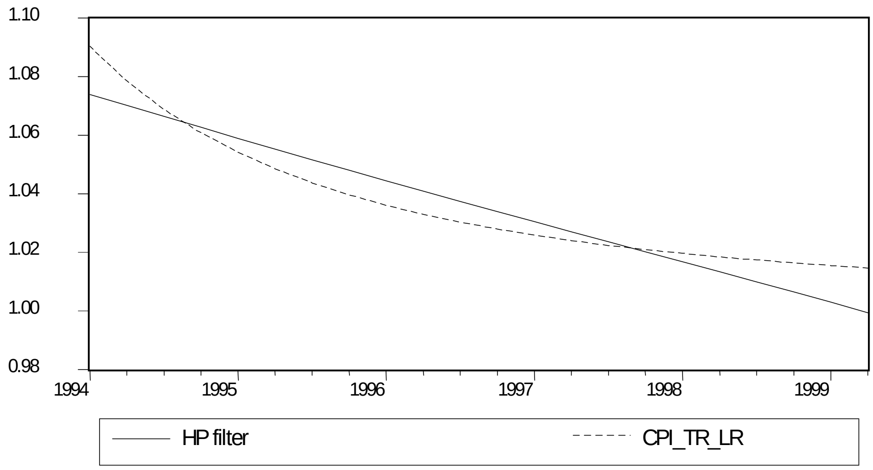

Figure 2.4 Differences in trends

2.4 Judgement of the reality of time function

In order to judge the reality of time function, we will compare the convergence determined by the time function with the intuitively established *sensible horizon of convergence*. The *sensible horizon* was derived from the level of Estonian prices and per capita GDP in 1999q2, which is the last quarter of time-series used in econometric processing.

The estimates of price and income levels of 1999q2 were based on the data of European Comparison Programme for 1996 and regular statistics. In 1996, Estonian prices amounted to 32% of the average price level of its industrial trade partners (Finland, Sweden, Denmark, Germany, Holland, USA). The REER calculated for these countries in the period of 1996q2-1999q2 was 1.16. Accordingly, Estonian relative price level in 1999q2 was (32%*1.16=) 37%.

In 1996, our GDP per capita was 31.6% of that of our industrial trade partners (according to the PPP based exchange rate). The external GDP grew by 8.7% up to 1999q2, GDP growth was 13% in Estonia. So GDP per capita amounted to ~33% in 1999q2.[20]

The following assumptions were applied in order to simplify the process of establishing the *sensible horizon*:

1) the price and GDP convergence means 100% harmonisation (i.e. after the end of convergence, Estonian price level equals foreign one);
2) the price and GDP convergence will end at about the same time;
3) the pace of price and GDP convergence is almost identical;
4) convergence will take place at a steady rate (although incorrect, such assumption will simplify the calculations because the yearly average growth rate can be used).

In establishing the *sensible horizon*, we searched for such duration of the convergence for which the growth rate of prices and GDP would be similar. For Estonia the growth

[20] Without taking into account the change in PPP.

rates would become more or less compatible (~3%[21]) if the convergence lasts for at least 35 to 40 years. This was taken as the *sensible horizon* of convergence.

Unfortunately, it appeared, when testing the time function, that the convergence horizon of (consumer price) inflation determined by the time function does not correspond to the *sensible horizon.* According to the function, the inflation convergence will take 30 years to complete (see figure 2.5).

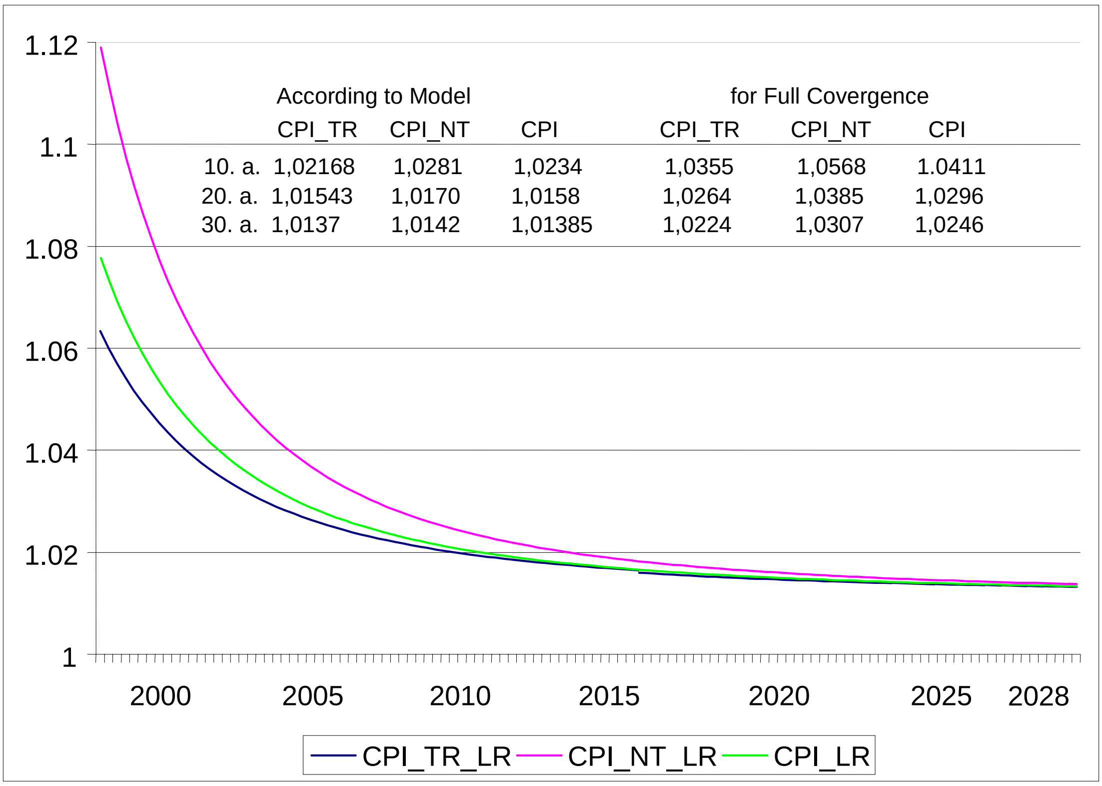

Figure 2.5 Long-term trends of CPI, CPI_TR, CPI_NT

Meanwhile, the modelled inflation rate was so low that it would lead the price level to only ~55% .[22] The result clearly contradicts the assumption that the inflation and price level convergence will end at approximately the same time.[23]

So we may conclude:

1. If we take the reasoning above to be true, the time function is not reflecting the actual long-term convergence;
2. Hopefully, the time function reflects the convergence in a shorter period. Afterwards the regime will change and there will be a new trend or trends;
3. The time function is applicable in practice when building the model for the medium-term period. After that, the time function has to be re-estimated.

[21] It is important to emphasise that both rates show extra growth with regard to the comparison base, i.e. these growth rates are characteristic of the extent to which Estonia’s growth must exceed the that of the EU countries.

[22] In order to reach the price level convergence in 30 years, the CPI per year should be 4.6%.

[23] No such contradictions arise if the external inflation rate is zero, which is clearly not the case.

3. Short-term equations[24]

3.1 Tradables

RES_CPI_TR= 0.3182*RES_DEF_M - 0.0765*GAP_RGDP(-1) + 0.0747*RES_CPI_NT(-1) + 0.0064*DME_9504_9603 - 0.0035*DME_9501_9503 + 0.6396*RES_CPI_TR(-1) - 0.3962*RES_CPI_TR(-2)

The equation includes four main processes:

1) the impact of demand which is reflected by GDP gap (GAP_RGDB). Although it contradicts the endogenity of money supply under CBA, the money supply M2/GDP (as a deviation or a difference) was tested as the proxy for the demand[25];

2) external transmission of inflation as a ground for the supply-side price setting. Externally transmitted inflation is reflected by the deviation of import price index from the trend (RES_DEF_M). We also used NEER in different forms, but it proved to be less suitable;

3) internal transmission of the inflation from the nontradable sector to the tradable sector. This is the feedback, which derives from internal price convergence. Convergence, first of all, takes place in the tradable sector and then it is carried on to the nontradables. Yet, in certain cases, it is the nontradable sector which triggers the tradables inflation. The price rise of nontrables is discretionary (due to the goods with controlled prices). In the case of active administrative action directed to rise the regulated prices, the prices of nontradables could exceed temporarily a certain steady level. Since the prices of the nontradables affect the tradable sector through several channels (e.g. as input, expectations, etc.), the general price level will rise;

4) backward looking adjustment process which is reflected by the two lagged components of the dependent variable.

Due to the first two processes – the impact of demand and external transition of inflation – the price equation of the tradables resembles the theoretical set-up of PC. The increase in the demand means higher prices. However, it is important to realise that due to the type of the variables we use (deviations from the trend), the parameter of gap cannot be interpreted according to the conventional PC. In case of the latter, the parameter represents the slope of the curve, which in its turn determines the elasticity of the inflation in respect to the gap. The tradables' equation is not subject of conventional interpretation. In order to explain the elasticity of the inflation, we

[24] The statistical diagnostics of the equations are given in Appendix 4.
[25] The role of money supply in generating the demand and therefore also the GDP gap can be seen in the following transformation. The conventional IS-equation $Y = C[(1-k)Y] + I[(i-\pi)] + G$ can be transformed to $yd = \zeta g + \theta(m-p) + \psi\pi$, where g is the demand of the open sector, m –money supply, p-price level, π - expected inflation and the rest are equation parameters. To hold the variables need to be specified as follows $Y = G^{\chi} e^{-\eta(i-\pi)}$ and $M/P = Y^{\alpha} e^{-\beta i}$, the Greek letters (except π) are equation parameters. (Scarth (1996), p.74)

need to simulate the effect of the gap shock (see Chapter 4). One should also take the small value of the parameter with certain reservation because this is due to the differences in the size of the variables' values.

The interpretation of the impact of import and nontradable sector prices is trivial. The change of the prices of either groups of goods (which is different from the steady level) brings about - via different channels of transmission and in the case of supply-side price setting - the change in the prices of the tradables.

Dummy variables do not render itself for economic interpretation. They help to eliminate the systematic component of the residual series.[26]

The interpretation of the backward looking adjustment process, however, is pretty complicated. Formally, the dependent variable (lagged by one quarter) in the right side could be interpreted as an indicator of the adaptation process (in the sense of adaptive expectations). The other dependent variable (lagged by two quarters) *RES_CPI_TR(-2)* represents nominally the error correction process with negative feedback.

The adjustment process is relatively quick. The duration and speed of the process can be seen from the time which is needed for adjustment of the deviations to zero-level. According to the equation, the one standard deviation sized shock of the tradables inflation disappears in about two years (see figure 3.1.).

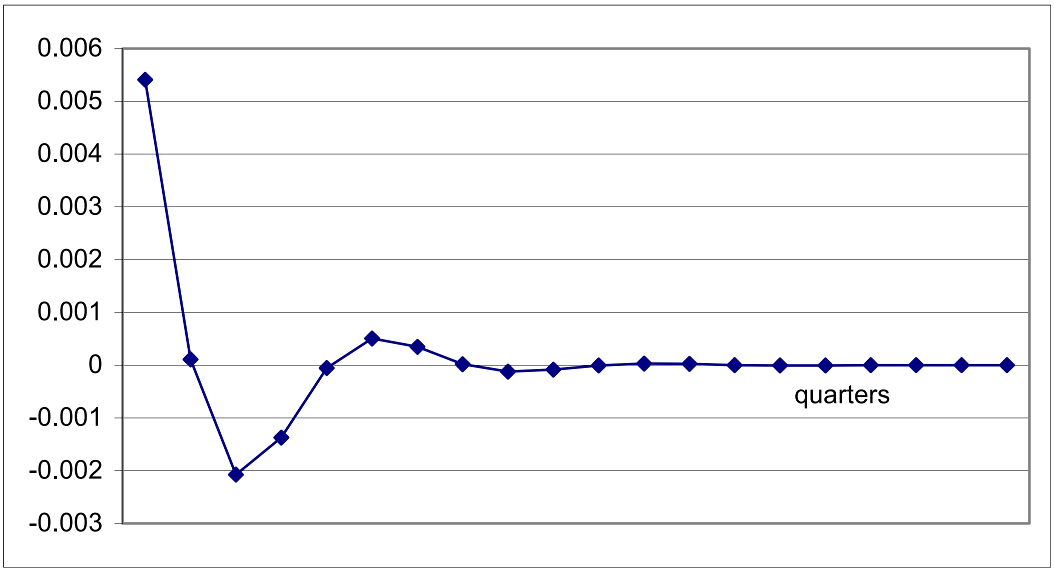

Figure 3.1 The adjustment of a RES_CPI_TR in respect to 1 standard deviation sized shock.

To a certain extent, the backward looking adjustment process is the outcome of the rigidity and inflation inertia. Unfortunately, the sources of such inertia in Estonia are not settled yet. Fundamental research would become necessary to establish whether

[26] DME_9501_9503 = 1 in the period of 95q1 up to 95q3; DME_9504_9603 = 1 in the period of 95q4 up to 96q3.

the causes of the inertia lie in the neo-keynesian, neoclassical or neo-classical synthesis paradigm. (See Walsh (1998), Goodfriend and King (1997)). Without being aware of the concrete reasons, the inertia of the inflation could be interpreted as per Apel and Jansson (1999, p. 378) as the nonseparated outcome of the expectations, nominal contracts, partial information etc.

3.2 The nontradables

The equation of the nontradable inflation was estimated in two representations:

a) similarly to the other deflators as a deviation of the four-quarter index from the trend;
b) and exceptionally, as a deviation of the quarterly chain index from the trend, what was included in the inflation model.

The equation of the four-quarter index is the following
*RES_CPI_NT = 0.447*RES_CPI_NT(-1) - 0.29*RES_CPI_NT(-2) + 0.0215*DMS_9404 + 0.0084*DMS_9601 + 0.009*(-DME_9604_9701) + 0.0078*DMS_9801 - 0.003*MNEER(-1)*

The presented equation, although being satisfactory with the view to statistical criteria, remains weak in the economic interpretation. The equation actually fails to explain the nontradable inflation as the economic phenomena. To leave aside the MNEER, the equation does not contain any of the factors which are subject to economic interpretation.[27]

The second drawback of the equation is optionality of the dummies. The dummies could be taken as the indicators of administrative changes in housing prices and tariffs. So DMS_9404 indicates the change in housing prices of 1994q2 which due to the four-quarter index is lagged by two quarters. The same holds for DMS_9601. But DMS_9801 designates the change in prices which happened in the same quarter. And what is even worse, the dummies, which represent the major price corrections of 1997q2 and 1999q1, could not be included in the equation.

