Disinflation Simulation with Disaggregated Output Gap Model for Hungary[1]

Viktor Várpalotai

Magyar Nemzeti Bank

Economics Department

Research Division

April 2004.

[1] I would like to thank András Simon and Péter Benczúr for substantial comments and suggestions. The paper also benefited from presentation at the 58th European Meeting of the Econometric Society in Stockholm. All the remaining errors are mine.

Contents

Abstract

This paper compares the cost of different disinflation strategies and scenarios for Hungary using a restrictive model. For the computation, the output gap variable of Benczúr–Simon–Várpalotai [2002] model was decomposed into household and government consumption, investment, export and import gaps. The behavioral equations of these gap variables were estimated using Hungarian quarterly GDP data for the period 1991–2002.

This new, more structured model was used to compute the costs and length of disinflation for severeal alternative scenarios. The effects of exchange rate appreciation, a loosening fiscal policy and a combination of these cases were simulated. Although we are reserved in the presentation of our numeric result for the sacrifice ratio, comparison of the different scenarios results in a clear message: *the disinflation process is not only faster but also cheaper when the demand tightening policy affect all sectors; in other words, when the fiscal and monetary policies are harmonized.* If these policies are not harmonized, the disinflation process becomes slower and more expensive.

Introduction

In May 2001, the Magyar Nemzeti Bank (MNB - National Bank of Hungary) widened its narrow exchange rate flotation band from ±2.25% to ±15%, giving leeway for exchange rate appreciation, in order to bring down inflation which had become stuck at an annual rate of 10%. Since then, the nominal exchange rate has appreciated by approximately 10%. This sharp appreciation was an impulse that triggered disinflation. By the end of 2002, the year-on-year consumer price index had fallen to 4.8%. Nevertheless, for 2003 market participants, the MNB and the government forecast a break in this steady decline, due to a strong consumption boom, originating mainly from election campaign promises. At the same time, the export and investment sectors are being negatively affected by the strong national currency and weak external demand. In this context, there is growing concern about the cost of disinflation. In this present debate the Magyar Nemzeti Bank is frequently criticized for imposing too high a burden on the export sector and worsening the country's competitiveness by way of the stronger currency. In this paper, we attempt to separate and compare these effects on the cost of disinflation using a restrictive model, allowing us to refute the grounds for such criticism.

Our calculation, however, is not a 'cost-benefit' analysis, i.e. we do not weight the various costs of disinflation against its virtues. This also means that we neglect any welfare effect from low inflation, any advantage of possible euro zone entry and any other factors that make successful disinflation desirable. We merely compute the costs of and necessary time periods for disinflation. No attempt is made to choose an optimal speed of disinflation, i.e. we do not consider the question that if faster disinflation entails higher costs, then how much sacrifice should be made in favor of speed. Nevertheless, our methodology enables us to select *efficient strategies*, that is to distinguish faster and cheaper scenarios from others.

For simulation purposes, we present a disaggregated gap model that is a developed version of the 'single-gap' model proposed by Benczúr-Simon-Várpalotai (2002). We decomposed the aggregate output gap according to the GDP components, resulting in a more structured and disaggregated model. The behavioral equations of these gap components were estimated differently than in our earlier calibrated model.

The remainder of the paper is organized as follows. The first section presents a brief introduction of the new model. Next, we point out how our results can be evaluated. The third section contains the simulation results, where the costs of different scenarios are compared, e.g. exchange rate appreciation, a nascent consumption boom that tries to offset the negative impact of appreciation, etc. In the fourth section we present our conclusions. The data transformation and the model estimation method are presented in the appendix.

1 Disaggregated output gap model

1.1 Structure of GDP components

In this section we present a new version of our former small-scale quarterly macromodel, in which the output gap is more detailed.[1] We decompose the output gap (y_t) into household consumption (c_t), government consumption (g_t), investment (inv_t), export (x_t) and import (m_t) cycles (gaps):[2]

$$y_t = c_t + inv_t + g_t + x_t - m_t, \tag{1}$$

where all variables are logarithmised.[3] External trade balance by definition: $tr_t = x_t - m_t$.

Considering that the output gap is a difference between actual and potential output, decomposition according to GDP statistics assumes that each GDP component (household and government consumption, investment, exports and imports) has a 'potential output' level, which is determined by the factors of production allocated for the

[1] The above-mentioned model can be found in Benczúr-Simon-Várpalotai (2002).
[2] In this paper the terms 'cycle', 'cyclic component' and 'gap' are synonymous.
[3] The calculation method of these variable from GDP data can be found in the appendix.

production of the one of these component. In other words, over the short-run modification of the factor allocation among production of GDP component is restricted. In the case of imports, we rather use the terminology "potential need", meaning an import quantity that is necessary for the production of other GDP component at a potential level. In this sense, over the short run the substitutability of imports for domestic goods is restricted as well.

Output gap decomposition is performed on seasonally-adjusted, quarterly GDP data for the period 1991 Q1 - 2002 Q4 for Hungary. Each gap is defined as the seasonally-adjusted data minus the Hodrick-Prescott filtered ($\lambda = 1600$) trend multiplied by the given GDP component / GDP ratio. Hence, each gap variable can be interpreted as a percentage of actual GDP.[4]

We assumed that the behavior of the gap variables defined above can be captured as follows:

- The household consumption gap (c) depends on its lagged value and on the aggregated output gap (y);
- The government consumption gap (g) is assumed to be exogenous;
- The investment gap (inv) depends on its lagged value, on foreign demand (wd) and the real exchange rate (q); and
- The import gap (m) is determined by the other gaps through fixed import ratios.

We assumed that lagged values play an important role in the behavioral equations, as the effects appear gradually through explanatory variables. Therefore, we estimated each behavioral equation with a relatively long lag structure, as we used 11 lagged values of each explanatory variable. One can safely state that this 3-year long lag structure is enough to evolve the full effects among the variables and to detect these varied dynamics by econometric estimation.

But these long lag structures require estimation of a fairly high number of parameters, which, due to the short available data series, cannot be accomplished (data is

[4]For more detail see the appendix.

available from the first quarter of 1991 to the end of 2002, rendering 44 observations). To make the estimate manageable, the lag structures were estimated with a smoothness prior, developed by Shiller (1973). This estimation method is a Bayesian approach, where the *a priori* information refers to the low volatility of lagged parameters, i.e. the parameter of lag t-th can not differ remarkably from the previous $t-1$-th or the succeeding $t+1$-th lags.

The behavior of cycles of GDP components were captured by the following linear functions (y_t, c_t, inv_t, x_t, m_t are endogenous, g_t is exogenous):

$$\begin{aligned} c_t &= f_1(c_{t-1},\ B_1(L)y_t) && (2)\\ inv_t &= f_2(inv_{t-1},\ B_2(L)wd_t,\ B_3(L)q_t) && (3)\\ x_t &= f_3(x_{t-1},\ B_4(L)wd_t,\ B_5(L)q_t) && (4)\\ m_t &= f_4(B_6(L)c_t,\ B_7(L)inv_t,\ B_8(L)g_t,\ B_9(L)x_t,\ B_{10}(L)q_t), && (5) \end{aligned}$$

where $B_i(L)$ are lag polinoms, wd_t the foreign demand gap, q_t the real exchange rate. When q decreases (increases) the real exchange rate appreciates (depreciates). The estimation process and estimated parameters of equation (2)-(5) are reported in the appendix.

1.2 Price and exchange rate blocks

The former estimated behavioral equations are completed by the following price and exchange rate equations and identities that are borrowed from the earlier paper of Benczúr-Simon-Várpalotai (2002). The small letters mark the logarithm of the proper variables.

In the model p_t denotes the domestic price index, i.e. the price index of goods that are produced domestically, p_t^* is the foreign price index measured in foreign currency and p_t^m is the domestic price of imported goods measured in domestic currency. The identities of price index and inflation are:

$$
\begin{aligned}
p_t &= p_{t-1} + \pi_t && (6)\\
p_t^* &= p_{t-1}^* + \pi_t^* && (7)\\
\pi_t^m &= p_t^m - p_{t-1}^m && (8)
\end{aligned}
$$

where π_t, π_t^*, π_t^m are domestic, foreign and imported goods inflation, respectively. We normalize these variables as follows. Foreign inflation is treated as exogenous, and is supposed to equal an annual rate of 2%. This value has been subtracted from each inflation data. Hence, in the model the inflation variables measure excess inflation over this 2% rate of inflation that is supposed to be the long-run equilibrium inflation rate. In the case of domestic inflation, we have made some further modifications, as we have filtered out the Balassa-Samuelson effect from the data as well. Of course, the results we report in the following sections contain the original not the transformed data.

Domestic consumer price inflation (π_t^{CPI}) is the weighted sum of inflation of domestic and imported goods (π_t and π_t^m respectively):

$$\pi_t^{CPI} = (1-\omega)\pi_t + \omega\pi_t^m. \tag{9}$$

Foreign prices pass through into prices of imported goods sold on the domestic market by the following process:

$$p_t^m = p_{t-1}^m + \beta_{pt}(p_{t-1}^* + s_{t-1} - p_{t-1}^m), \tag{10}$$

where s_t denotes the nominal exchange rate measured in the unit of foreign currency. At this point, it is clear what the difference between the foreign and imported prices is: the foreign price denotes the price one must pay abroad in foreign currency and the imported price is the amount that one must pay for the same goods at home in local currency. It also means that the 'law-of-one-price' condition for tradable goods does not hold in short run.

A notable modification compared to our previous model is that we have eliminated the nominal exchange rate equation which was based on the uncovered interest parity condition. In the new model the nominal exchange rate is exogenous. This choice has been encouraged by the poor performance of the uncovered interest parity condition in predicting the evolution of the exchange rate.[5]

In the model q_t the real exchange rate is the difference of the foreign prices in the national currency $(p_t^* + s_t)$ and the domestic price level:

$$q_t = s_t + p_t^* - p_t, \tag{11}$$

where decreasing (increasing) q_t denotes real exchange rate appreciation (depreciation). Obviously, in our case this concept based on purchasing power parity that means that the real exchange rate is in equilibrium if and only if the foreign price in domestic currency $(p_t^* + s_t)$ equals the domestic price level (p_t). However, this very restrictive equilibrium concept can be softened by rescaling of the price levels so that the equilibrium real exchange rate should mean a specific (not necessarily 1 to 1) ratio of foreign and domestic prices.