In order to avoid optional and fictional outcome several variants were tried out. Only the quarterly index equation gave a satisfactory result[28]. The series of deviations of nontradables inflation consists of at least two essentially different parts, the latter of which starts in 1997q01 (see figure 3.2). Typical for this period is:

a) relative stability of the inflation rate;
b) especially clear impact of administrative decisions.

[27] We tried also GAP_RGDP, RES_M1/2, RESID_DEF_M-GA as explanatory variables.
[28] The deviation of quarterly index is defined as RES_CPI_NT_Q= quarterly index of the nontradables inflation - CPI_NT_LR - 1

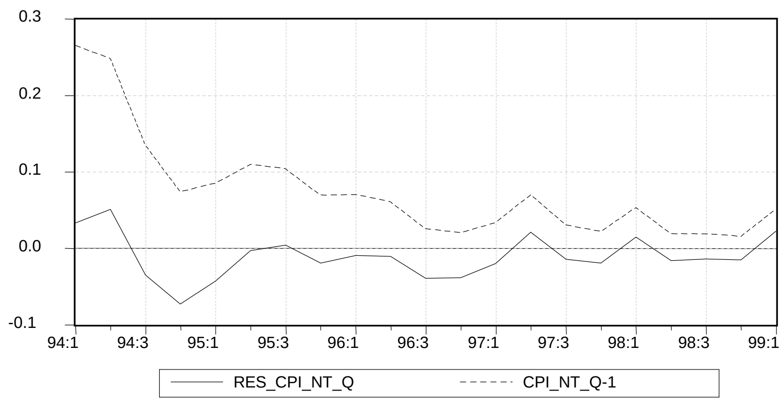

Figure 3.2 RES_CPI_NT_Q and CPI_NT_Q

So we chose to estimate the equation in the period of 1997q1 – 1999q2 and arrived at the following:

*RES_CPI_NT_Q = 0.0342*DUM_ADMIN - 0.352*CPI_NT_LR(-1)*

This equation first of all reflects the impact of administrative price changes on the nontradables' inflation.[29] The reasons for such impact is obvious. The major part of the nontradable sector is formed by goods with controlled prices. The only way to bring the prices of the nontradables into line with the change of the general price level is to apply administrative action.

DUM_ADMIN is the dummy variable to specify administrative price change, a key component of which is the increase in the housing tariffs and rates. DUM_ADMIN equals 1 in 1997q2, 1998q1, 1999q1; otherwise DUM_ADMIN is zero. The same quarters stand out also in figure 3.2. The explanation for that lies in the following administrative price increases:

1997q2 in April water supply +26% and sewerage +17%;
in May electricity +34%, gas +30% and phone services +17%;

1998q1 in January, water supply +28% and sewerage +13%, electricity +8%;

1999q1 in January electricity +15% and sewerage +11%;
in February phone services +9%;
in March gas +25%.

The other factor of the equation is the lagged trend of nontradable inflation. The interpretation of this impact is more complicated, but still possible. The trend sets a path for underlying inflation of nontradables. Considering the declining value of the trend one could conclude that the liberalisation of regulated prices, which is one of the leading factors of nontradables' inflation, has almost reached the end stage. On the other hand, the more far-developed the liberalisation, the closer the regulated prices are to the equilibrium prices and the smaller the deviation of administratively not regulated prices from the trend is.

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[29] We tried also GAP_RGDP, RES_M1/2, RESID_M_DEF as explanatory variables.

3.3 Other deflators

The equation of **producer prices index** RES_PPI is estimated from 1997q1. If the estimation period had started earlier, the dummy variable should have been included in the equation from 1997q1 until the end of the period, or from the beginning of the estimation period 1996q4. In the first case, it was impossible to provide an obvious economic interpretation for the dummy and therefore its future behaviour is unclear. As to the second case, the estimated equation provided an inconsistent ex ante forecast. Therefore, the dummies were disregarded and the equation was estimated as of 1997q1.

RES_PPI = -0.1209(NER_USD_GEOM4Q-1) - 0.1371*GAP_RGDP - 0.0045*

The equation shows the impact of both supply- and demand-side factors on the price formation. Producers set the prices depending on:

a) the change in (imported) input prices which is indicated by the exchange rate of the dollar. The negative value of the nominal exchange rate index is caused by NER construction. $NER\_USD = \frac{USD/EEK}{USD_{-1}/EEK_{-1}}$. If NER_USD > 1, then $\frac{USD}{EEK} > \frac{USD_{-1}}{EEK_{-1}}$, in other words the dollar depreciates and import prices in *kroons* decrease which causes prices to go down. Otherwise - NER_USD < 1 – the dollar appreciates and import prices increase which brings prices up[30];
b) the demand, which is reflected by the GDP gap and its interpretation is analogous to the tradable deflator equation.

Equation of the import deflator (RES_DEF_M)

*RES_DEF_M=0.5196*RES_DEF_X+0.4814*RES_DEF_GDP(-1)-*
*0.0115*DMS_9802-0.0019*

became statistically acceptable after serious examination. Unfortunately the economic interpretation of the equation remains still vague. In consideration of this, we could have disregarded the equation of the import deflator and exclude it from the model. For the prognosis, however, it was not a suitable solution. RES_DEF_M is the explanatory variable for the tradables' inflation. Accordingly, in order to forecast the tradables inflation, we need to predict the import prices, which can be easily done with the use of the model including corresponding equation alongside with the forecast of other deflators.

We tried to estimate **export deflator**, considering its dependency from demand and supply factors, i.e. domestic producer prices, foreign demand and consumer prices, (incl. GAP_RGDP, W, RES_CPI_TR, RES_PPI, NEER, XNEER, NER_USD and the

[30] We tried also RES_CPI_TR, RES_CPI_NT, RES_DEF_M, W_4Q as explanatory variables.

growth of weighted average GDP of industrial trade partners). Out of those, domestic producer prices and the exchange rate of the USD proved statistically relevant:

*RES_DEF_X = 0.0567 - 0.0581*NER_USD + 0.9360*RES_PPI*

The **GDP deflator** equation has been estimated since 1995q3. Earlier available observations dating from the beginning of 1995 happened to be untypical and extra dummies would have been needed.

The GDP deflator is presented as a function of deflators of GDP components.[31]

*RES_DEF_GDP = 0.5781*RES_CPI_TR + 0.4933*RES_CPI_NT(-3) + 0.0115*DMS_9801 + 0.3798*RES_DEF_X*

The variables included into the equation do not, however, cover all the GDP components. Some deflators were disregarded due to multicollinearity. For example, RES_PPI and RES_DEF_M were significant in equations specified separately. However, due to correlation with RES_CPI_TR and RES_DEF_X they became irrelevant in an equation which comprised all the mentioned variables.

The whole system of equations is in Appendix 7.

4. Quantitative analysis[32]

The purpose of quantitative analysis is to analyse the characteristics and the quality of the model, in other words – whether the model works properly in simulations and prognoses. The analysis of the model has some similarity with the analysis of the equations. Nevertheless, the analysis of the inflation model makes a distinction between two basic issues:

1) in the analysis of the equations, each equation is taken separately; in the analysis of the model, the equations are taken as a system (i.e. some exogenous variables of the analysis of the equations become endogenous in the model);
2) in the analysis of the equations, we were examining subindices (i.e tradables and nontradables deflators). In the analysis of the model, synthetic price indices (CPI, for example) are taken together with the subindices.

Quantitative analysis includes:

1) assessment of the adequacy of the dynamic ex post simulations;
2) analysis of the impact of exogenous variables shocks;
3) analysis of the impact of endogenous variables shocks;
4) assessment of the adequacy of ex ante prognoses.

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[31] As an alternative, the GDP deflator could have been modelled with the help of economic factors. For instance we attempted to estimate it as a function of gap, but we failed.
[32] The system of equations of the model is given in Appendix 8.

4.1 Dynamic ex post simulations

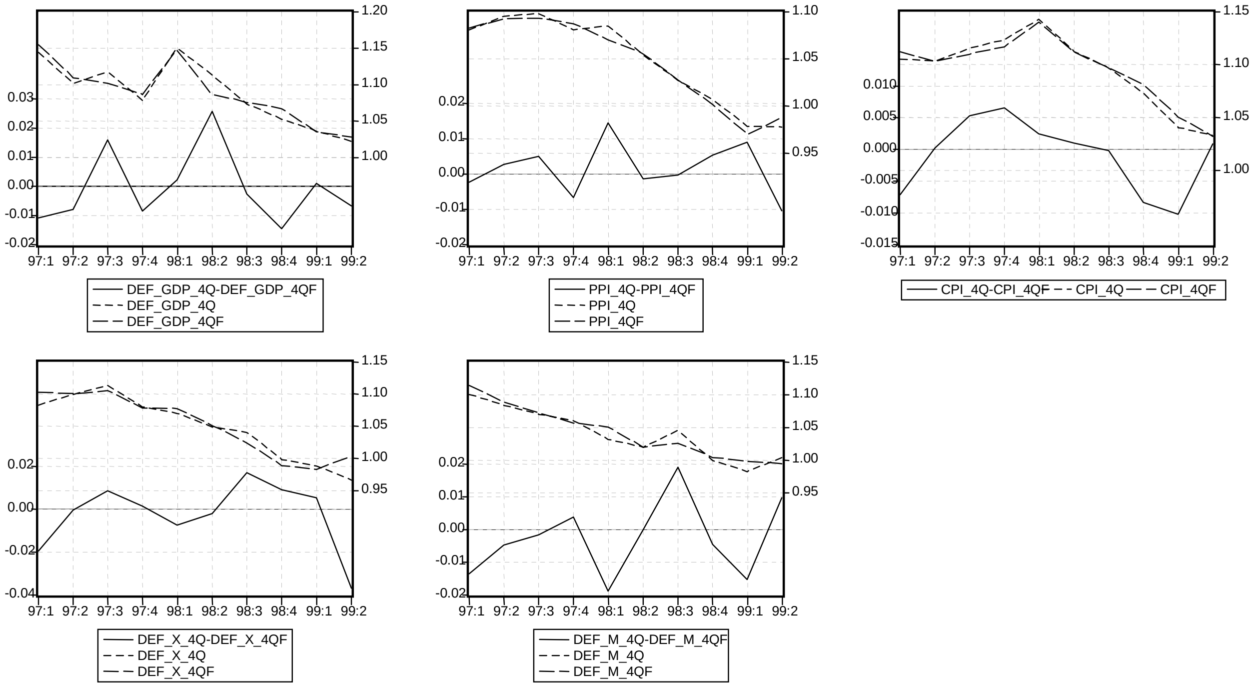


Figure 4.1 Dynamic ex post prognosis of the model

Table 4.1

The statistics of ex post prognoses

	CPI_4QF	PPI_4QF	DEF_M_4QF	DEF_X_4QF	DEF_GDP_4QF
Root Mean Squared Error	0.005506	0.007137	0.011326	0.015102	0.012001
Mean Absolute Error	0.004221	0.005743	0.009096	0.010786	0.009627
Mean Abs. Percent Error	0.388388	0.552963	0.878873	1.05462	0.879172
Mean Error	0.000958	-0.00153	0.002622	0.002524	0.000634
Mean Percent Error	0.096430	-0.14184	0.252752	0.259579	0.071802
Theil Inequality Coefficient	0.002513	0.003403	0.005436	0.007184	0.005506
Bias proportion	0.030330	0.046028	0.053620	0.027937	0.002796
Variance proportion	0.253232	0.006013	0.023351	0.011725	0.029625
Covariance proportion	0.716437	0.947958	0.923028	0.960337	0.967577

The model performs in the ex post dynamic forecast relatively well. For example, the mean absolute percentage error (see table 4.1) is below 1%; only in the case of the export deflator its value is higher: 1.06%. Other ex post statistics are also quite satisfactory.

Only the components of the Theil's inequality coefficient are poor. CPI_4Q ex post prognosis variance proportion statistics are more problematic. The latter implies that the CPI_4Q prognosis varies more than its real value. The analysis of the prognosis showed that the mentioned problem arises due to a short observation period. When the period became longer, the values of the Theil coefficient components became acceptable.

4.2 Analysis of the shocks.

The simulation results of the impact of exogenous variable shocks (see table 4.2.) show that:

T a b l e 4.2
The impact of 1 standard deviation shock on exogenous variable in relation to the standard deviation of endogenous variable.

	GAP_RGDP	NER_USD
RES_DEF_M	-0.54912	-0.66181
RES_DEF_X	-0.51407	-0.82505
RES_PPI	-0.62185	-0.65944
RES_CPI_TRr	-0.5744	-0.25863
RES_DEF_GDP	-0.48209	-0.41154

- GAP_RGDP and NER_USD have an almost equal impact on RES_PPI and RES_DEF_M;
- RES_DEF_X is highly dependent on ner_usd;
- GAP_RGDP shock changes all price indices (except the nontradables) by more than a half of the standard deviation;
- GAP_RGDP and NER_USD effect have a substantial difference in their spheres of impact. GAP_RGDP has a impact on all prices, whereas the the exchange rate is primarily influencial on export, import and producer prices.

In order to establish the impact of administrative price change, we used a different way of simulation. Since the standard deviation of the dummy is difficult to interpret, we simulated the impact of administrative price change on the dummy variable by equalising it to one. During the shock we also exogenized RES_DEF_M in order to eliminate the effect of administrative shock to tradable prices and GDP deflator via import prices.

T a b l e 4.3
The impact of administrative price changes (in %%)

	1st quarter	2nd quarter	3rd quarter	4th quarter
RES_CPI_TR	0	0.063224	0.16724	0.2728
RES_CPI_NT	0.84625	1.70602	2.55464	3.41909

In a shock period, a rise in the administrative prices only brings about the rise of the nontradables' price index (see table 4.3). Due to the lags the impact on the tradable sector index becomes evident in the next quarter. In total the upshot of the nontradables' price index is 3.4 and the tradables' price index 0.3 percentage points in the longer horizon.

The stability of the model in respect to exogenous shocks was assessed on the basis of multipliers. The model proved to be stable if the multiplier took the constant value during the post-shock adaptation period. When we shocked the inflation model, the multipliers settled on a constant level (see Annex 6). Therefore, we may conclude that the model is stable in the case of exogenous shocks.

As a result of the analysis of endogenous shocks we can see how big is the effect of a shock of the endogenous variable (in the size of one standard deviation) on the other endogenous variables. The shocking helps to explain mutual impact of the variables as well as to study the stability of the model.

In simulations we are interested in the post-shock dynamics of deflators. It is vital for stability whether after the shock the deflator diverges from the long-term trend or converges the trend after a short deviation period. If the latter proves to be the case, the model can be considered stable, otherwise not.

The figures indicate that the impact of shocks vanish rather quickly – mostly after two years. Accordingly, the model is stable, also in the case of endogenous shocks. Shock simulations are given in Annex 5.

4.3 Ex ante forecasts

4.3.1 Forecast and assumptions of exogenous variables

To keep the exercise as simple as possible the prognosis does not include probable administrative actions – establishment of custom tariffs or other trade restrictions, change in tax rates, etc. We assumed only the pseudo seasonal correction of regulated prices in the first quarter, which has been regular in the last years.

NER_USD prognosis was made in two variants – as changing (marked with "m") and as constant ("p"). The changing prognosis m is taken from the November 1999 edition of "Foreign Exchange Consensus Forecast" according to which the dollar will lose its value vis a vis to the euro and by year 2001 the exchange rate will be 1,163USD=1EUR. For the subsequent period, the dollar is expected to become stable at the same level. The prognosis of variant p is meant for the situation when the USD does not decline and the rate will stay at the level of 1999q3.

The GAP_RGDP forecast is also made in two versions. The variant "1" is based on the historical behaviour of gap reflected by the ARMA model. Since according to ARMA forecast the economy recovers from the decline unrealistically quickly, the recovery path was judgementally smoothed (see figure 4.2). Thus we arrived at the alternative forecast (marked by "0") for GDP_GAP.

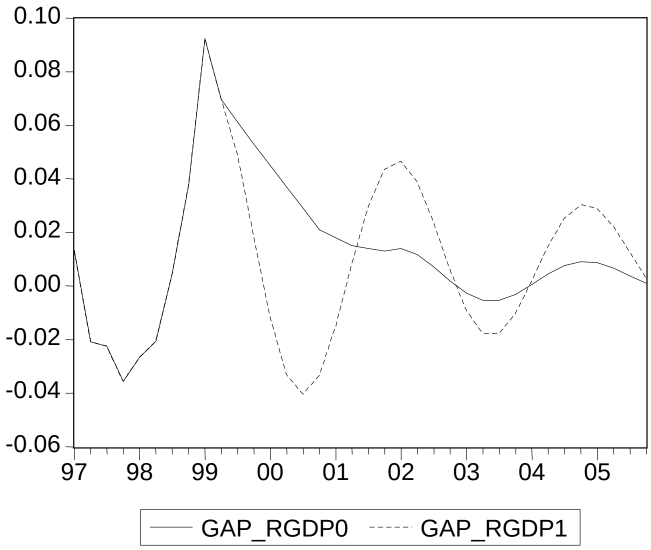


Figure 4.2 Forecast of GAP_RGDP

4.3.2 Results

First of all, let us consider the prognosis when the USD rate is stable (figure 4.3).

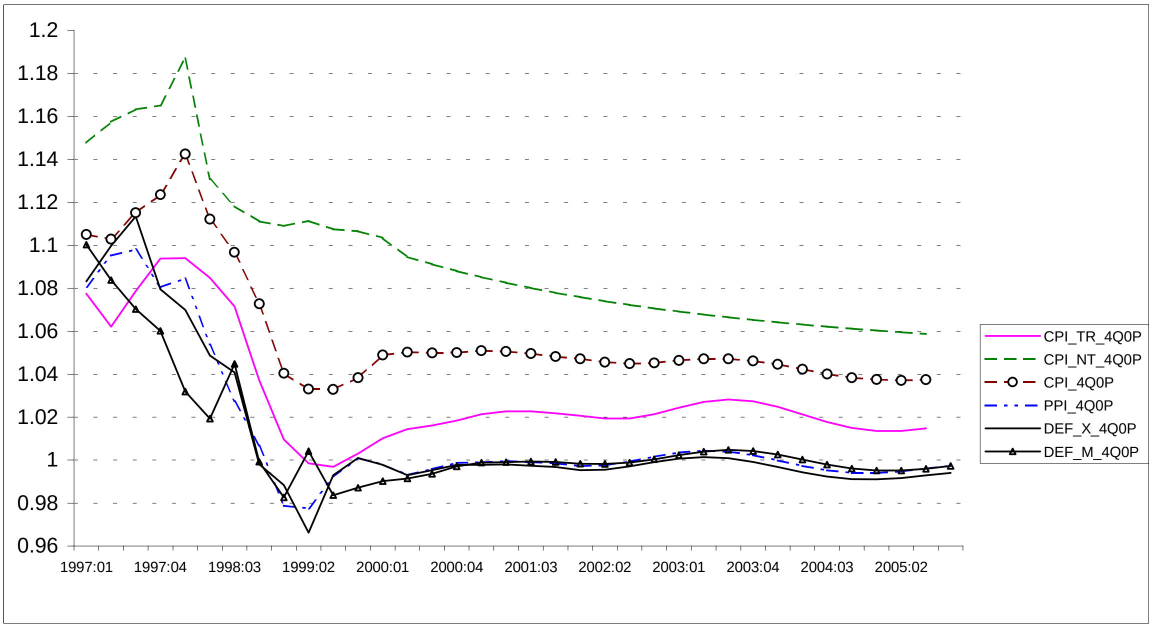


Figure 4.3 The forecasting case of stable USD exchange rate and variant 0 of GAP_RGDP prognosis

The tradables' four-quarter deflator is stabilizing at 2.5% for a long-run, which is quite realistic considering the dynamics of GAP_RGDP (alternative 0). Due to ongoing internal convergence and administrative regulations, the ratio of nontradables' inflation will stay at a higher level – yet again, in the interval which is intuitively acceptable. A nontradables' price index causes a higher CPI as compared to the tradables' price index. The values of producer price index and import and export deflators are also logical.

In conclusion, the ex ante prognosis appears to be realistic taken in the framework of the applied assumptions and is thus an indicator of the adequacy of the model.

Nevertheless, the sensitivity of the prognosis to GDP gap is worth mentioning. With a wider variation of gap (version 1 consistent with the ARMA model), the inflation prognosis will be considerably different (figure 4.4).

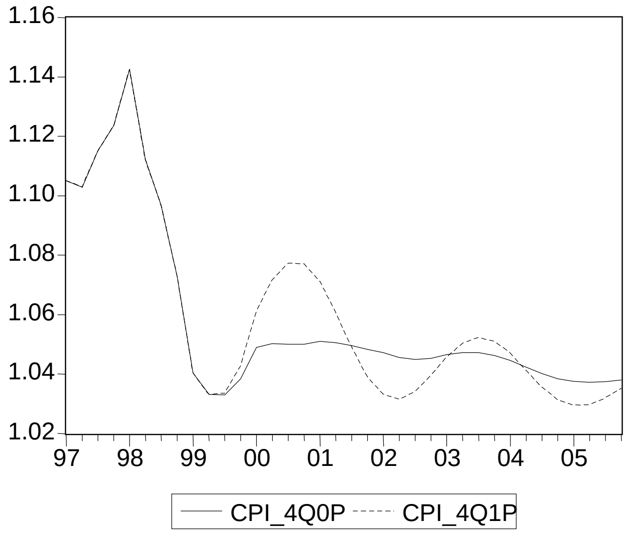


Figure 4.4 CPI prognosis in the case of a stable USD exchange rate and alternative GAP_RGDP prognoses

The change of the USD exchange rate is equally effective with the GDP gap. Still, we know from the analysis of exogenous shocks that, unlike GAP_RGDP, the exchange rate affects mostly the export-import and producer prices. The impact on domestic consumer prices is less significant.

The decline of USD has an effect on export-import deflators and the producer price index. Of course, the expected depreciation of USD is relatively sharp – from the December 1999 rate 1EUR=1,011USD (1USD=15.47EEK) to 1EUR=1.163USD (1USD=13.45EEK) in 2001. This would mean that over a period of two years, the dollar will fall 12.8% (or 6.2% per year). In such circumstances, the prognosis of price indices (decline by ~1% points) could be considered quite realistic.

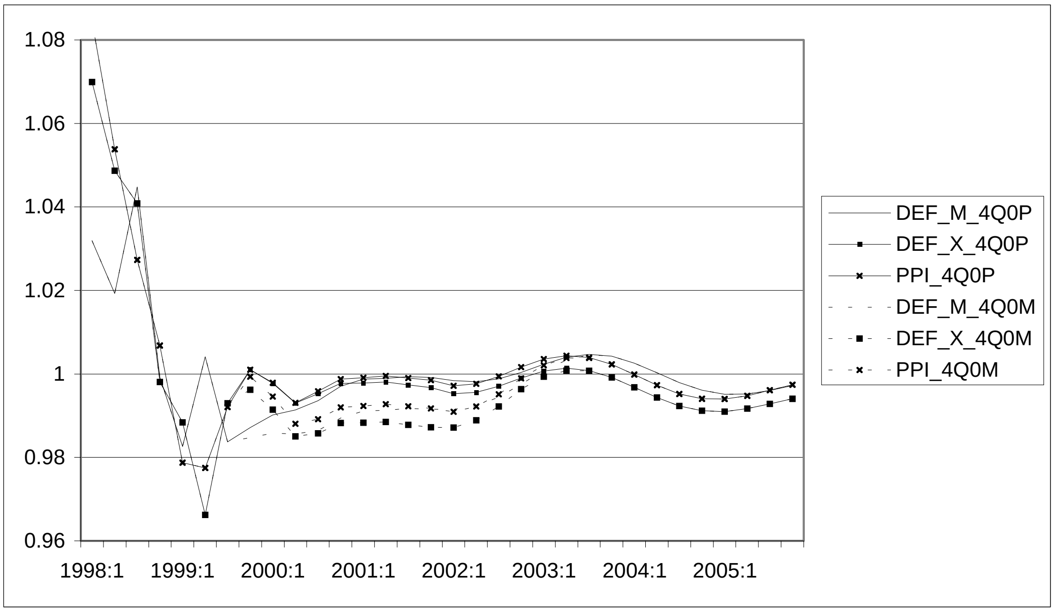


Figure 4.5 Impact of USD exchange rate on export and import deflators and PPI

5. Interpretation of the model

The scheme (figure 5.1.) shows that inflation dynamics in the short-run is determined by three main elements – proportion of demand to supply, the exchange rate of the dollar which could be treated as the proxy for foreign prices, and administration action taken to correct regulated prices.