The supply side of the model is captured by a Phillips-curve:

$$\pi_t = \alpha_{unit} \cdot [\alpha_\pi \pi_{t-1} + (1 - \alpha_\pi)\pi_{t+1}] + \eta \left(\alpha_y y_t + \alpha_c c_t + \alpha_q q_t\right) \tag{12}$$

which also contains some modifications compared to our formal standard Phillips-curve equation; namely, here the consumption gap (c_t) appears beside the usual (aggregated) output gap (y_t). Furthermore, we introduced α_{unit} that proved to be indispensable in order to avoid producing an oscillating model solution.[6]

[5] This problem is analysed more deeply by Benczúr (2003).

[6] There is no obstacle to incorporating every gap variable separately with differing inflation effect in the Phillips-curve:

$$\pi_t = \alpha_{unit} \cdot [\alpha_\pi \pi_{t-1} + (1 - \alpha_\pi)\pi_{t+1}] + \phi_y y_t + \phi_c c_t + \phi_g g + \phi_{inv} inv + \phi_x x + \phi_m m + \alpha_q q_t.$$

1.3 Model calibration

In contrast to the estimated behavioral equation, the parameters of the price and exchange rate block have been calibrated. The import/domestic share in the consumer price basket in equation (9) has been set as $\omega = 0.3$. The value of the $\beta_{pt} = 0.16$ pass-through parameter in equation (10) has been borrowed from our previous paper, meaning a 50 percent pass-through annually.

As we could not succeed in estimating a Phillips-curve that resulted in a non-oscillating solution, we had to calibrate this equation as well. This unpleasant property emerges from our exogenous nominal exchange rate assumption, considering that this means a price level anchor while the adjustment process describing the change of price (inflation) dynamic yields a systematic overshoot (oscillating solution).

One possible way to resolve this problem is to reduce parameter α_{unit} below 1, so we let $\alpha_{unit} = 0.93$. This size of the parameter seems high enough that it can be interpreted as the persistence of inflation (the inflation diminishes by a quarter every year without any loss), but it was enough low to remove the oscillation from the solution of the model.

We use $\alpha_\pi = 0.8$ as the parameter of the forward-backward lookingness of inflation. Compared to our previous paper, this parameter choice reflects more price and wage stickiness based on the experience of the past few years.[7]

As our model framework originates from Svensson (2000), who by deducing the model parameters from the microeconomic base (See in Svensson (1998)) shows that a change in α_π yields a change in other parameters (α_y^*, and α_q^*) as well, we assume $\alpha_y^* = (1 - \alpha_\pi) \cdot 0.2 = 0.04$, and $\alpha_q = (1 - \alpha_\pi) \cdot 0.07 \cdot 0.25 = 0.0035$. The original Svensson model had output gap only, but with our model we can distinguish the gap effects of different GDP components. Hence, we assume that the gap of household consumption has an effect three times stronger on CPI inflation than the aggregate gap has ($\alpha_c = 3\alpha_y$), but their overall effect on inflation remains $\alpha_y^* = 0.04$. Hence, we use $\alpha_c = 3/4 \cdot \alpha_y^* = 0.03$ and $\alpha_y = 1/4 \cdot \alpha_y^*$.

[7] In the literature we can find for parameter α_π 0.6 [Svensson (2000)], 0.8 [Batini-Haldane (1999)], but even 1 [Mankiw (2001)].

This means that we have only taken the ratio of parameters α_y^* (de facto α_y and α_c) and α_q from the original Svensson model. However, there was a further criteria of calibration that the model should reproduce the Hungarian disinflation process starting from band widening in May 2001 (without any oscillation, of course). This challenge has been met by choosing $\eta = 0.3$ in equation (12). Actually, we have calibrated α_{unit} and η simultaneously, as we have had to adjust both in order to eliminate any oscillating solution and roughly reproduce the past disinflation process. At the same time, one should be aware that these parameters mutually have an effect on the speed and the costliness of disinflation. This means, that the smaller (higher η) the parameter α_{unit} the faster and less costly the disinflation process is. In conclusion of the calibration, the parameters have turned to lower than implicitly assumed in our previous paper ($\alpha_{unit} = 1$ and $\eta = 1$). Thus, the effect of the gaps and real exchange rate has became smaller, the parameter α_{unit} counterbalances this, and the model generates a sacrifice ratio very similar to our previous model version after all.

2 The purpose of the simulation

2.1 Identifying dominant scenarios

The speed of a converging process is usually measured as a dominant eigenvalue of the model. This measure depends on model structure and parameters only; thus it is independent from the starting and terminal condition values and shocks. However, we have adopted an alternative definition for the speed of convergence when we assess different scenarios. We consider a disinflation process faster if average annual inflation falls below 2.5 percent earlier. This concept is linked with the practical view in a country aiming for euro zone membership that disinflation is successful if it meets the inflation criteria of Maastricht Treaty.[8] Choosing this definition also entails that not only the model structure and parameters determine the speed of disinflation, but the shocks hitting the disinflation process also. That is why we find different speeds

[8] At the present time, the inflation reference value calculated according to the Maastricht criteria has been 2.7% since March 2003.

depending on the targeted nominal exchange rate level or the applied fiscal policy.

The disinflation models based on demand-tightening (output gap) are not used to analyze the optimal speed of disinflation, in other words to inquire into the relation between the cost and the speed of disinflation. Namely, these types of models consider parameters as fixed either estimated or calibrated. This means that monetary policy is credible by definition hence disinflation is always successful. Therefore, the model ignores any 'unsuccessful disinflation'. The reason behind this is the forward-looking part of the Phillips-curve. If the final outcome is unquestionably known by the market, then the cost of disinflation becomes infinitesimal when we let inflation inertia 'fade out'. This also means that the faster the disinflation process, the more expensive it is.

In the real world, the motivation for a relatively fast disinflation strategy is not to choose the less expensive path for a given parameter combination, but is to influence the process's parameters favorably, i.e. to curb inflation expectations, to lower the inertia of the pricing, etc., yielding disinflation which is really less expensive. Behind this idea there is that assumption that with slow disinflation the markets do not see and do not believe in the final goal, therefore disinflation will also not be realized. Supporters of a forceful disinflation strategy often use this argument.

This paper does not intend to investigate these considerations. Therefore, we cannot say anything about the optimal speed of disinflation. Instead, we try to detect policies that deliver successful disinflation faster and less expensive than others.

We computed disinflation paths for different scenarios. We cannot rank solutions where the disinflation is faster (slower) but more expensive (cheaper) as well. If, however, we find a disinflation path that is faster and cheaper than another, then we can rank it as a dominating path relative to others, and we can draw some strong conclusions. Our goal is to find and demonstrate these cases.

2.2 Ambiguous sacrifice ratio

In addition to this modest goal, we compute sacrifice ratios for each scenario, but we do not consider them as a best estimate for different economy policy. We cannot do this either, because we will demonstrate that the sacrifice ratio depends strongly on equilibrium real exchange rate assumption that cannot be justified credibly.[9] Nevertheless, we will show that a change in the equilibrium assumption does not change the relative costs of different scenarios, hence the ranking remains unaffected.

3 Simulations

Baseline: Unchanged exchange rate with a consumption boom

We consider this scenario as a baseline and use its results as a reference value for comparison. In this scenario, we postulated that the nominal exchange rate remains unchanged at its May 2001 level. Practically, it uses a hypothesis that the narrow band exchange regime would have subsisted with abolishing the crawling peg. As the model needs an initial value for the real exchange rate, we chose the two following alternatives: (1) the real exchange rate was undervalued by 5% in May 2001, and (2) the real exchange rate was in equilibrium in May 2001. The two alternatives are more or less in line with the MNB's view on the equilibrium exchange rate; moreover there were no clear signs that the exchange rate was far from equilibrium.

The assumption for the value of the initial real exchange rate does not imply that either before 2001 or after 2001 we assume an unchanged real exchange rate. On the contrary, according to the logic of the model the real exchange rate remains unchanged only if the rate of depreciation equals the difference between domestic and foreign inflation, aside from Balassa-Samuelson effect. In May 2001, annual domestic and foreign inflation were around 10% and 2%, respectively, while the monthly rate of devaluation was 0.2%. If these values had been unchanged then the real exchange rate would have overvalued by $(10\% - 2\%) - 12 \times 0.2\% = 5.6\%$ during one year, or, by the same argument, it would have been weaker by almost the same value one year before (in May 2000).

The starting values of gap variables were initialized to be in line with our gap

[9] At the Magyar Namzeti Bank there is a research project in progress with the aim of estimating the real equilibrium exchange rate for Hungary using different approaches. At this time, however, we are hesitant as to what level to set as an equilibrium level.

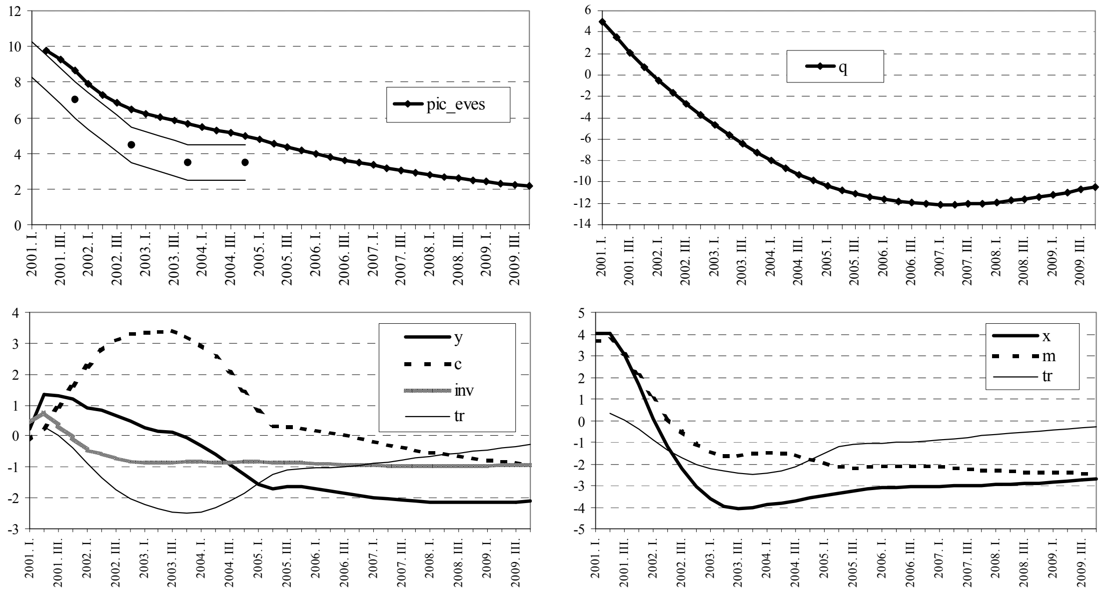
data. We ran our model from the second quarter of 2001. We incorporated into this scenario the effect of the fiscal and consumption boom starting from 2001 as well. As our model does not explicitly contain fiscal transfers, we translate the two sector boom into a household consumption boom only (stemming from increasing real wages, government transfers, mortgage expansion, etc.) that lasts for 4 years with a slow evolution, peaking at 3%, and a gradual decay. Until this time, this assumed shock traces the actual consumption gap fairly well (see **Graph A-1** in the appendix).