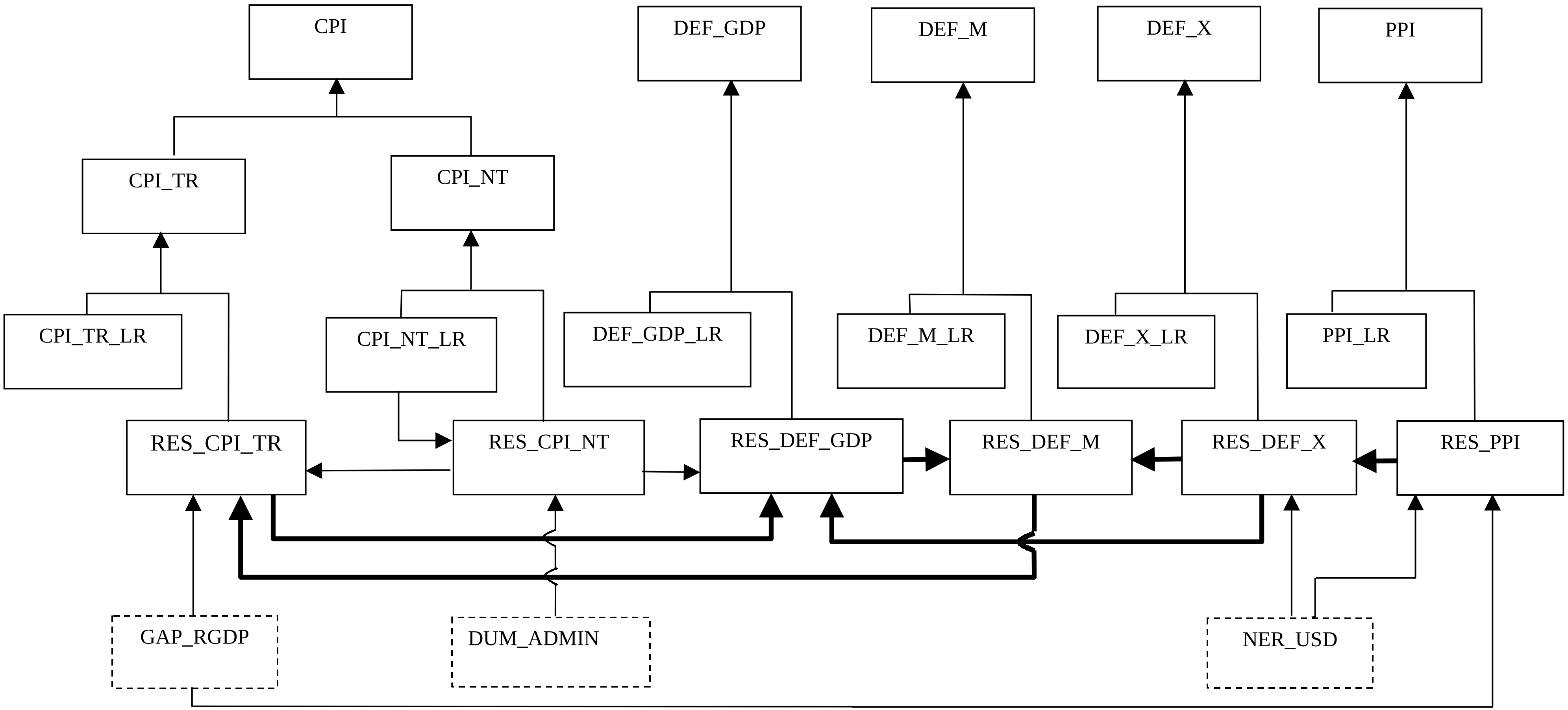


Figure 5.1 Basic flow-chart

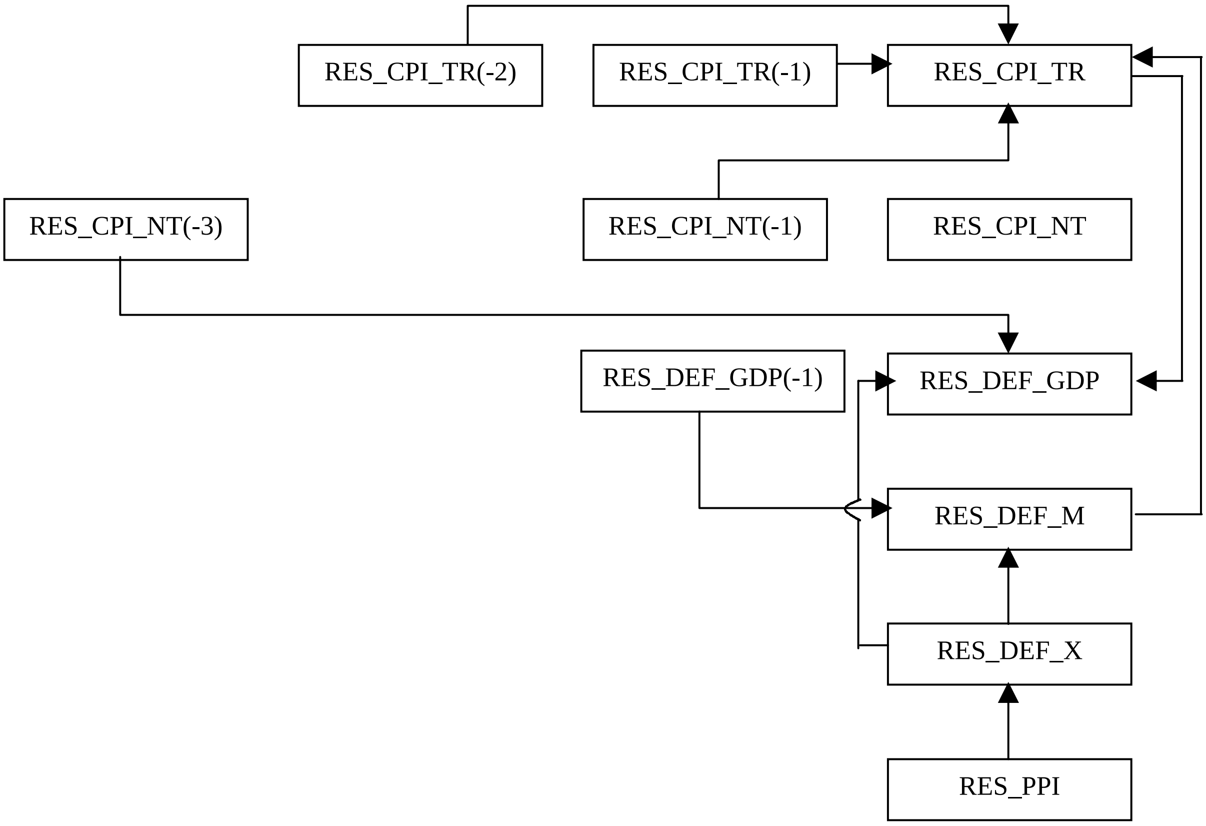


Figure 5.2 Deviations' flow-chart with the lags

The model is quite simple in its construction. The links between the variables are nothing but a transmission – the impact effect is transferred from one variable to another. The adjustment mechanism is not significant. It manifests itself only in the case of the tradable price index.

The fact that there are no adjustment mechanisms within the inflation model is logical. The inflation model itself is partial and the adaptation circles effective in the economy reach beyond the inflation model.

The transmission schemes work on the level of the deviations and in the short-run prospect. Bold arrows are used in the flow-chart to denote this. There are two characteristic features of the transmission process (see figure 5.2.):

1) The dominating role of producer prices in generating impacts.

If we believe the supply side price formation (see Clarida, Gali and Gertler (1999)), which is a logical prerequisite of a small market, to be true, such impact relationship corresponds to the intuition. So, the producers establish their prices either depending on

a) (imported) input prices (the change in the prices of imported inputs reflects the change in the exchange rate of the dollar) or
b) the demand (shown by the GDP gap).

The producer prices are in turn the basis for export prices and, through GDP transmission, also for prices in the domestic market.

2) The key role of GDP deflator in the transmission mechanism.
Although quite logical hypothetically – considering that the GDP deflator is the most wide-ranging characteristic of inflation – for Estonia's data it serves as an emergency solution, as the reliability of GDP deflator time series is at least questionable. The key role of the GDP deflator is due to the fact that it is used as the explanatory variable of import deflator. This was the only possibility to build an import deflator equation which would provide more or less satisfactory results.

Summary of the estimation results

1. Failures in empirical exercise led us to the conclusion that it was impractical to estimate the underlying inflation as a function of fundamentals. Therefore we determined the underlying inflation as a trend, which has been specified as the function of time, ARMA process, moving average or HP filter.

Although at first sight the use of a trend might seem artificial, it need not be so. An adequate trend reflects the long-term (steady) path of the variable. In the real world, the latter corresponds to the long-term (equilibrium) trajectories of other indicators. Consequently, the well-estimated trend is consistent with the long-term features of the economy under consideration.

2. On the basis of a visual judgement and in accordance with the assumptions about the path of convergence, the long-run function for the transformed price index was specified as $0{,}003 + \frac{c1}{t^{c2}}$. The constant 0.003 of the function is predetermined and can be interpreted as the ratio of the inflation which our inflation is expected to reach when the convergence is completed.

3. If we suppose that the assumptions given in section 2 are true, the model's trend is not reflecting the actual long-term convergence. The time function reflects hopefully the convergence in a shorter period. Afterwards the regime will change and there will be a new trend or trends. The time function is applicable in practice when building the model for the medium-term period.

4. Although the residuals of the trend are stationary, they do not follow according to the Jarque-Bera test the normal distribution. If we want to get a residual's series having a normal distribution, we will have to admit that the convergence of inflation ended in 1999. Although the reason for such result – untypically low inflation over the last quarters which is caused by a recession in the business cycle – is obvious, it will nevertheless make that early end of the convergence more realistic. In fact, the convergence will continue due to the disparity of the purchasing power in the year 2000 and later. This was the main reason why we gave up the ARMA and similar methods in determination of underlying inflation and preferred the time function.

5. The model performs in the ex post dynamic forecast relatively well and the ex post statistics were quite satisfactory. Only the components of the Theil's inequality coefficient were problematic. The analysis of the prognosis showed that the mentioned problem arises due to a short duration of observation period. When the

period became longer, the values of the Theil coefficient components became acceptable.

The stability of the model in respect to exogenous and endogenous shocks was assessed. The model proved to be stable in the case of exogenous shocks if the multiplier took the constant value during the post-shock adaptation period. When we shocked the inflation model, the multipliers settled on a constant level. Therefore, we may conclude that the model is stable in the case of exogenous shocks.

In simulations we are interested in the post-shock dynamics of deflators as well. It is vital for stability whether after the shock the deflator diverges from the long-term trend or converges the trend after a short deviation period. Shock simulations indicate that the impact of shocks vanish rather quickly – mostly after two years. Accordingly, the model is stable, also in the case of endogenous shocks.

6. We analysed the adequacy of the model also on the basis of ex ante prognosis. The ex ante prognosis appears to be realistic taken in the framework of the applied assumptions and is thus an indicator of the adequacy of the model.

7. The model shows that the short-term dynamics of the inflation is determined by three main aspects – the proportion of demand to supply, the exchange rate of the dollar as the proxy for foreign prices, and administrative actions taken to correct regulated prices.

8. The model is quite simple in its construction. The links between the variables are nothing but a transmission – the impact effect is transferred from one variable to another. The adjustment mechanism is not significant. It manifests itself only in the case of the tradables' price index.

The fact that there are no adjustment mechanisms within the inflation model is logical. The inflation model itself is partial and the adaptation circles effective in the economy reach beyond the inflation model.

The transmission schemes work on the level of the deviations and in the short prospect.

9. There are two characteristic features of the transmission process:

1) The dominating role of producer prices in generating impacts.

If we believe the supply side price formation (see Clarida, Gali and Gertler (1999)), which is a logical prerequisite of a small market, to be true, such impact relationship corresponds to the intuition. So, the producers establish their prices either depending on

c) (imported) input prices (the change in the prices of imported inputs reflects the change in the exchange rate of the dollar) or
d) the demand (shown by the GDP gap).

The producer prices are in turn the basis for export prices and, through GDP transmission, also for prices in the domestic market;

2) The key role of GDP deflator in the transmission mechanism.

Although quite logical hypothetically – considering that the GDP deflator is the most wide-ranging characteristic of inflation – for Estonia's data it serves as an emergency solution, as the reliability of GDP deflator time series is at least questionable. The key role of the GDP deflator arises from the fact that it is used as the explanatory variable of import deflator. This was the only possibility to build an import deflator equation which would provide more or less satisfactory results.

Appendix 1. Variables of the Model[33]

Endogenous variables:

DEF_AD	Deflator of aggregate demand (AD=DD+X=M+GDP)
DEF_DD	Deflator of domestic demand (DD=M+GDP-X)
DEF_INV	Investments' deflator
DEF_M	Import deflator
DEF_GDP	GDP deflator
DEF_X	Export deflator
CPI	Consumer price index
CPI_TR	Tradable sector price index
CPI_NT	Nontradable sector price index
PPI	Producer price index

Exogenous variables:

GAP_GDP	GDP gap as ratio
REER	Real effective exchange rate
NEER	Trade weighted nominal effective exchange rate
NER_USD	Nominal exchange rate of USD
NER_FIM	Nominal exchange rate of FIM
MNEER	NEER, weighted by import countries
XNEER	NEER, weighted by export countries
W	Average wage
RGDP	Real GDP
DUM_ADMIN	Dummy variable for shocks in regulated prices

Prefixes and suffixes:

RES_	Difference between long run trend and 4-quarter index
_BQ	Base index
_4Q	Four-quarter index
_Q	Qyarterly index
_GEOM4Q	Geometric average of four-quarter index
_LR	Long run
_TR	Tradable sector
_NT	Nontradable sector

[33] Including the variables, which were used in the model-building but became irrelevant in the final version.

Appendix 2. Data

The sources of the data are the following:

- CPI, PPI base indices – Statistical Office of Estonia (SOE)
- DEF_GDP, DEF_INV, DEF_AD, DEF_DD, DEF_M, DEF_X – the authors' calculations on the basis of GDP components in fixed and current prices published by SOE.
- CPI_TR, CPI_NT – The Bank of Estonia.
- MNEER, XNEER, NEER, NER_USD, NER_FIM – the Bank of Estonia, authors' calculations
- RGDP, W – SAO
- GAP_RGDP – calculated using the Estonian macromodel MMOM. The GDP gap is the difference between the long-term trend and domestic supply, i.e. if the supply is less than the long-term trend, the gap is positive and vice versa.

Most of the data were available for the period of 1993q1 – 1999q2, which leaves 1994q1 – 1999q2 as the period of four-quarter indices. Some equations have been estimated on the basis of a shorter period because the series contained structural breaks.

Since the GDP data are published on a quarterly basis, the sequence of the model is quarter. The four-quarter indices were used to eliminate the seasonality. Only the indicators of exchange rates were not seasonally adjusted as the seasonal component could not be established.

Appendix 3. ADF Test Statistics

APPENDIX 3.1

ADF Test Statistic	-2.199166	1% Critical Value*	-2.6968
		5% Critical Value	-1.9602
		10% Critical Value	-1.6251

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID_TR)
Method: Least Squares
Date: 10/06/99 Time: 12:14
Sample(adjusted): 1994:4 1999:2
Included observations: 19 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID_TR(-1)	-0.356257	0.161996	-2.199166	0.0429
D(RESID_TR(-1))	1.001692	0.146296	6.847008	0.0000
D(RESID_TR(-2))	-0.278127	0.229172	-1.213616	0.2425

R-squared	0.767128	Mean dependent var	-0.001029
Adjusted R-squared	0.738019	S.D. dependent var	0.006133
S.E. of regression	0.003139	Akaike info criterion	-8.545896
Sum squared resid	0.000158	Schwarz criterion	-8.396774
Log likelihood	84.18601	F-statistic	26.35363
Durbin-Watson stat	1.969641	Prob(F-statistic)	0.000009

APPENDIX 3.2

ADF Test Statistic	-5.170222	1% Critical Value*	-2.6968
		5% Critical Value	-1.9602
		10% Critical Value	-1.6251

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES_CPI_NT)
Method: Least Squares
Date: 12/13/99 Time: 16:47
Sample(adjusted): 1994:4 1999:2
Included observations: 19 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_CPI_NT(-1)	-0.743953	0.143892	-5.170222	0.0001
D(RES_CPI_NT(-1))	0.567158	0.128543	4.412196	0.0004

R-squared	0.645283	Mean dependent var	-0.000843
Adjusted R-squared	0.624417	S.D. dependent var	0.010067
S.E. of regression	0.006169	Akaike info criterion	-7.239169
Sum squared resid	0.000647	Schwarz criterion	-7.139755
Log likelihood	70.77211	F-statistic	30.92555
Durbin-Watson stat	1.708233	Prob(F-statistic)	0.000034

APPENDIX 3.3

ADF Test Statistic	-0.700222	1% Critical Value*	-2.7158
		5% Critical Value	-1.9627
		10% Critical Value	-1.6262

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES_PPI)
Method: Least Squares
Date: 12/13/99 Time: 17:01
Sample(adjusted): 1995:2 1999:2
Included observations: 17 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_PPI(-1)	-0.180784	0.258181	-0.700222	0.4945
D(RES_PPI(-1))	0.033187	0.277649	0.119527	0.9064

R-squared	-0.016775	Mean dependent var	-0.001240
Adjusted R-squared	-0.084561	S.D. dependent var	0.005169
S.E. of regression	0.005384	Akaike info criterion	-7.500780
Sum squared resid	0.000435	Schwarz criterion	-7.402755
Log likelihood	65.75663	Durbin-Watson stat	1.757286

APPENDIX 3.4

ADF Test Statistic	-1.948536	1% Critical Value*	-2.6889
		5% Critical Value	-1.9592
		10% Critical Value	-1.6246

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES_DEF_M)
Method: Least Squares
Date: 12/13/99 Time: 17:03
Sample(adjusted): 1994:3 1999:2
Included observations: 20 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_DEF_M(-1)	-0.448463	0.230154	-1.948536	0.0671
D(RES_DEF_M(-1))	0.148579	0.254580	0.583625	0.5667

R-squared	0.183857	Mean dependent var	-0.000387
Adjusted R-squared	0.138516	S.D. dependent var	0.008011
S.E. of regression	0.007436	Akaike info criterion	-6.870453
Sum squared resid	0.000995	Schwarz criterion	-6.770879
Log likelihood	70.70453	F-statistic	4.054963
Durbin-Watson stat	1.778679	Prob(F-statistic)	0.059239

APPENDIX 3.5

ADF Test Statistic	-0.391249	1% Critical Value*	-2.7158
		5% Critical Value	-1.9627
		10% Critical Value	-1.6262

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES_DEF_X)
Method: Least Squares
Date: 12/13/99 Time: 17:07
Sample(adjusted): 1995:2 1999:2
Included observations: 17 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_DEF_X(-1)	-0.128873	0.329389	-0.391249	0.7015
D(RES_DEF_X(-1))	0.055068	0.350491	0.157118	0.8774
D(RES_DEF_X(-2))	-0.033255	0.269563	-0.123365	0.9036

R-squared	0.000220	Mean dependent var	-0.000927
Adjusted R-squared	-0.142606	S.D. dependent var	0.005844
S.E. of regression	0.006247	Akaike info criterion	-7.154536
Sum squared resid	0.000546	Schwarz criterion	-7.007498
Log likelihood	63.81355	F-statistic	0.001538
Durbin-Watson stat	1.976405	Prob(F-statistic)	0.998463

APPENDIX 3.6

ADF Test Statistic	-1.716946	1% Critical Value*	-2.6968
		5% Critical Value	-1.9602
		10% Critical Value	-1.6251

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES_DEF_GDP)
Method: Least Squares
Date: 12/13/99 Time: 17:08
Sample(adjusted): 1994:4 1999:2
Included observations: 19 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_DEF_GDP(-1)	-0.408743	0.238064	-1.716946	0.1042
D(RES_DEF_GDP(-1))	-0.077943	0.239585	-0.325325	0.7489

R-squared	0.234732	Mean dependent var	4.79E-05
Adjusted R-squared	0.189716	S.D. dependent var	0.008954
S.E. of regression	0.008060	Akaike info criterion	-6.704433
Sum squared resid	0.001104	Schwarz criterion	-6.605018
Log likelihood	65.69211	F-statistic	5.214435
Durbin-Watson stat	1.696055	Prob(F-statistic)	0.035536

Appendix 4. Statistical Protocols of the Equations

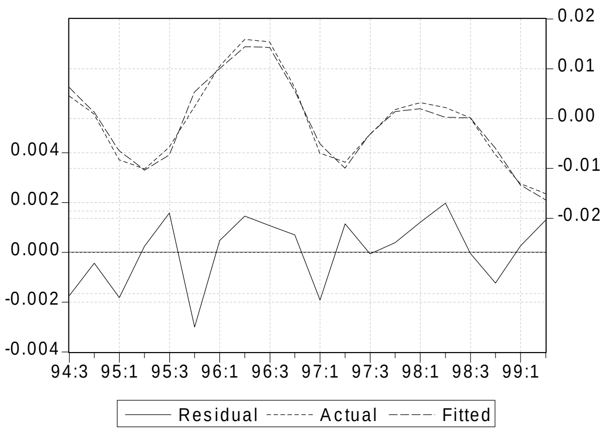
Appendix 4.1 Tradable Sector

Dependent Variable: RES_CPI_TR
Method: Least Squares
Date: 11/16/99 Time: 10:50
Sample: 1994:3 1999:2
Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_DEF_M	0.318169	0.056580	5.623335	0.0001
GAP_RGDP(-1)	-0.076484	0.014363	-5.325199	0.0001
RES_CPI_NT(-1)	0.074726	0.036764	2.032589	0.0630
DME_9504_9603	0.006444	0.001077	5.981105	0.0000
DME_9501_9503	-0.003526	0.001152	-3.061610	0.0091
RES_CPI_TR(-1)	0.639574	0.113122	5.653845	0.0001
RES_CPI_TR(-2)	-0.396223	0.090320	-4.386863	0.0007

R-squared	0.975502	Mean dependent var	-0.000774
Adjusted R-squared	0.964195	S.D. dependent var	0.008763
S.E. of regression	0.001658	Akaike info criterion	-9.697068
Sum squared resid	3.57E-05	Schwarz criterion	-9.348562
Log likelihood	103.9707	F-statistic	86.27631
Durbin-Watson stat	2.008431	Prob(F-statistic)	0.000000

Actual, fitted and residual graph



Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	3.652	0.455	1.949	0.377
ARCH LM test	2.141	0.710	0.860	0.650

		Probability
White's Heteros. Test (n*R2 statistic)	13.89031	0.30777
J.B.- statistic	1.85445	0.39565

Appendix 4.2 Non Tradable Sector

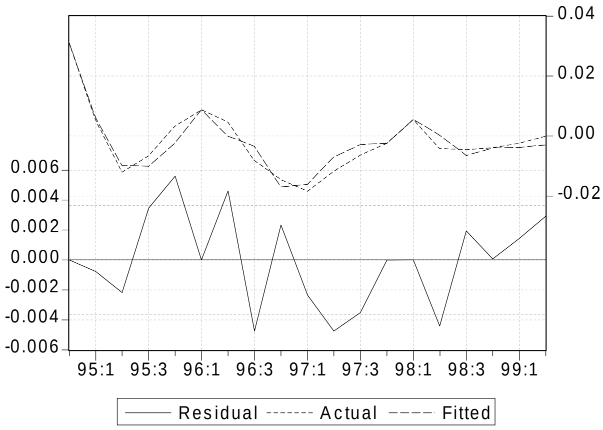
Equation of four-quarter index

Dependent Variable: RES_CPI_NT
Method: Least Squares
Date: 11/04/99 Time: 13:40
Sample(adjusted): 1994:3 1999:2
Included observations: 20 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_CPI_NT(-1)	0.446961	0.097784	4.570887	0.0005
RES_CPI_NT(-2)	-0.290095	0.044241	-6.557233	0.0000
DMS_9404	0.021500	0.004336	4.958401	0.0003
DMS_9601	0.008391	0.003787	2.216048	0.0451
-DME_9604_9701	0.008961	0.002919	3.069688	0.0090
DMS_9801	0.007832	0.003752	2.087374	0.0571
MNEER(-1)	-0.002992	0.000939	-3.187050	0.0071

R-squared	0.928756	Mean dependent var	-0.001059
Adjusted R-squared	0.895874	S.D. dependent var	0.011267
S.E. of regression	0.003636	Akaike info criterion	-8.126746
Sum squared resid	0.000172	Schwarz criterion	-7.778240
Log likelihood	88.26746	F-statistic	28.24530
Durbin-Watson stat	1.962960	Prob(F-statistic)	0.000001

Actual, fitted and residual graph



Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	1.588	0.811	1.017080	0.601373
ARCH LM test	2.157878	0.706748	0.496619	0.780119

		Probability
White's Heteros. Test (n*R2 statistic)	12.04491	0.282062
J.B.- statistic	0.498187	0.779507

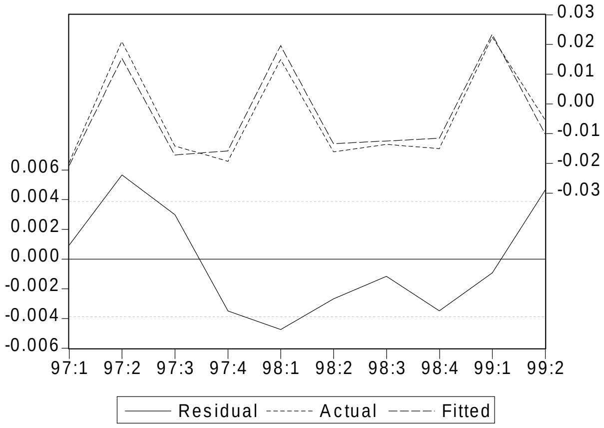
Equation of quarter index

Dependent Variable: RES_CPI_NT_Q
Method: Least Squares
Date: 11/04/99 Time: 13:42
Sample: 1997:1 1999:2
Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DUM_ADMIN	0.034191	0.002656	12.87250	0.0000
CPI_NT_LR(-1)	-0.351988	0.034308	-10.25971	0.0000

R-squared	0.954438	Mean dependent var	-0.004504
Adjusted R-squared	0.948742	S.D. dependent var	0.017099
S.E. of regression	0.003871	Akaike info criterion	-8.093670
Sum squared resid	0.000120	Schwarz criterion	-8.033153
Log likelihood	42.46835	F-statistic	167.5838
Durbin-Watson stat	1.024525	Prob(F-statistic)	0.000001

Actual, fitted and residual graph



Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	7.530603	0.110367	6.512087	0.038541
ARCH LM test	2.788590	0.593804	0.684348	0.710225

		Probability
White's Heteros. Test (n*R2 statistic)	1.988695	0.574756
J.B.- statistic	0.909761	0.634524

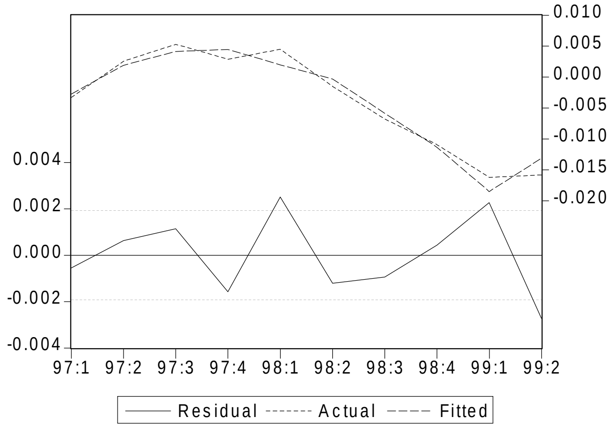
Appendix 4.3 Producer Prices

Dependent Variable: RES_PPI
Method: Least Squares
Date: 11/17/99 Time: 08:37
Sample: 1997:1 1999:2
Included observations: 10

Variable	Coefficient	Std. Error	t-Statistic	Prob.
NER_USD_GEOM4Q-1	-0.120875	0.043457	-2.781460	0.0272
GAP_RGDP	-0.137082	0.020315	-6.747704	0.0003
C	-0.004515	0.000997	-4.527664	0.0027

R-squared	0.956861	Mean dependent var	-0.003955
Adjusted R-squared	0.944536	S.D. dependent var	0.008167
S.E. of regression	0.001923	Akaike info criterion	-9.426087
Sum squared resid	2.59E-05	Schwarz criterion	-9.335311
Log likelihood	50.13043	F-statistic	77.63298
Durbin-Watson stat	2.696567	Prob(F-statistic)	0.000017

Actual, fitted and residual graph



Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	7.910354	0.094918	6.430787	0.040140
ARCH LM test	5.259350	0.261706	2.178113	0.336534

		Probability
White's Heteros. Test (n*R2 statistic)	6.270887	0.179811
J.B.- statistic	0.443723	0.801026

Appendix 4.4 Import Deflator

Dependent Variable: RES_DEF_M
Method: Least Squares
Date: 12/10/99 Time: 09:19
Sample: 1995:1 1999:2
Included observations: 18
RES_DEF_M=C(1)*RES_DEF_X+C(2)*RES_DEF_GDP(-1)+C(3)
*DMS_9802+C(4)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.519574	0.124868	4.160982	0.0010
C(2)	0.481441	0.119283	4.036136	0.0012
C(3)	-0.011476	0.004064	-2.823464	0.0135
C(4)	-0.001939	0.000957	-2.024878	0.0624

R-squared	0.825153	Mean dependent var	-0.002795
Adjusted R-squared	0.787686	S.D. dependent var	0.008330
S.E. of regression	0.003838	Akaike info criterion	-8.094512
Sum squared resid	0.000206	Schwarz criterion	-7.896651
Log likelihood	76.85060	F-statistic	22.02334
Durbin-Watson stat	1.904053	Prob(F-statistic)	0.000014

Actual, fitted and residual graph

Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	0.983477	0.912291	0.547903	0.760369
ARCH LM test	1.938377	0.747092	1.919053	0.383074

		Probability
White's Heteros. Test (n*R2 statistic)	8.105304	0.150527
J.B.- statistic	0.389029	0.823234

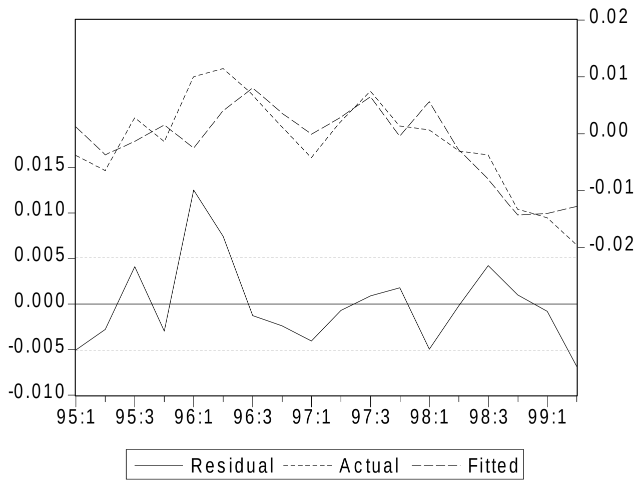
Appendix 4.5 Export Deflator

Dependent Variable: RES_DEF_X
Method: Least Squares
Date: 03/23/00 Time: 14:23
Sample: 1995:1 1999:2
Included observations: 18

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.056687	0.030879	1.835768	0.0863
NER_USD	-0.058096	0.031129	-1.866313	0.0817
RES_PPI	0.936045	0.170891	5.477454	0.0001