The results presented below are computed with our assumption (1), i.e. the initial real exchange rate is undervalued by 5%. The results with assumption (2) can be found in subsection 'Effects of the equilibrium real exchange rate assumption on the sacrifice ratio'.

The solution characterizes a slow disinflation process, that has a total 16.4% output loss measured by percentage of GDP. This implicates a 2.05 sacrifice ratio $(16.4/(10-2))$ that is higher than our previous model has, but still well lower than the values in the literature. In their paper Mankiw-Reis (2001) assume 7.5 citing Okun (1978) and Gordon (1997), who consider the sacrifice ratio in the United States to be between 6 and 18, and 6.4, respectively. At the Magyar Nemzeti Bank, Világi (2001) estimated an optimistic 1-1.3 sacrifice ratio for Hungary, citing the experiments of Portugal, Ireland and Spain in 1980s and 1990s. Nevertheless, in the experience of the cited countries the estimates for sacrifice ratios are 0.3-2.9 for Ireland, 0.1-2.0 for Portugal, 1.8-14.0 for Spain in 1980s, and 1.6-4.6, 1.1-1.6 and 1.2-7.1 in 1990s, respectively.

On the top left hand side graph one can find the year-on-year consumer price index (pic_eves), as well as the inflation targets and tolerance band of the Magyar Nemzeti Bank. The top right hand side graph shows the real exchange rate gap, i.e. the discrepancy between the equilibrium and actual real exchange rate. Finally, the bottom left and right side graphs depict the gaps of GDP components.

Graphs 1-4: Simulation results of Baseline



As **Table 1** illustrates, the unchanged nominal exchange rate fixed at the level of May 2001 yields the result that inflation would have decreased below 2.5% only after the second quarter of 2009. The 2% year-on-year rate of inflation is the rate of foreign, equilibrium inflation rate implying that over the long run domestic inflation will adjust to this value. As we have mentioned above, we defined the disinflation process as ended when average annual inflation falls below 2.5%, i.e. fulfils the Maastricht criteria.

In this scenario persistent inflation gradually overvalues the real exchange rate by 12%. This is a considerable 17% rise as we started from 5% undervaluation. This appreciation hinders investments and exports. The initial positive gaps of investments and exports are attributed to high foreign demand. Disinflation slows when the consumption boom peaks. Despite the decline in investments and exports, the consumption boom causes a positive aggregate output gap, therefore the inflation restraining forces are missing.

Interestingly, consumption does not share the cost of disinflation as can be seen in **Table 1**. This means that households remain shielded from the real exchange rate appreciation, while the external trade and investment sector are burdened with almost the total cost of disinflation 57.9 and 40.8 percent, respectively.

Table 1: Costs of disinflation

Assumption: the real exchange rate was undervalued by 5 percent in May 2001.

	Baseline (Unchanged exchange rate at level of May 2001 with consumption boom)	Exchange rate appreciation (+10%) with consumption boom	Exchange rate appreciation (+10%) without consumption boom	Exchange rate appreciation (+10%) with consumption tightening	Exchange rate at level of May 2001 with consumption tightening
	Percentage of 2001's GDP				
Consumption	-0,2	-6,4	-12,7	-15,9	-9,7
Investment	-9,5	-13,9	-11,0	-9,6	-5,2
Export	-29,9	-43,1	-34,6	-30,4	-17,1
Import	-23,2	-36,1	-34,4	-33,5	-20,7
Trade balance	-6,7	-7,0	-0,2	3,2	3,5
Output gap	-16,4	-27,3	-24,0	-22,4	-11,4
Sacrifice ratio	**2,05**	**3,41**	**3,00**	**2,79**	**1,43**
Date of reaching price stability*	2009.Q2	2007.Q3	2007.Q1	2006.Q3	2009.Q2
	The length of disinflation starting from 2001.Q1 in quarters				
	33	26	24	22	33
	Distribution of costs				
Consumption	-1,3%	-23,4%	-53,0%	-71,1%	-85,2%
Investment	-57,9%	-50,8%	-46,0%	-43,1%	-45,8%
Export	-182,6%	-158,0%	-144,2%	-135,8%	-149,7%
Import	-141,9%	-132,3%	-143,3%	-150,0%	-180,6%
Trade balance	-40,8%	-25,8%	-0,9%	14,2%	30,9%

* We defined price stability when the average annual inflation rate falls below 2.5 percent.

Scenario II: Exchange rate appreciation with a consumption boom

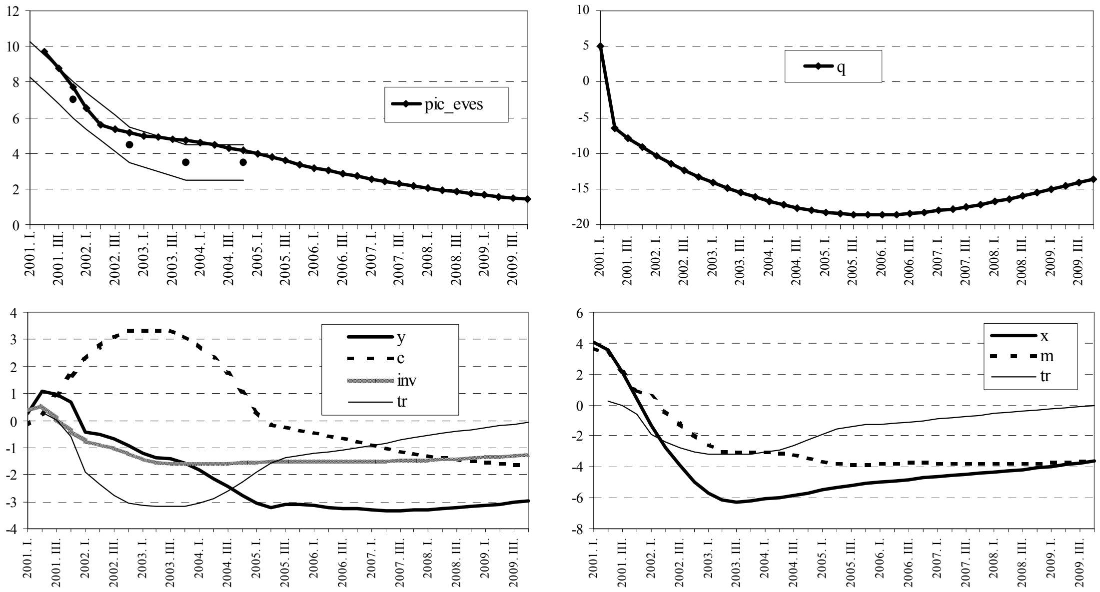
In this case we made only one change compared to the baseline scenario: we appreciated the nominal exchange rate by 10% permanently.

The stronger currency accelerates the disinflation process: average annual inflation decreases to 2.5% in the third quarter of 2007, representing a two year gain compared to the baseline scenario. But this faster disinflation comes at a higher cost. The total cost of disinflation amounts to around one-fourth of GDP (3.41 sacrifice ratio), that is higher by 1.36 percentage points than the corresponding ratio of the baseline, but still not an extreme value in the related literature. Confronting the two scenarios: the country incurs costs amounting to approximately one-tenth of GDP for the faster disinflation.

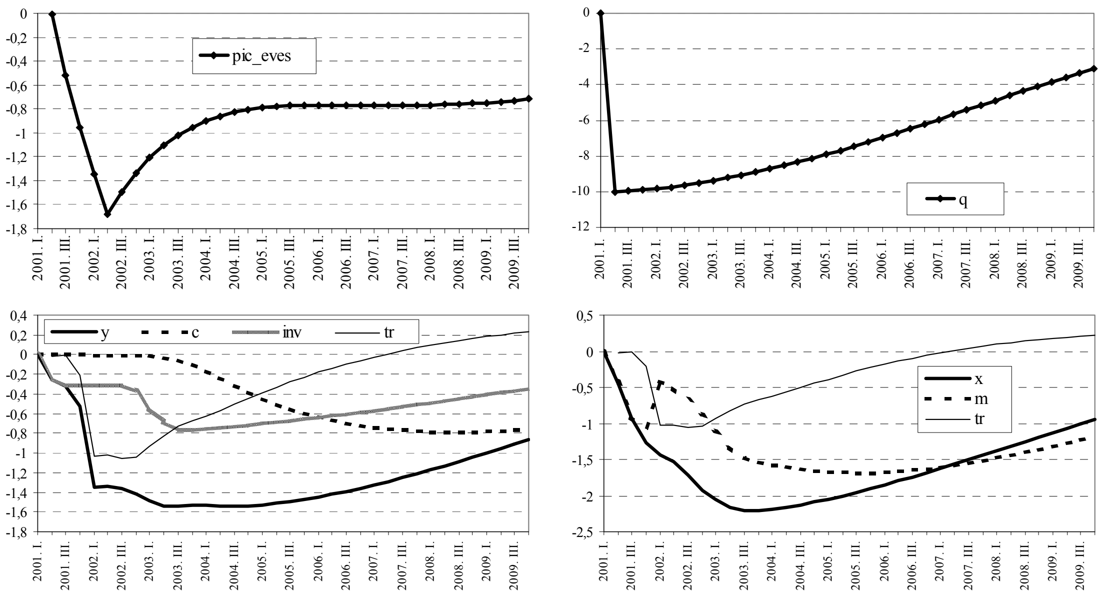
Disinflation has two phases. The first period of fast disinflation comes from pass-through triggered by the marked nominal exchange rate appreciation. The real effects of appreciation evolve in the first 1-1.5 year starting the second, costly phase. During the consumption boom the first phase remains intact, but in the second phase the necessary demand tightening is missing that restrains further disinflation. The new disinflation impulse starts only after the consumption boom. The side effect of the halt in disinflation generates even higher real appreciation, yielding further tightening in investments and exports. Nevertheless, the trade balance resulting from this process does not deteriorate so much, although exports decline by an additional 13.2 percentage points compared to the baseline, and imports decrease as well, as a consequence of lower domestic use.

The extra burden of nominal exchange rate appreciation is visible in the graphs that depict the difference from the baseline value. The mechanism is very similar. The stronger real exchange rate discourages investments and exports, yielding lower aggregated income, which also moderates consumption.