R-squared	0.671449	Mean dependent var	-0.001469
Adjusted R-squared	0.627642	S.D. dependent var	0.008362
S.E. of regression	0.005103	Akaike info criterion	-7.567157
Sum squared resid	0.000391	Schwarz criterion	-7.418761
Log likelihood	71.10441	F-statistic	15.32749
Durbin-Watson stat	1.538072	Prob(F-statistic)	0.000237

Actual, fitted and residual graph



Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	0.579410	0.683809	0.328781	0.725615
ARCH LM test	0.127668	0.968571	0.324435	0.728624

		Probability
White's Heteros. Test (n*R2 statistic)	2.820868	0.588236
J.B.- statistic	3.51303	0.172795

Appendix 4.6 GDP Deflator

Dependent Variable: RES_DEF_GDP
Method: Least Squares
Date: 11/22/99 Time: 12:05
Sample: 1995:3 1999:2
Included observations: 16

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_CPI_TR	0.578062	0.159835	3.616606	0.0035
RES_CPI_NT(-3)	0.493267	0.080289	6.143650	0.0000
DMS_9801	0.011519	0.003728	3.089614	0.0094
RES_DEF_X	0.379797	0.166485	2.281274	0.0416

R-squared	0.901085	Mean dependent var	-0.000100
Adjusted R-squared	0.876357	S.D. dependent var	0.010208
S.E. of regression	0.003589	Akaike info criterion	-8.209390
Sum squared resid	0.000155	Schwarz criterion	-8.016243
Log likelihood	69.67512	F-statistic	36.43892
Durbin-Watson stat	2.475582	Prob(F-statistic)	0.000003

Actual, fitted and residual graph

Residuals' Tests

	Lag 4		Lag 2	
	LM statistic	probability	LM statistic	probability
Serial Correlation LM test	5.999338	0.199198	3.132942	0.208781
ARCH LM test	3.727643	0.444118	2.680693	0.261755

		Probability
White's Heteros. Test (n*R2 statistic)	11.36852	0.123333
J.B.- statistic	1.022156	0.599849

Appendix 4.7 ARMA(1,1)

Dependent Variable: CPI_TR_4Q^0.25-1
Method: Least Squares
Date: 12/07/99 Time: 09:18
Sample: 1994:1 1999:2
Included observations: 22
Convergence achieved after 9 iterations
Backcast: 1993:4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.908822	0.037079	24.51013	0.0000
MA(1)	0.841190	0.118527	7.097060	0.0000

R-squared	0.969767	Mean dependent var	0.035975
Adjusted R-squared	0.968255	S.D. dependent var	0.024350
S.E. of regression	0.004338	Akaike info criterion	-7.956080
Sum squared resid	0.000376	Schwarz criterion	-7.856895
Log likelihood	89.51688	F-statistic	641.5196
Durbin-Watson stat	1.393290	Prob(F-statistic)	0.000000

Actual, fitted and residual graph

Appendix 4.8 Moving Average

Dependent Variable: CPI_TR_4Q^0.25-1
Method: Least Squares
Date: 12/07/99 Time: 11:15
Sample(adjusted): 1994:1 1999:1
Included observations: 21 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LIBISEV	1.010497	0.009073	111.3683	0.0000

R-squared	0.994048	Mean dependent var	0.037705
Adjusted R-squared	0.994048	S.D. dependent var	0.023525
S.E. of regression	0.001815	Akaike info criterion	-9.739036
Sum squared resid	6.59E-05	Schwarz criterion	-9.689296
Log likelihood	103.2599	Durbin-Watson stat	1.098756

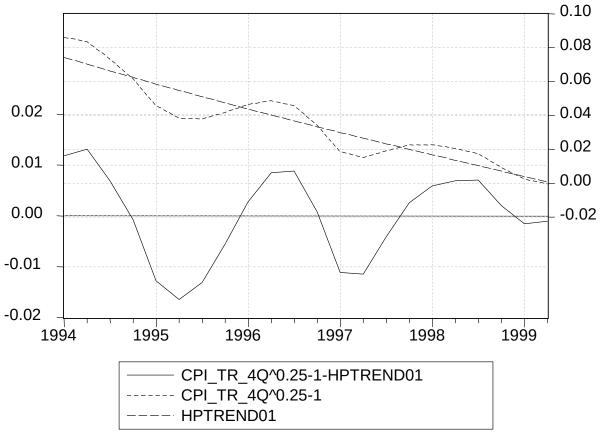
Actual, fitted and residual graph

Appendix 4.9 HP filter

Dependent Variable: CPI_TR_4Q^0.25-1
Method: Least Squares
Date: 12/13/99 Time: 17:25
Sample: 1994:1 1999:2
Included observations: 22
CPI_TR_4Q^0.25-1=HPTREND01

R-squared	0.873512	Mean dependent var	0.035975
Adjusted R-squared	0.873512	S.D. dependent var	0.024350
S.E. of regression	0.008660	Akaike info criterion	-6.615791
Sum squared resid	0.001575	Schwarz criterion	-6.566198
Log likelihood	73.77370	Durbin-Watson stat	0.496738

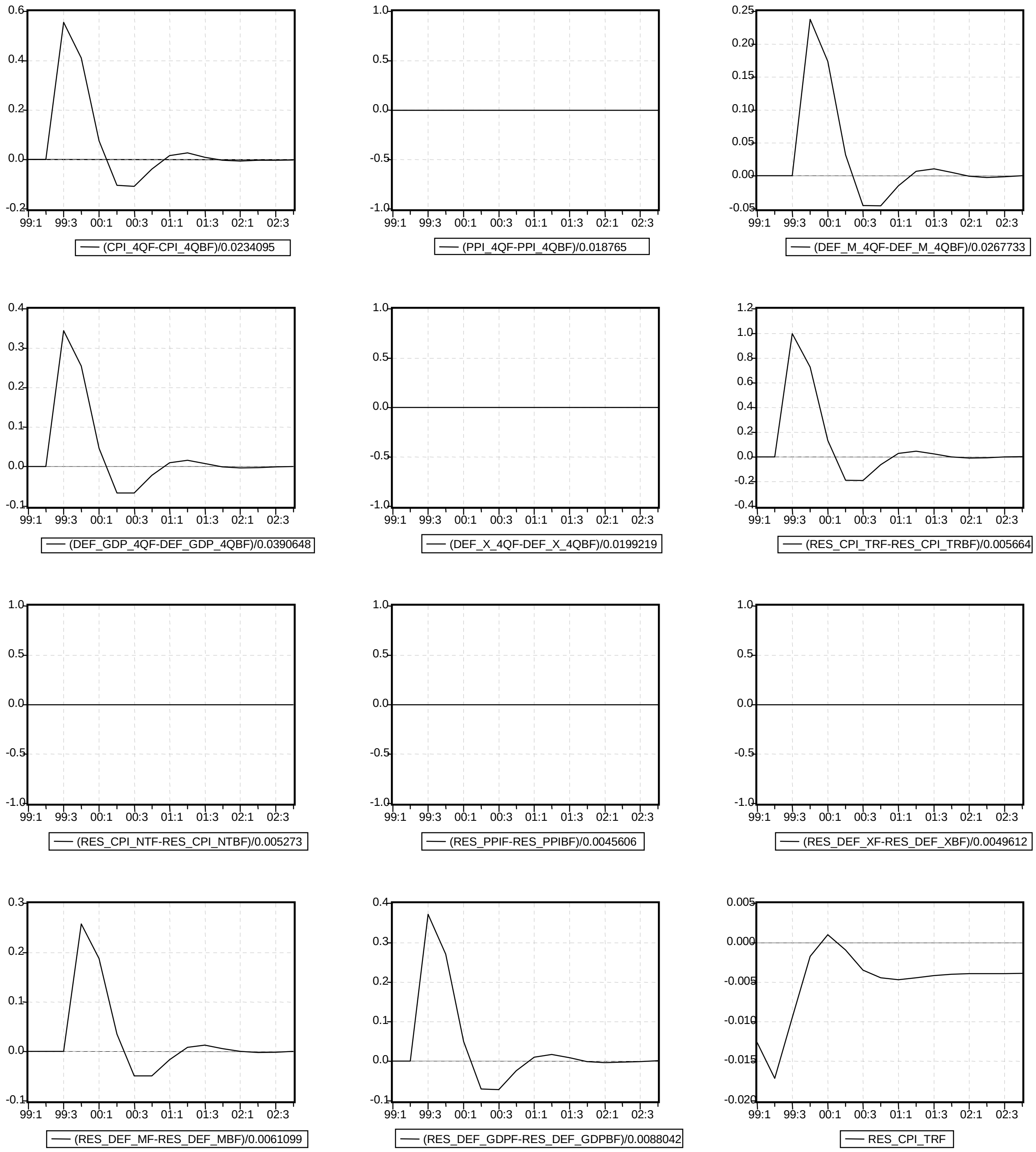
Actual, fitted and residual graph



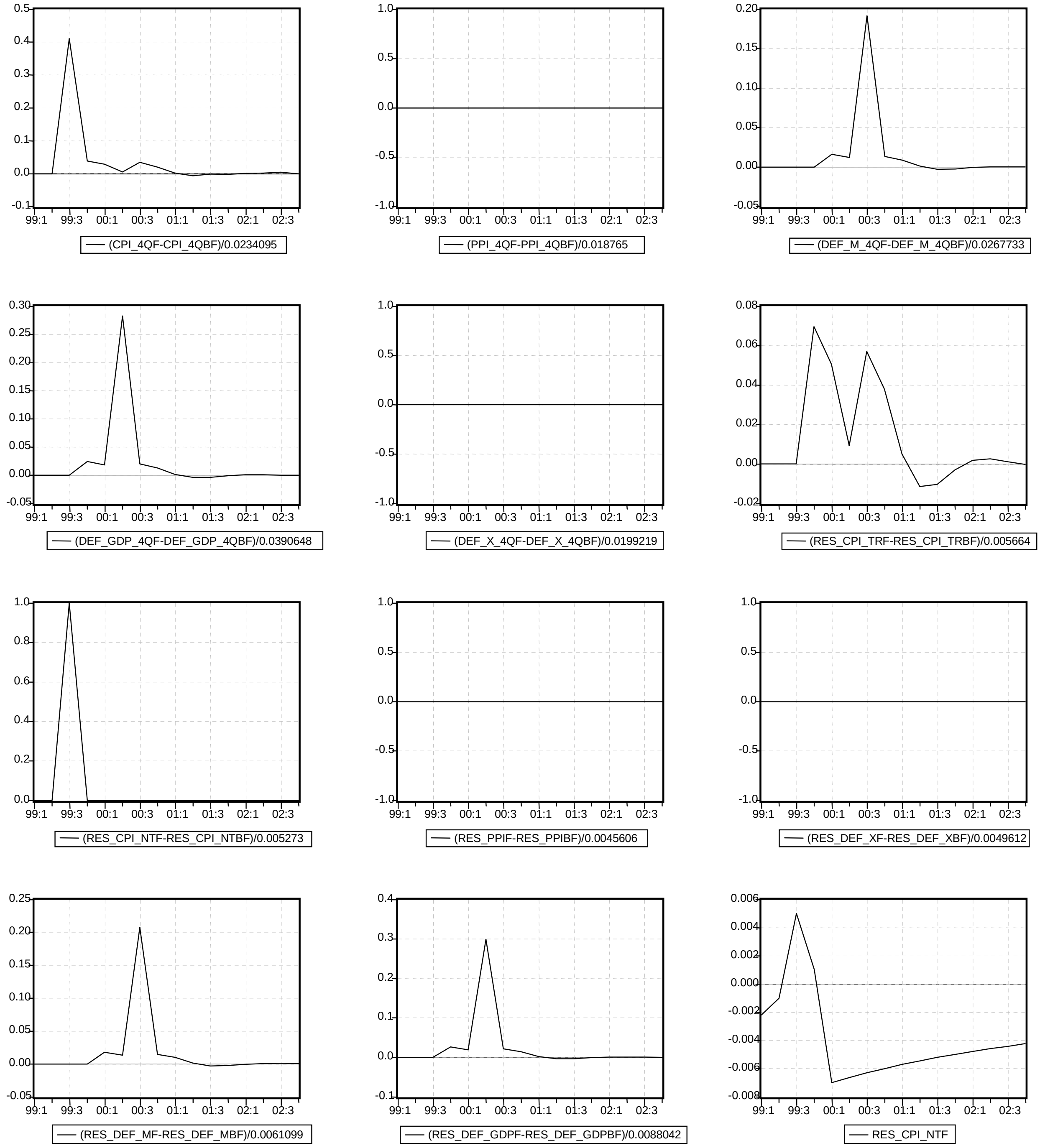
Appendix 5. Figures of the Impact of Endogenous Shock

Shock occurs in 1999q3 and the simulation period is from 1999q1 till 2002q4.