Graphs 5-8: Simulation results of scenario ‘Exchange rate appreciation (+10%) with a consumption boom’



Graphs 9-12: Simulated value of scenario ‘Exchange rate appreciation (+10%) with a consumption boom’, difference from Baseline



Scenario III: Exchange rate appreciation without a consumption boom

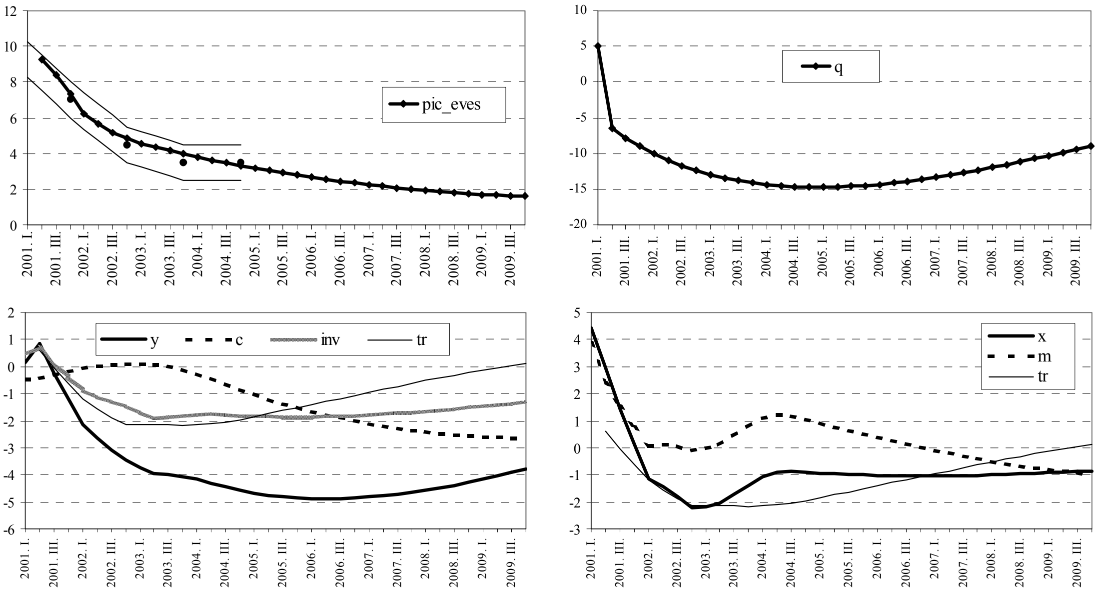
This scenario differs from scenario II, in the absence of a consumption boom only. Here we see disinflation with a lower cost, where the sacrifice ratio is 3.00. This variant not only has lower costs, but results in faster disinflation, as average annual inflation will have already dropped below 2.5 percent for first quarter of 2007, yielding a one-half year extra gain.

The graphs reflect that investments and exports drop less, thanks to faster disinflation that appreciates the real exchange rate less. However, the absence of a consumption boom results in some extra burden on households. Reduced demand curbs the trade balance deficit.

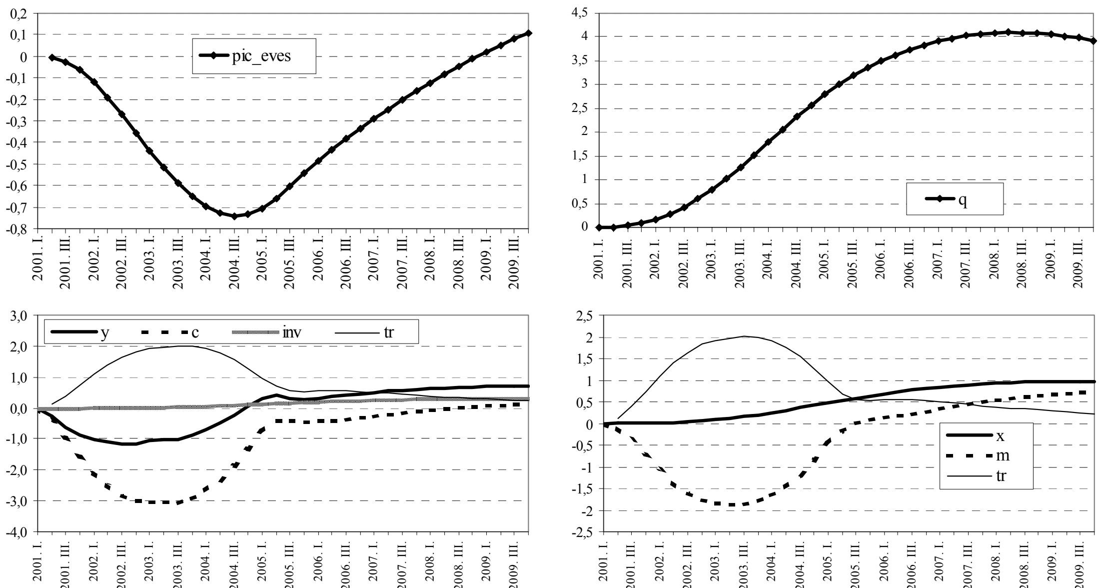
Table 1 shows that the total cost of disinflation is lower without a consumption boom. This reduces the total cost from 27.3% of GDP to 24.0%, representing savings of 3.3 percentage points. The distribution of cost changes significantly: the share of consumption roughly doubles (jumps from 6.4% to 12.7%), while the total burden on investments and exports eases to 11.0% and 34.6%, respectively, accompanied by a solid 0.2% trade deficit.

The graphs also reveal that in this scenario inflation evolves according to the target of the Magyar Nemzeti Bank over the entire time horizon. Comparing this to the inflation path of scenario II, which oversteps the upper tolerance band, it is quite obvious that the consumption boom is one of the main factors that can be blamed for the foreseeable missing of the target of 2003.

Graphs 13–16: Simulation results of scenario 'Exchange rate appreciation (+10%) without a consumption boom'



Graphs 17–20: Simulated values of scenario 'Exchange rate appreciation (+10%) without a consumption boom', difference from Baseline



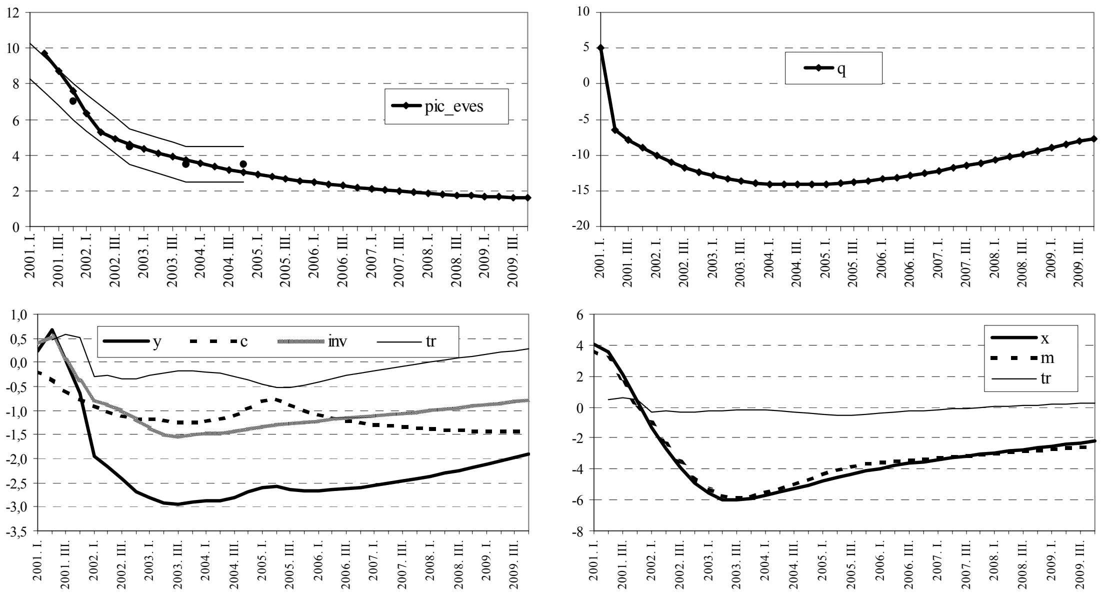
Scenario IV: Exchange rate appreciation with consumption tightening

We examined the hypothetical case of exchange rate appreciation being followed by consumption tightening. We supposed that the consumption tightening had the same shape as the consumption boom, but with a negative sign and half the size, thus the bottom of the consumption is at around -1.5% (see **Graph 23**).

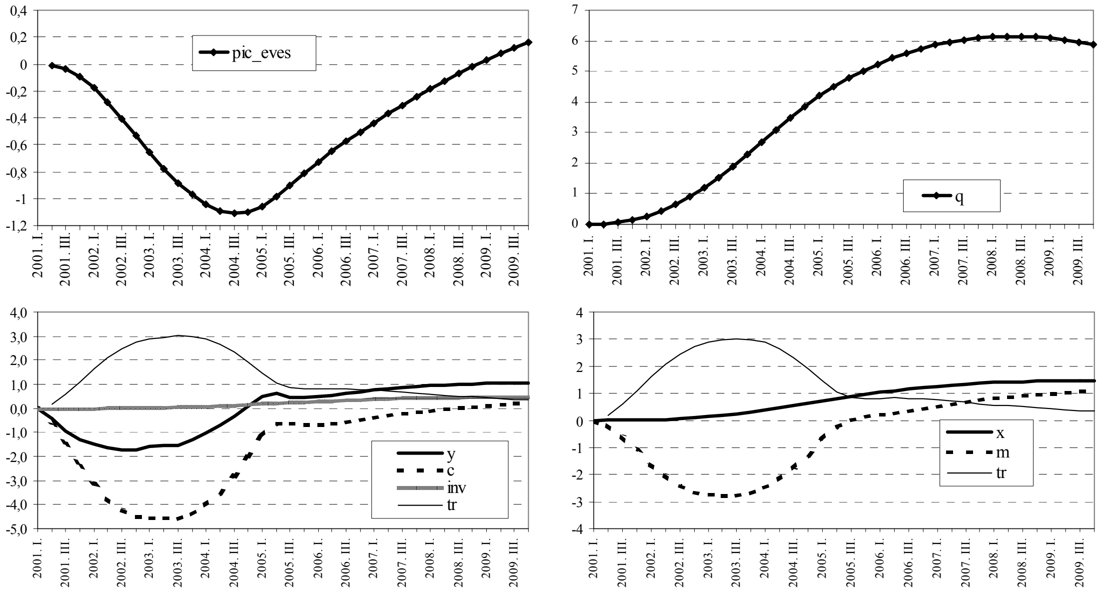
This simulation result confirms the lessons from scenario III. Consumption tightening would have assisted the disinflationary effects of exchange rate appreciation, that can further reduce the real appreciation, implying an even lower sacrifice ratio.

Table 1 shows that three-quarters of the burden falls on consumption, but parallel to this, investments and exports are relieved of a considerable portion of the costs.

Graphs 21–24: Simulation results of scenario 'Exchange rate appreciation (+10%) with consumption tightening'



Graphs 25–29: Simulated values of scenario 'Exchange rate appreciation (+10%) with consumption tightening', difference from Baseline



Scenario V: Consumption tightening without exchange rate appreciation

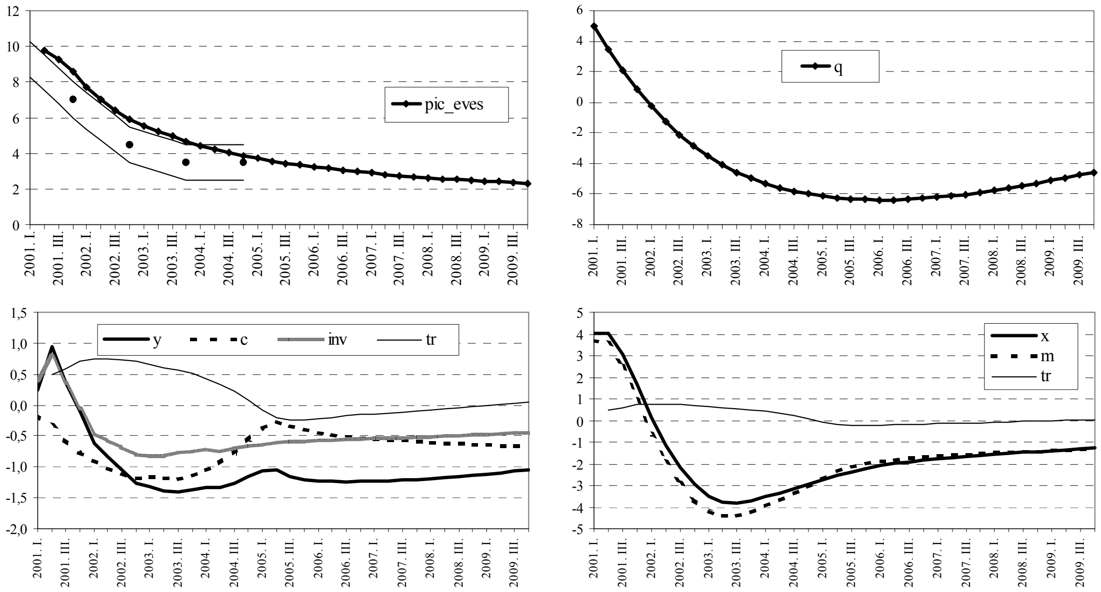
We saw in the previous scenario that if exchange rate appreciation is accompanied by consumption tightening then this latter assists bringing down inflation and moreover diminishes the total cost. Therefore, we investigated a case when there is consumption tightening, but no exchange rate appreciation.

This scenario is a good example of a situation when, by varying assumptions immoderately, the model produces wild prediction. If, for example, the exchange rate appreciates just by a very small degree, i.e. the nominal exchange rate is fixed at a low level, then an inflation boosting shock does not increase the cost and length of disinflation collaterally, it extends the cost only, while the speed of disinflation remains unchanged. The reason for this is the perfect credibility and the special monetary policy in the model; the latter determines not only the equilibrium inflation, but through the fixed exchange rate assumption the equilibrium price level as well. Under this circumstance, if the model is hit by an inflation increasing shock then after the shock fades out inflation must overshoot into the opposite direction in order to meet the price level criteria; however, the inflation criteria has already been met at the time of overshooting. Hence, this scenario is based on this model's arbitrary treatment of credibility, which assumes that rather then increasing them, an initial positive inflation shock reduces inflation expectations. This is because the markets trust completely in monetary policy and expect a reversal in inflation that returns the price level to its target set by the exchange rate.

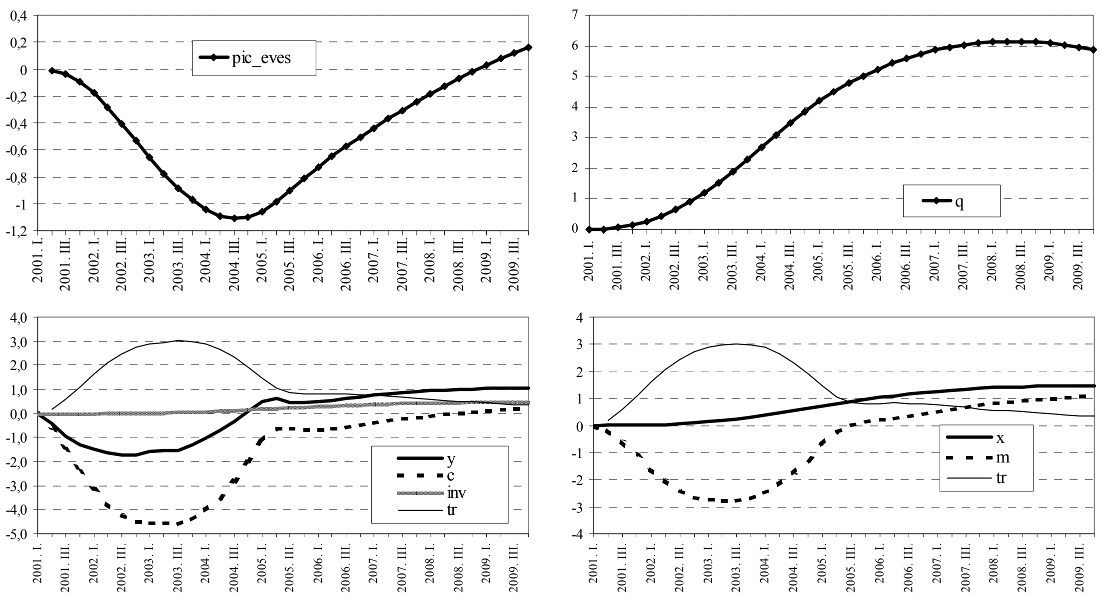
The results are very informative: the sacrifice ratio is fairly low (1.43), while disinflation does not accelerate. (Actually, similar to the baseline, average annual inflation only falls below 2.5 percent by 2009 Q2.) We already mentioned this kind of problem in section 2. In these models the longer the disinflation process is, the less expensive it is. This feature ensues from the model structure and the parameters assumed to be fixed. However, in reality the issue can rightly be raised, that a disinflation process lasting more than a decade involves varying parameters and ambiguous credibility.

Comparing this scenario to the baseline we can discover the reasons behind non-accelerating disinflation. Paradoxically, inflation broken down by the initial consumption tightening in the early periods results a slight appreciation only (at around 2008 the real exchange rate is undervalued by 6% relative to baseline), that can only bring down inflation modestly after the consumption tightening periods. Contrarily, it is the consumption boom that overvalues the real exchange rate in the baseline so much that it can be the driving force for disinflation in the subsequent periods.

Graphs 30–33: Simulation results of scenario 'Consumption tightening without exchange rate appreciation'



Graphs 34–37: Simulated values of scenario 'Consumption tightening without exchange rate appreciation', difference from the Baseline