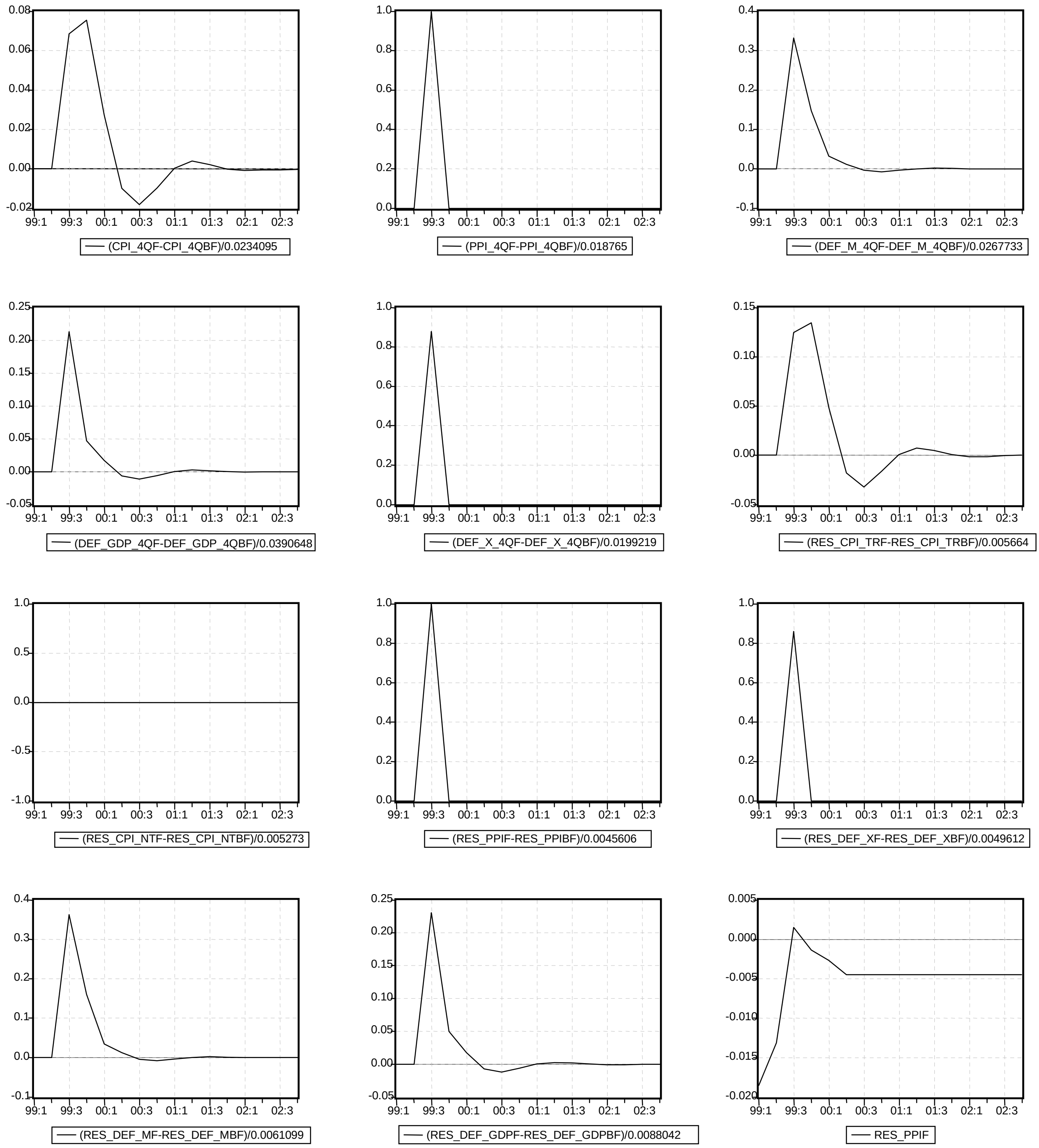
The impact of RES_CPI_TR 1 standard deviation sized shock.



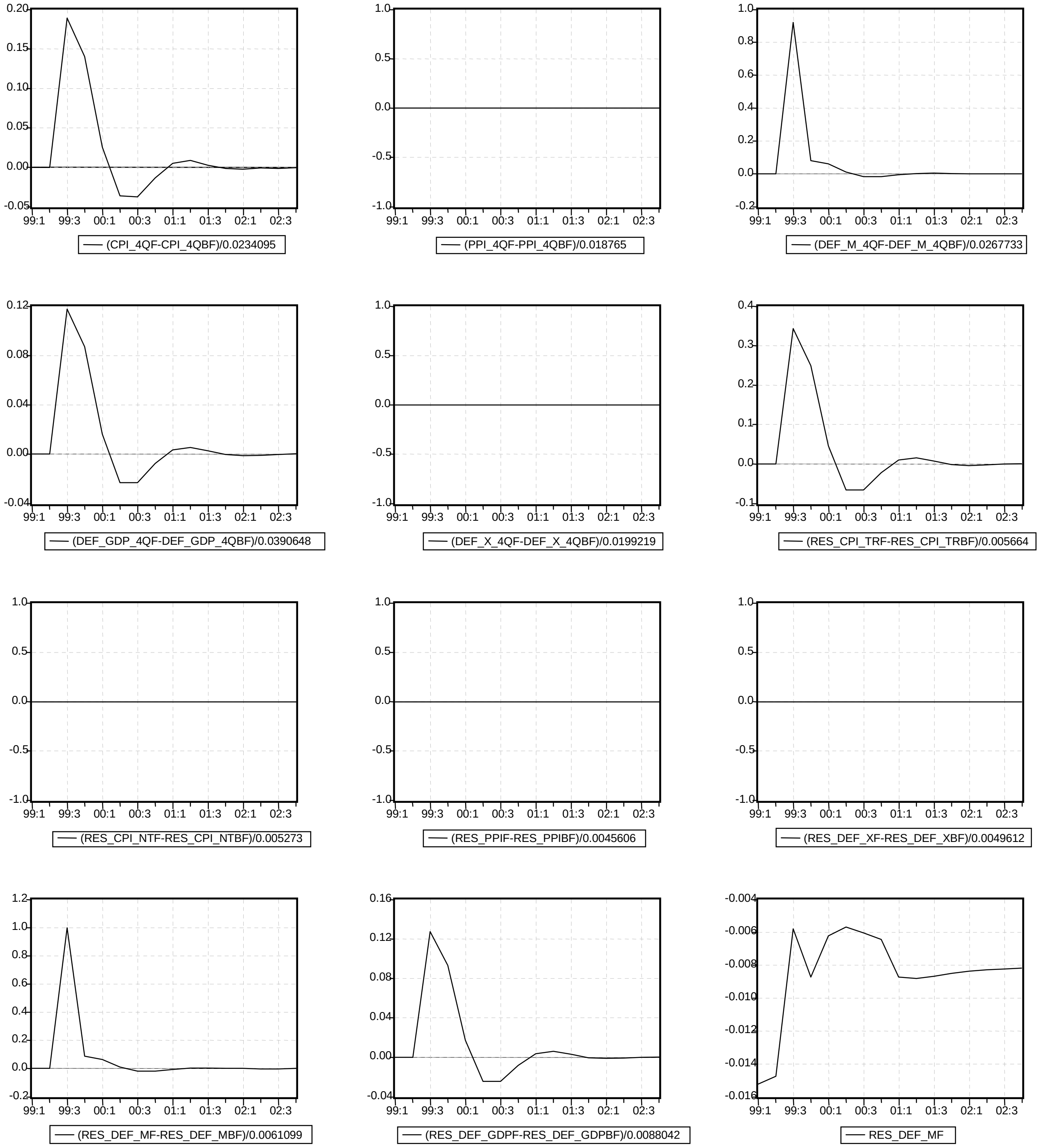
The impact of RES_CPI_NT 1 standard deviation sized shock.



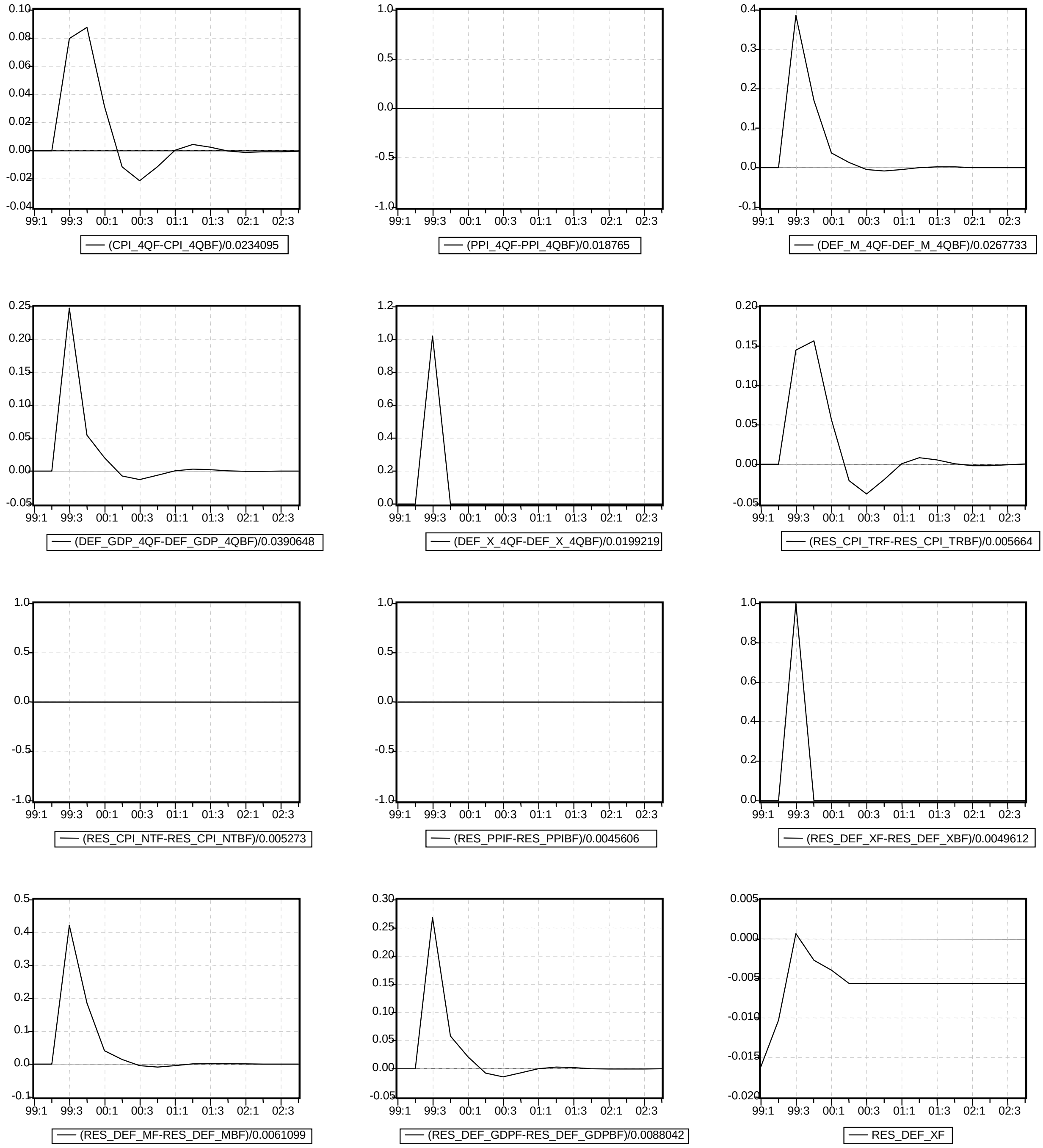
The impact of RES_PPI 1 standard deviation sized shock.



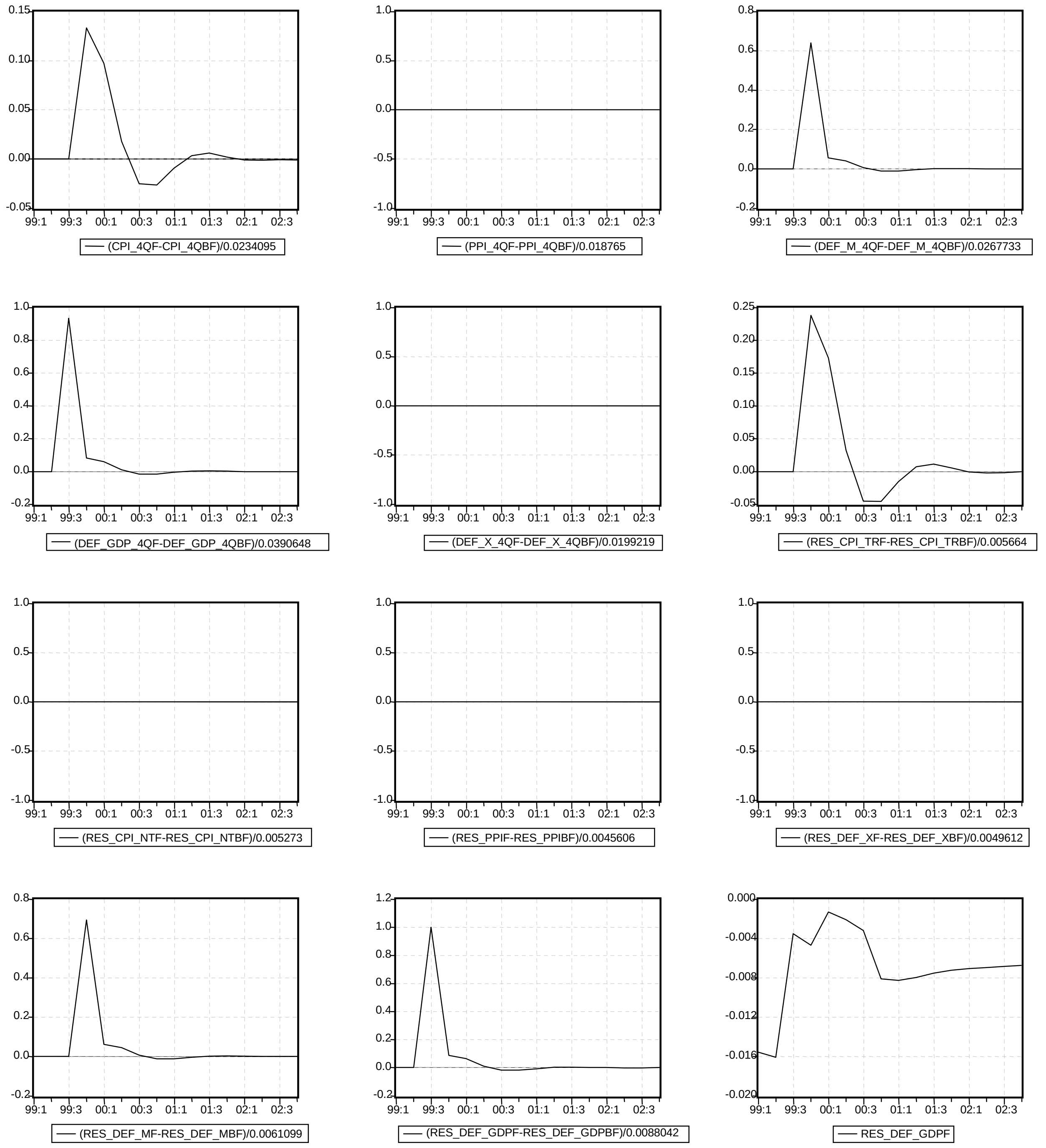
The impact of RES_DEF_M 1 standard deviation sized shock.