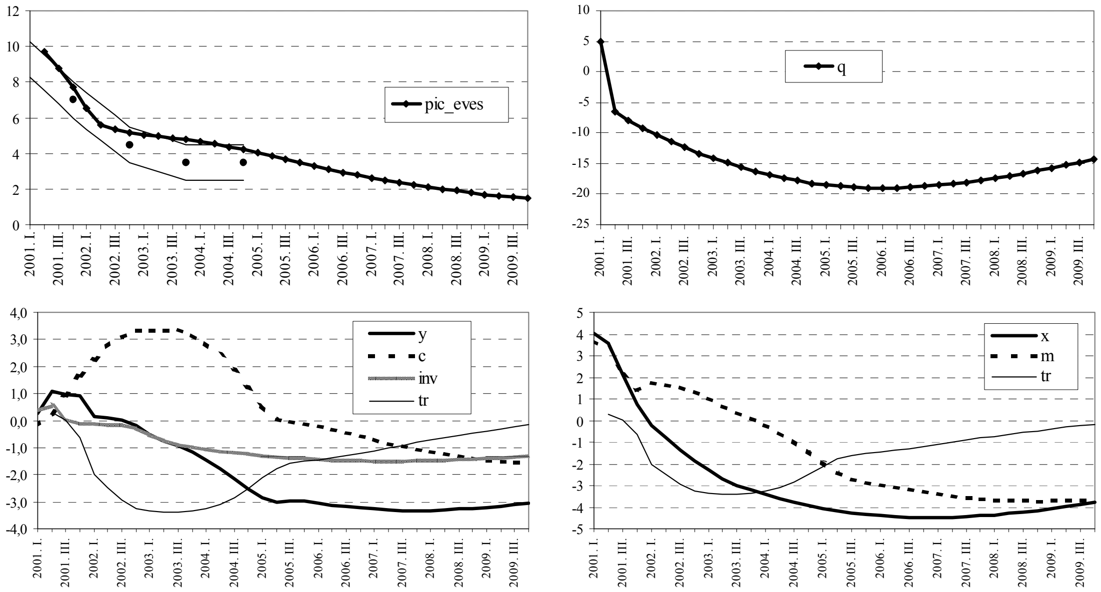


Scenario VI: Effect of a decline in foreign demand

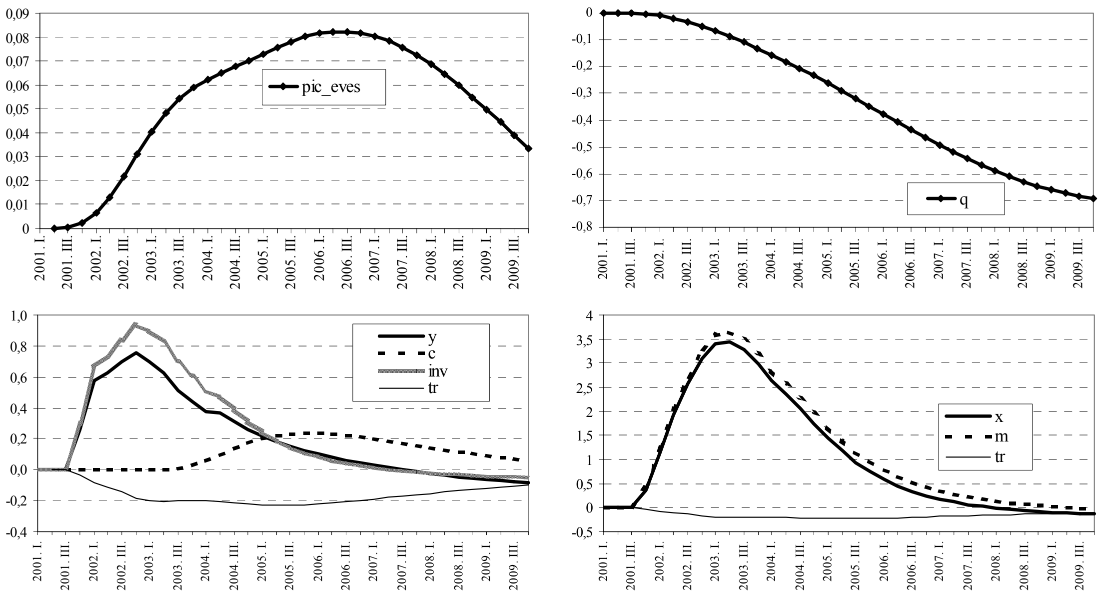
In the previous scenarios the model's gap variables were initialized according to data except for the real exchange rate, therefore each scenario covers the effects of the decline in foreign demand in the years 2001-2004. In this scenario we blocked off this fall, assuming an almost zero foreign demand gap for the entire simulation horizon. The modified foreign demand gap variables can be seen in **Graph 46**. The other starting values were taken from scenario II. Thus, the results can be compared to scenario II directly, but the differences between this and second scenarios give the same valid consequence due to the roughly additive nature of the model.

The main effect of the decline in foreign demand can be seen in **Graphs 42-45**. Obviously, in this hypothetical scenario, mainly in the years 2002-2003 investments and exports would not have been jeopardized so much, without the fall in foreign demand. Meanwhile, as expected, consumption has hardly been affected. Comparing the cost of disinflation in **Table 2** some conclusions can be drawn. On the model horizon the decline in foreign demand does not change the sacrifice ratio significantly (3.30 instead of 3.41), but there is a considerable change in the distribution of cost among the GDP components, as the fall increases the burden of investments and exports by 15.1% and 23.0%, respectively. This extra cost is even higher, if we calculate it for a shorter horizon until the end of 2003. In this period the decline in foreign demand doubles the loss in investments, and exports suffer a loss that is higher by two and a half times. In other words, 67% and 71% of the fall in investments and exports, respectively, can be attributed to the decline in foreign demand. Consequently, mainly over the short run one must not solely blame exchange rate appreciation for the present unpleasant stance of investments and exports; in contrast, one should note that the appreciation has caused only a minor part of the burden. This is a clear message for Hungary. Namely, the negative effect of appreciation on exports and investments is common talk, while the deterioration effect of the decline in foreign demand is usually neglected.

Graphs 38–41: Simulation result of scenario 'Effect of a decline in foreign demand'



Graphs 42–45: Simulated values, difference from scenario 'Exchange rate appreciation with a consumption boom'



Graph 46: The actual foreign demand and the assumption for scenario VI.

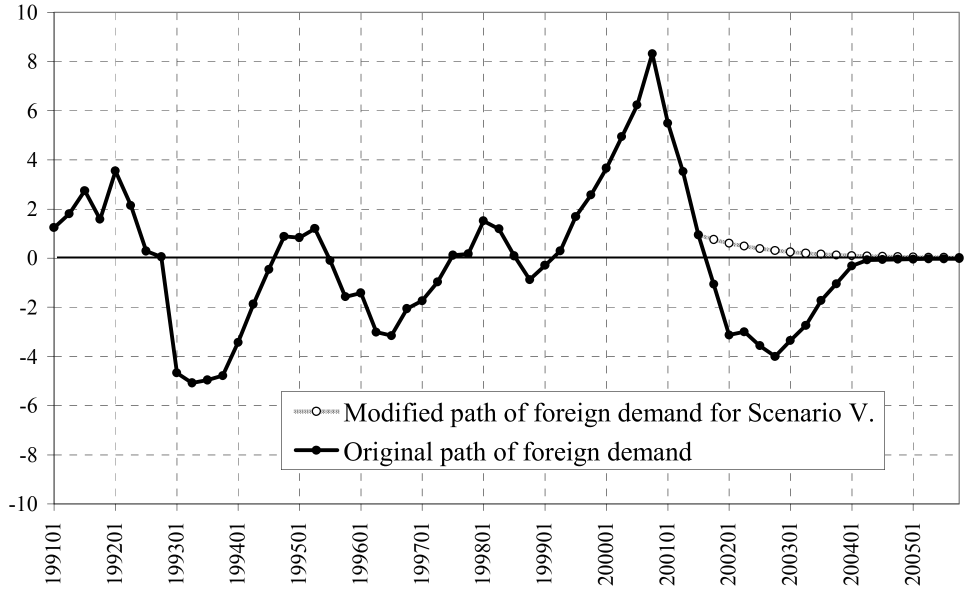


Table 2: The cost effect of a decline in foreign demand

	Entire horizon			Till the end of 2003		
	Exchange rate appreciation (+10%) with consumption boom and foreign demand decline	Exchange rate appreciation (+10%) with consumption boom without foreign demand decline	Excess burden due to decline in foreign demand (in percent)	Exchange rate appreciation (+10%) with consumption boom and foreign demand decline	Exchange rate appreciation (+10%) with consumption boom without foreign demand decline	Excess burden due to decline in foreign demand (in percent)
	Percentage of 2001's GDP					
Consumption	-6,4	-5,9	8,3%	6,9	6,9	-0,2%
Investment	-13,9	-12,0	15,1%	-2,4	-0,8	199,4%
Export	-43,1	-35,1	23,0%	-7,8	-2,2	247,2%
Import	-36,1	-26,6	35,8%	-2,0	3,9	-151,9%
Trade balance	-7,0	-8,5	-17,1%	-5,8	-6,1	-5,5%
Output gap	-27,3	-26,4	3,3%	-1,4	-0,1	2323,1%
Sacrifice ratio	**3,41**	**3,30**	**3,3%**			
Date of reaching price stability*	2007.Q3	2007.Q4				

* We defined price stability when the average annual inflation rate falls below 2.5 percent.

Effects of the equilibrium real exchange rate assumption on the sacrifice ratio

In presenting the baseline scenario, we mentioned that we assumed a 5% undervaluation in the real exchange rate in May 2001. Here, we present the results for the assumption that the real exchange rate was in equilibrium in May 2001. The first five columns of **Table 3** show the simulation results with this assumption in the same structure as **Table 1**. The last column presents the deviations from scenarios calculated with 5% undervalued real exchange rate assumption, that holds for each scenario.

Table 3: Cost of disinflation

Assumption: the real exchange rate was in equilibrium in May 2001.

	Baseline (Unchanged exchange rate at level of May 2001 with consumption	Exchange rate appreciation (+10%) with consumption boom	Exchange rate appreciation (+10%) without consumption boom	Exchange rate appreciation (+10%) with consumption tightening	Exchange rate at level of May 2001 with consumption tightening	Deviation from scenarios with assumption 5% undervaluation
	Percentage of 2001's GDP					
Consumption	-3,5	-9,6	-16,0	-19,1	-13,0	-3,2
Investment	-11,9	-16,3	-13,5	-12,1	-7,7	-2,4
Export	-36,6	-49,9	-41,4	-37,1	-23,9	-6,7
Import	-29,9	-42,7	-41,0	-40,2	-27,3	-6,7
Trade balance	-6,7	-7,1	-0,3	3,1	3,5	-0,1
Output gap	-22,1	-33,0	-29,7	-28,1	-17,2	-5,7
Sacrifice ratio	**2,76**	**4,13**	**3,72**	**3,51**	**2,15**	**0,72**
Date of reaching price stability*	2008.2Q	2007.Q1	2006.Q2	2005. Q4	2007. Q3	
The gained periods from earlier reaching of price stability*	4Q	2Q	3Q	3Q	7Q	
	Distribution of costs					
Consumption	-15,6%	-29,1%	-53,7%	-68,1%	-75,6%	
Investment	-53,8%	-49,4%	-45,3%	-42,9%	-44,6%	
Export	-165,7%	-151,0%	-139,0%	-132,0%	-138,9%	
Import	-135,2%	-129,5%	-138,0%	-143,1%	-159,1%	
Trade balance	-30,5%	-21,5%	-1,0%	11,0%	20,1%	

* We defined price stability when the average annual inflation rate falls below 2.5 percent.

The common consequence of changing the initial real exchange rate assumption is that the stronger the initial real exchange rate is, the faster disinflation is. The reason behind this is that the stronger real exchange rate causes higher output loss, and that loss dampens inflation. The total cost of disinflation grows by 5.7 percentage point of GDP in each scenario. In the first four cases the length of disinflation becomes shorter by roughly one-half to one year. Only in the last case do we see remarkably shorter disinflation, due to the combination of an initially fairly low exchange rate and consumption tightening offsetting each other. Hence, assuming a stronger real exchange rate yields faster disinflation than in the baseline scenario. However, it holds that the consumption tightening delivers faster and cheaper disinflation.

Comparing the costs it is clear why we do not want to assess the absolute level of sacrifice ratio but only the relative levels, as the absolute values of sacrifice ratios depend on the initial real exchange rate level assumption, which is fairly ambiguous as we have mentioned before. Conversely, any change in the initial real exchange rate assumption affects each scenario uniformly; hence the ranking of the sacrifice ratio does not change.

4 Policy conclusion

Although, the numerical results are interesting in their own right, the main conclusions can be drawn from the comparison of the different scenarios.

Comparing the sacrifice ratio and the length of disinflation, we can not rank the baseline scenario and scenario II, as neither of them dominates the other one.

Scenario III dominates scenario II, because it has a lower sacrifice ratio and a shorter disinflation period as well, while scenario IV dominates II and III for the same reason. From **Table 1** one can see that the total loss is 22.4% of GDP in scenario IV, compared to 27.3% in scenario II; moreover, the disinflation period is shorter by 5 periods. The lesson is straightforward: *disinflation is cheaper and faster when demand tightening reaches every sector, in other words when the monetary and fiscal policy are harmonized.*

Each scenario also differs in the distribution of sacrifice. The consumption boom may reduce the total sacrifice of households to 6.4% from 12.7%, comparing the exchange rate appreciation to the unchanged exchange rate case. But this 6.3 percentage point reduction of households sacrifice involves a decrease of 8.2% in the assets of households[10] as a percentage point of GDP, an additional 2.9% burden on investment and a 6.8% burden on external trade balance, yielding a total 17.9% decrease in the assets of the country. This asset-decrease will lower potential income in the future. We may argue that this is the total cost of protecting households from the burden of a sudden decline in their consumption. However, this argument is very poor. Is it really acceptable to consume 6.3% of GDP while we loose a further 11.3%, i.e. to devote a total of 17.9% in exchange for 6.3%?