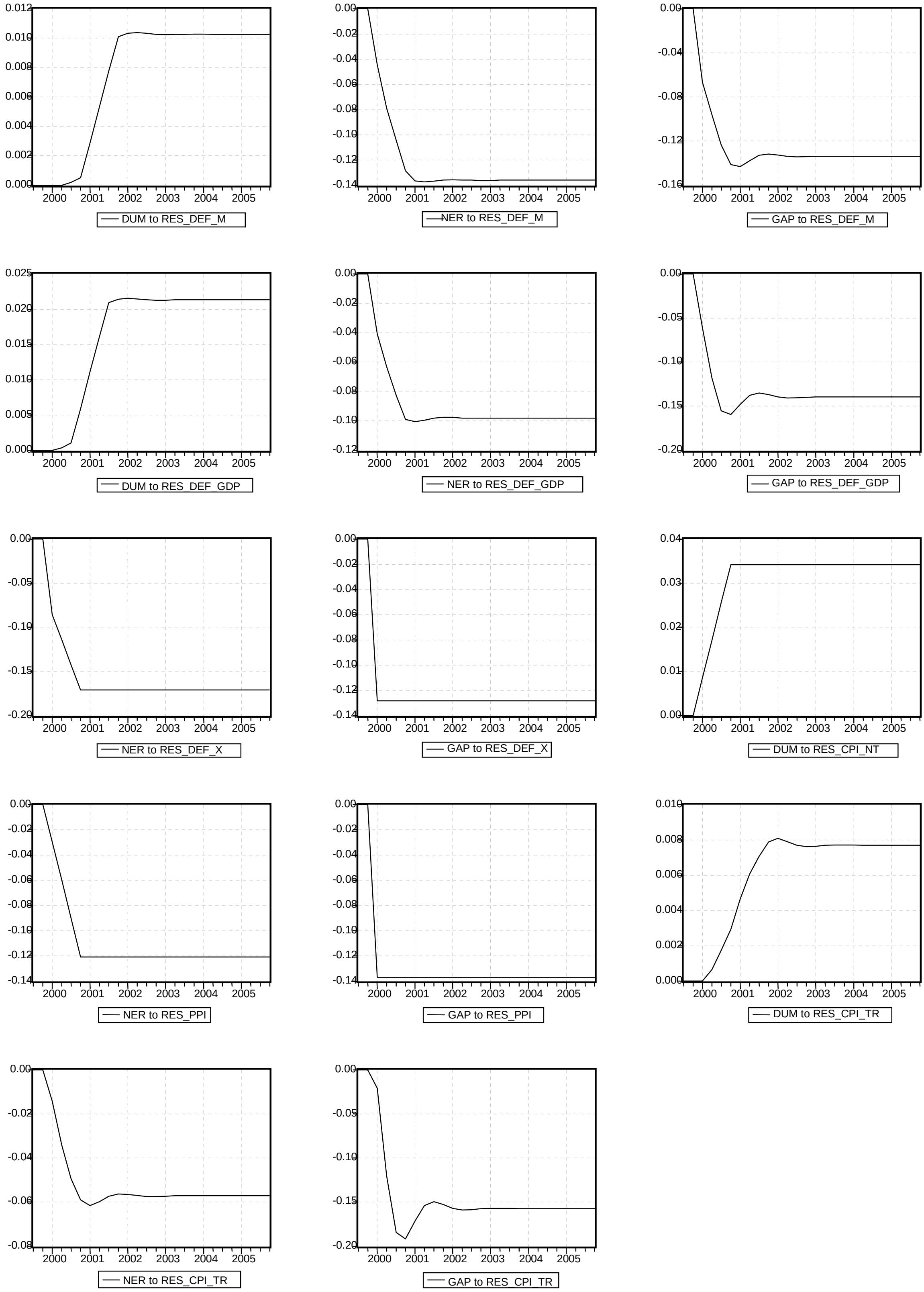
The impact of RES_DEF_X 1 standard deviation sized shock.



The impact of RES_DEF_GDP 1 standard deviation sized shock.



Appendix 6. The Impact of the Exogenous Shock



Appendix 7. System of Equations

The system of equations of the model consists of three parts:

1) LONG RUN EQUATIONS

DEF_M_LR = 0.003016+466.899/@TREND(90:01)^3
DEF_X_LR= 0.003016+2477.539/@TREND(90:01)^3.5
PPI_LR=0.003016+4494.974/@TREND(90:01)^3.7
CPI_TR_LR=0.003016+67.755/@TREND(90:01)^2.4
CPI_NT_LR=0.003016+407.736/@TREND(90:01)^2.7
DEF_GDP_LR=0.003016+71.51/@TREND(90:01)^2.3

2) SHORT RUN EQUATIONS

RES_CPI_TR= 0.3182*RES_DEF_M - 0.0765*GAP_RGDP(-1) + 0.0747*RES_CPI_NT(-1) + 0.0064*DME_9504_9603 - 0.0035*DME_9501_9503 + 0.6396*RES_CPI_TR(-1) - 0.3962*RES_CPI_TR(-2)

RES_CPI_NT_Q = 0.0342*DUM_ADMIN - 0.352*CPI_NT_LR(-1)
(RES_CPI_NT +1)^4=(RES_CPI_NT_Q +CPI_NT_LR+1)*(RES_CPI_NT_Q(-1)+CPI_NT_LR(-1)+1)*(RES_CPI_NT_Q(-2)+CPI_NT_LR(-2)+1)*(RES_CPI_NT_Q(-3)+CPI_NT_LR(-3)+1)

RES_PPI = -0.1209*(NER_USD_GEOM4Q-1) - 0.13708*GAP_RGDP - 0.0045

RES_DEF_M=0.5196*RES_DEF_X+0.4814*RES_DEF_GDP(-1)-0.0115*DMS_9803(1)-0.0019

RES_DEF_X = 0.05668748494 - 0.05809585876*NER_USD + 0.936045183*RES_PPI

RES_DEF_GDP= 0.5781*RES_CPI_TR + 0.4933*RES_CPI_NT(-3) + 0.0115*DMS_9801 + 0.3798*RES_DEF_X

3) TECHNICAL EQUATIONS FOR THE INDEX CALCULATIONS

CPI_TR_4Q=(RES_CPI_TR+CPI_TR_LR+1)^4
CPI_TR_Q=CPI_TR_4Q*CPI_TR_Q(-4)/CPI_TR_4Q(-1)
CPI_TR_BQ=CPI_TR_BQ(-4)*CPI_TR_4Q

CPI_NT_4Q=(RES_CPI_NT+CPI_NT_LR+1)^4
CPI_NT_Q=CPI_NT_4Q*CPI_NT_Q(-4)/CPI_NT_4Q(-1)
CPI_NT_BQ=CPI_NT_BQ(-4)*CPI_NT_4Q

CPI_4Q=TR4Q_KAAL_CPI4Q*(CPI_TR_4Q)+(1-TR4Q_KAAL_CPI4Q)*(CPI_NT_4Q)
CPI_Q=CPI_4Q*CPI_Q(-4)/CPI_4Q(-1)
CPI_BQ=CPI_BQ(-4)*CPI_4Q

DEF_M_4Q=(RES_DEF_M+DEF_M_LR+1)^4
DEF_M_Q=DEF_M_4Q*DEF_M_Q(-4)/DEF_M_4Q(-1)
DEF_M_BQ=DEF_M_BQ(-4)*DEF_M_4Q

DEF_X_4Q=(RES_DEF_X+DEF_X_LR+1)^4
DEF_X_Q=DEF_X_4Q*DEF_X_Q(-4)/DEF_X_4Q(-1)
DEF_X_BQ=DEF_X_BQ(-4)*DEF_X_4Q

PPI_4Q=(RES_PPI+PPI_LR+1)^4
PPI_Q=PPI_4Q*PPI_Q(-4)/PPI_4Q(-1)
PPI_BQ=PPI_BQ(-4)*PPI_4Q

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DEF_GDP_4Q=(RES_DEF_GDP+DEF_GDP_LR+1)^4
DEF_GDP_Q=DEF_GDP_4Q*DEF_GDP_Q(-4)/DEF_GDP_4Q(-1)
DEF_GDP_BQ=DEF_GDP_BQ(-4)*DEF_GDP_4Q

DEF_DD_BQ=(RGDP*DEF_GDP_BQ-RX*DEF_X_BQ+RM*DEF_M_BQ)/(RGDP-RX+RM)
DEF_AD_BQ=(RGDP*DEF_GDP_BQ+RM*DEF_M_BQ)/(RGDP+RM)
DLOG(DEF_INV_BQ)=0.8557*DLOG(DEF_GDP_BQ)+0.1169*(DMS_9801-DMS_9801(1))

TR4Q_KAAL_CPI4Q=(CPI_TR_BQ(-4)*((-CPI_NT_BQ(-4)*CPI_TR_KAAL_CPI*
CPI_TR_BQ)+(CPI_NT_BQ(-4)*CPI_NT_BQ*CPI_TR_KAAL_CPI)+
(CPI_NT_BQ*CPI_TR_KAAL_CPI(-4)*CPI_TR_BQ(-4))-(CPI_NT_BQ*CPI_NT_BQ(-4)*
CPI_TR_KAAL_CPI(-4))))/(CPI_BQ(-4)*(-CPI_TR_BQ*CPI_NT_BQ(-)+CPI_NT_BQ*
CPI_TR_BQ(-4)))
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References

Apel, M. and Jansson, P. (1998) A theory-consistent system approach for estimating potential output and the NAIRU. Sveriges Riksbank WP Series No. 74

Apel, M. and Jansson, P. (1999) System estimates of potential output and the NAIRU Empirical Economics Spring, p.343-388

Blejer, M.J. and Frenkel, J.A. (1992) Monetary Approach to the Balance of Payments. The New Palgrave - Dictionary of Money & Finance, p.724-727

Berg, C. and Lundkvist, P. (1997) Has the inflation process changed? Sveriges Riksbank Quarterly Review No.2

Devereux, M.B. (1999) Real Exchange Rate Trends and Growth: A Model of East Asia. International Economics, 7(3), p. 509-521

Faruqee, H. (1995) Pricing to Market and the Real Exchange Rate. IMF WP/95/12

Gali, J. and Gertler, M. (1999) Inflation Dynamics: A Structural Economic Analysis. CEPR, Discussion Paper Series No.2246

Clarida, R, Gali, J. and Gertler, M (1999). The Science of Monetary Policy: A New Keynesian Perspective. CEPR Discussion Paper Series No.2139

Ghosh, A.R., Gulde, A.-M. and Wolf, H.C. (1998) Currency Boards: The Ultimate Fix? IMF WP/98/8

Goodfriend, M. and King, R.G. (1997) The New Neoclassical Synthesis and the Role of Monetary Policy. NBER Macroeconomic Annual 1997, p.231-283

Hernandes and Cata, E. (1999) Price Liberalization, Money Growth, and Inflation During the Transition to a Market Economy . IMF Working Paper 99/76

Ito, T., Isard, P. and Symansky, S. (1999) Economic Growth and Real Exchange Rate: An Overview of the Balassa-Samuelson Hypothesis in Asia, in “Changes in Exchange Rates in Rapidly Developing Countries”, The University of Chicago Press, p. 109-132

Kadiyali, V. (1997) Exchange rate pass-through for strategic pricing and advertising: An empirical analysis of the U.S. photographic film industry. Journal of International Economics 43 No. 3/4

Koen, V. and De Masi, P. (1997) Prices in the Transition: Ten Stylized Facts. IMF WP/97/158

Krugman, P. (1987) Pricing to Market When the Exchange Rate Changes. Real-Financial Linkages among Open Economies

Kugler, P. (1999) Price level trend-stationarity and the instrumentsand targets of monetary policy: An empirical note. Economics Letters Vol.63 p.97-101

Kydland, F.E. and Prescott, E.C. (1990) Business Cycles: Real Facts and a Monetary Myth. Federal Reserve Bank of Minnesota Quarterly Review. Spring 1990, p.3-18

Laxton, D., Isard, P., Faruqee, H., Prasad, E. and Turtelboom, B. (1998) MULTIMOD Mark III - The Core Dynamic and Steady-State Models. IMF Occasional Paper No. 164

Leppä, A.(1996). MODEST - An Econometric Macro Model for the Estonian Economy. Ministry of Finance Discussion Papers #52

Leppä, A., Martihhina, A. and Meriküll, J.(1999). The effect of the Russian crises 1998 on the Estonian economy, simulations with ESTMOD. Paper presented in “Modelling Economies in Transition”, Rydzyna, Poland, Dec. 1999

McCarthy, D. and G. Zanalda (1996) "Economic Performance in Small Open Economies: the Caribbean Experience 1980-92, "Centro Studi Luca d’Agliano Working Paper No. 102

Mikkelson, J.G. (1998) A Model for Financial Programming IMF WP/98/80

Nagayasu, J. (1998) Does the Long-Run PPP Hypothesis Hold for Africa?: Evidence from Panel Co-Integration Study IMF WP/98/123

Niemera, M.P. and Klein, P.A. (1994) Forecasting Financial and Economic Cycles. John Wiley & Sons, Inc.

Papell, D.H. (1997) Searching for stationarity: Purchasing power parity under the current float. Journal of International Economics Vol. 43, p.313-332

Papell, D.H. (1998) The Great Appreciation, the Great Depreciation, and the Purchasing Power Parity Hypothesis. Oesterreichische Nationalbank WP No.30

Raim, J. (1999) The Price Differences Between Estonia and European Union and Their Causes: the Explanatory Power of Balassa-Samuelson Effect. Tallinn Technical University WP No. 99/34

Rell. M. and Randveer, M. (1999)*Ekspordihindade kujunemine. Uurimistöö. EP. MMO*

Scacciavillani, F.and Swagel, P. (1999) Measures of Potential Output: An Application to Israel. IMF WP/99/96

Scarth, W.M. (1996). Macroeconomics. An Introduction to Advanced Methods. An Integration of New Classical and New Keynesian Insights. Dryden

Sepp, U. (1997) Currency board arrangement and inflation in Estonia. Paper for the international conference on Transition to advanced market institutions and economies, Warsaw, June 18-21 1997

Sepp, U. (1999). Factors of Trade-Deficit Convergence in Estonia. Eesti Pank. WP #1

Tarkka, J.and Mayes, D. (1999) Managing Monetary Policy Under Uncertainty: The Value of Publishing Official Central Bank Forecasts. Paper prepared for the Project LINK Fall Meeting , Nov 1-5, 1999

Võrk, A. (1998) Price Increases in the Non-Tradable Goods Sector Determine Estonian Inflation: An Econometric Analysis. Transformation of Economic and Political Systems in the Baltic Sea Region, Selected Student Papers I, Tartu (23.-25.10.98) p. 142-147

Walsh, C.E. (1998). Monetary Theory and Policy. MIT Press