Another informative result is that as a consequence of the consumption boom *even if the exchange rate had remained at its May 2001 level, then disinflation would have involved a considerable cost*. The reason for this is stagnating inflation due to excess demand that overvalues the real exchange rate.

Finally, decomposing the effect of certain factors on the development of investments and exports, we can conclude that at least two-thirds of the drop in investments and exports is caused by the decline in foreign demand and at most only one-third can be attributed to nominal exchange rate appreciation during the period 2001-2003.

[10] The several-year consumption boom peaking at 3% requires an extra 8.3% spending, yielding a decrease of the same measure in the assets of households.

References

Ball, Laurence [1994]:What Determines the Sacrifice Ratio. In Monetary Policy, Edited by Mankiw, N. Gregory, The University of Chicago Press, pp. 155-193.

Bankim, Chada – Masson, Paul R. – Meredith, Guy [1992]: Models of Inflation and the Costs of Disinflation. International Monetary Fund Staff Papers, No 39, pp. 395-431.

Batini, Nicoletta – Haldane, Andrew [1999]: Forward-Looking Rules for Monetary Policy. In Monetary Policy Rules, Edited by Taylor, John B., pp. 157-201.

Benczúr Péter [2003]: The Behavior of Nominal Exchange Rate at the Beginning of Disinflations. MNB Working Paper, 2003/1.

Benczúr Péter – Simon András – Várpalotai Viktor [2002]: Disinflation Simulation with Small Macromodel. MNB Working Paper, 2002/4. (available only in Hungarian)

Gordon, Robert J. [1997]: The Time-Varying Nairu and Its Implications for Economy Policy. Journal of Economic Perspectives, Winter, pp. 11-32.

Mankiw, N. Gregory – Reis, Ricardo [2001]: Sticky Information Versus Sticky Prices: a Proposal to Replace the New Keynesian Phillips Curve. NBER Working Paper, No 8290.

Okun, Arhtur [1978]: Efficient Disinflationary Policies. American Economic Review, 68(2), pp. 348-352.

Svensson, Lars E. O. [1998] Open Economy Inflation Targeting. CEPR Working Paper, No 1989.

Svensson, Lars E. O. [2000] Open Economy Inflation Targeting. Journal of International Economics, 50(1), pp. 155-184.

Várpalotai Viktor [2002a]: Disaggregated Cost Based Econometric Inflation Forecasting model. MNB Working Paper, 2003/4.

Várpalotai Viktor [2002b]: Numerical Methods for Estimating Economic Data. Statisztikai Szemle, 2002/9. (available only in Hungarian)

Világi Balázs [2001]: The Real Costs of Disinflation. MNB mimeo. (available only in Hungarian)

Appendix

A Source data and data manipulation

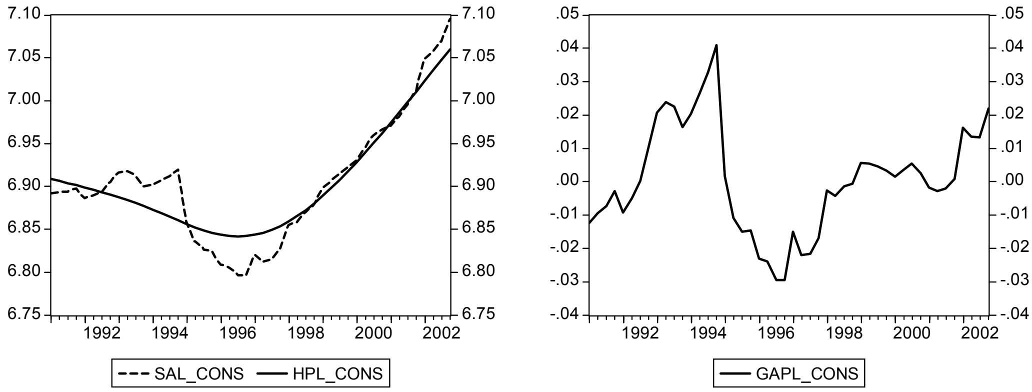
Our source data are the quarterly GDP statistics available officially from 1995 Q1 released by the Hungarian Central Statistical Office. However, there is an estimated quarterly GDP table for the period from 1991 Q1 to 1994 Q4 also (see in Várpalotai (2002a)); by putting these two databases together it is possible to obtain homogeneous data from 1991 Q1 to 2002 Q4 at this time. The foreign demand index is a weighted average of the GDPs of Hungary's external trade partners using the import-export turnovers as weights. The real exchange rate index is based on consumer price indices. Each variable in the model is logarithmised.

The gap variables of the model have been defined as follows. First, the GDP components (c consumption, inv investments, g government consumption, x exports and m imports) and the foreign demand have been seasonally adjusted, and then they have been Hodrick-Prescott filtered ($\lambda = 1600$). In the next step, we have calculated gaps as the difference of the seasonally-adjusted and the HP-filtered series. Thereby, we have the 'raw' gap series in terms of a (logarithmic) percentage difference from the Hodrick-Prescott trend. However, in order to define the GDP components' gaps as a percentage of GDP and to fulfill the GDP identity $y = c + inv + g + x - m$, the raw gap series have been multiplied by the ratio of the Hodrick-Pescott trends of the raw gap variable and GDP.

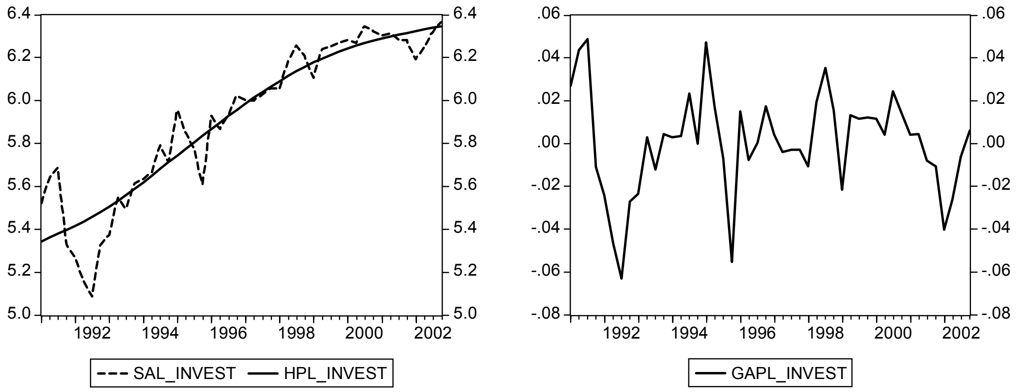
For the real exchange rate gap we followed an alternative strategy. We estimated a *linear trend* for the period 1997 Q1 - 2001 Q1, that can be thought of as a relatively stable period, as the nominal exchange rate always moved along with the stronger end of the flotation band. We have used this trend to project it to the rest of the periods defining the misalignment in real exchange rate measured in percentage points. Practically, we have tried to filter out the Balassa-Samuelson effect by this simple linear trend.

The next graphs show the gap variables defined above. In each line the graphs on the left hand side depict the logarithmised, seasonally adjusted (with prefix SAL_) and its Hodrick-Prescott trend series (with prefix HPL_), while on the right hand side the gap variable can be seen (with prefix GAPL_), i.e. the difference of the two series of the left hand side comprising the transformation mentioned above also.

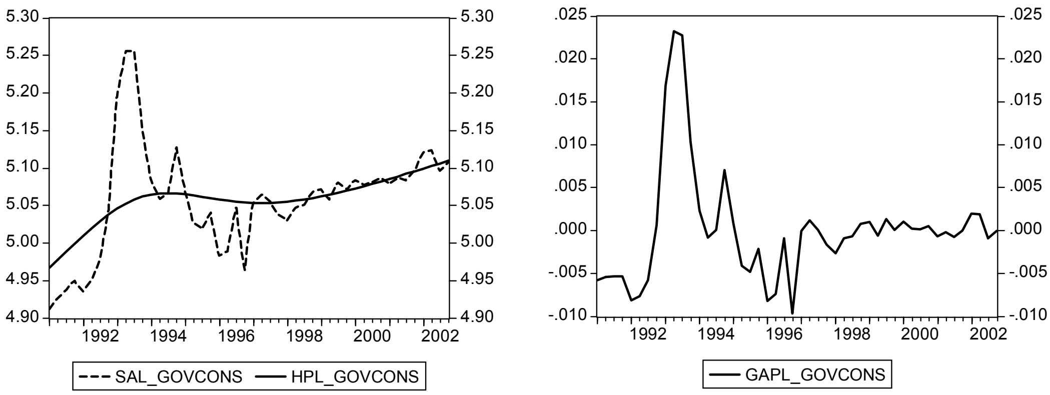
Graph A-1.: Consumption of Households



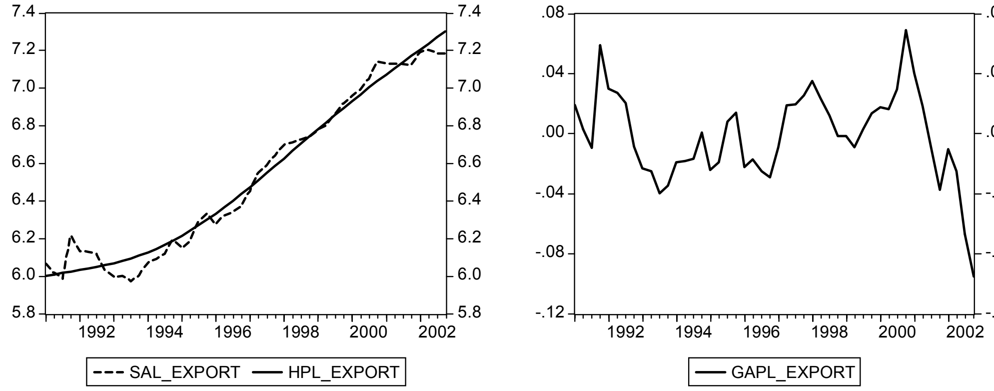
Graph A-2.: Investment



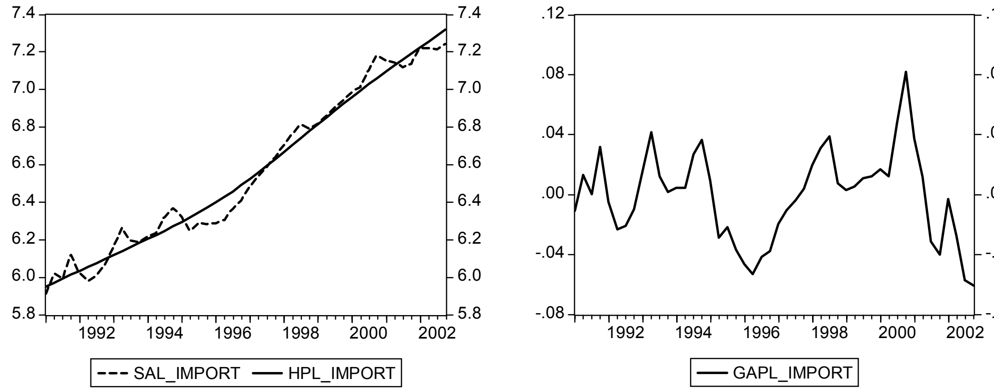
Graph A-3.: Government consumption



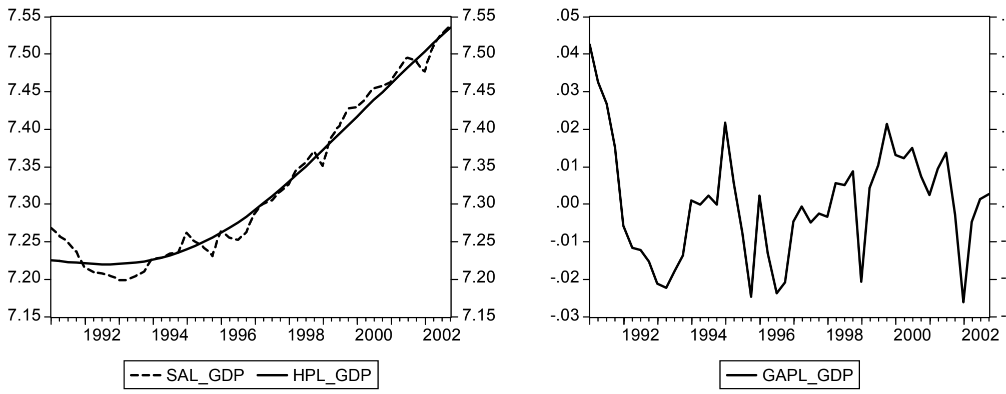
Graph A-4.: Export



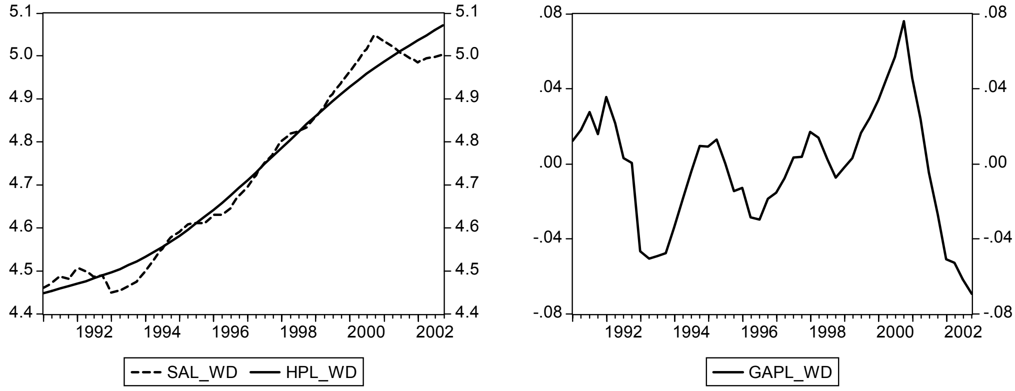
Graph A-5.: Import



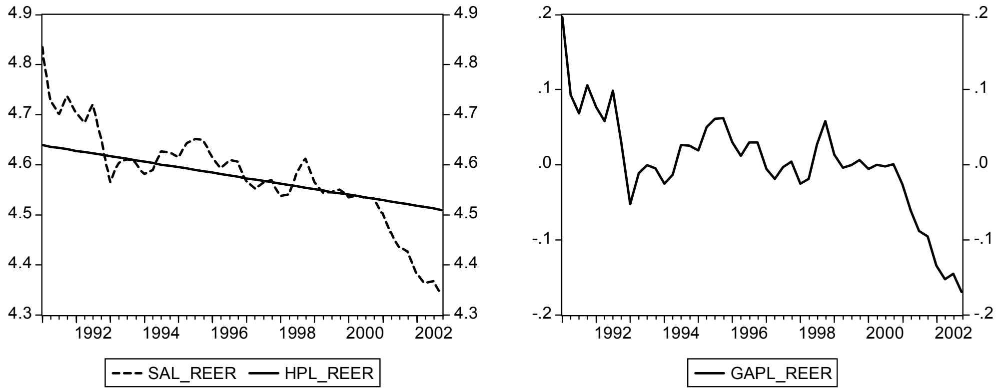
Graph A-6.: GDP



Graph A-7.: Foreign demand



Graph A-8.: Consumer price index based real exchange rate



B Estimation technique of behavioral equations of gaps

The behavioral equation has been defined in terms of the following general distributed lag formulae: (Here v denotes the dependent variable, while z_j-s mark the independent variables.)

$$v_t = \beta + \beta_{AR} \cdot v_{t-1} + \sum_{i=0}^{T_1} \beta_{1,i} \cdot z_{1,t-i} + \sum_{i=0}^{T_2} \beta_{2,i} \cdot z_{2,t-i} + ... + \sum_{i=0}^{T_n} \beta_{n,i} \cdot z_{n,t-i} + \varepsilon_t. \quad (13)$$

For this formula we defined smoothness priors and posed some sign constraints. The smoothness priors formalize our a priori information that the parameters of lagged variables can vary from a lag period to other only gradually. This kind of variability has been captured by the form below:

$$\sum_{j=1}^{n} w_j \sum_{i=1}^{T_j-1} \left[\left(\beta_{j,i} - \beta_{j,i-1}\right) - \left(\beta_{j,i+1} - \beta_{j,i}\right) \right]^2, \tag{14}$$

where w_j is the weight of the variability of independent variable j-th, that has to be calibrated. Technically, the estimation with smoothness priors is analogous to the ordinary least square method, it differs only in part $\boldsymbol{\beta}'\mathbf{S}\boldsymbol{\beta}$ that 'measures' the smoothness:

$$\begin{aligned} &\min_{\beta} (\mathbf{v} - \mathbf{Z}\boldsymbol{\beta})'(\mathbf{v} - \mathbf{Z}\boldsymbol{\beta}) + \boldsymbol{\beta}'\mathbf{S}\boldsymbol{\beta} \\ &\text{s.t.} \quad \langle \boldsymbol{\phi} \rangle \, \boldsymbol{\beta} \geq \mathbf{0}, \end{aligned} \tag{15}$$

where $\mathbf{v}$ is the vector of dependent variable, $\mathbf{Z}$ is the data matrix of the independent variables, $\boldsymbol{\beta}$ is the vector of parameters to be estimated, $\mathbf{S}$ is the matrix formula of (14) that measures the smoothness, $\boldsymbol{\phi}$ is the vector for sign constraints (its elements are either 1 or -1), and $\langle \boldsymbol{\phi} \rangle$ is a diagonal matrix made from vector $\boldsymbol{\phi}$. Moreover, $\mathbf{S} = \mathbf{W}\mathbf{Q}$, where $\mathbf{W} = \mathbf{w} \otimes \mathbf{I}$ and $\mathbf{Q} = \mathbf{P} \otimes \mathbf{I}$, where $\mathbf{I}$ is the identity matrix, $\mathbf{w}$ is the vector made from the w_i weights and finally $\mathbf{P}$ is a matrix, where:

$$\mathbf{P} = \begin{bmatrix} 1 & -2 & 1 & 0 & \dots & \dots & \dots & 0 \\ -2 & 5 & -4 & 1 & 0 & \dots & \dots & 0 \\ 1 & -4 & 6 & -4 & 1 & & & \vdots \\ 0 & 1 & -4 & 6 & \ddots & \ddots & & \vdots \\ 0 & 0 & 1 & \ddots & \ddots & \ddots & 1 & 0 \\ \vdots & & & \ddots & \ddots & 6 & -4 & 1 \\ 0 & \dots & \dots & 0 & 1 & -4 & 5 & -2 \\ 0 & \dots & \dots & \dots & 0 & 1 & -2 & 1 \end{bmatrix}. \tag{16}$$

For the estimation we used quadratic problem (15). In the following we show the estimated distributed lag profiles. The lags increase from left to right in the graphs below. The sum of the estimated lag coefficients, or in other words the pass-through parameters, can be interpreted as a total but gradual response of the dependent variable to a one-time 1 percent shock in a dependent variable (disregarding the multiplicator effect).

All the lag coefficients presented below are estimated, we have not imposed any constraint on parameters (except sign constraints). The estimated autoregressive coefficients and the sum of lag parameters are reported in **Table A-1**. The fit of our estimation is shown in **Graph A-9-1**. The distributed lag profiles are depicted on **Graph A-13-16**. The single-equation impulse response functions are shown in **Graph A-17-20**, where one can follow the effects of a permanent 1 percent increase of each of the independent variables.

Table A-1.: The fit and coefficients of the estimated behavioral equations

	β_{AR}	$\Sigma\beta_y$	$\Sigma\beta_{wd}$	$\Sigma\beta_q$	$\Sigma\beta_c$	$\Sigma\beta_{inv}$	$\Sigma\beta_g$	$\Sigma\beta_x$	R^2
c	0,86	0,08	–	–	–	–	–	–	0,86
inv	0,07	–	0,16	0,07	–	–	–	–	0,41
x	0,50	–	0,35	0,12	–	–	–	–	0,86
m	–	–	–	-0,11	0,64	0,65	0,38	0,90	0,94

The form of the behavioral equation of household consumption gap to be estimated is: $c_t = \beta^c + \beta^c_{AR} \cdot c_{t-1} + \sum_{i=0}^{11} \beta^c_{y,i} \cdot y_{t-i}$. The autoregressive parameter of consumption gap is very high, that refers to the permanence of the consumption cycles. The sum of the income pass-through parameters is low, which at first sight could be interpreted to mean that income influences consumption only moderately. However, this weak effect is amplified by the autoregressive coefficient, that is a one-off 1 percent increase in income yields prolonged excess consumption of a total of 0.56 percent.

The form of the behavioral equation of the investment gap we have estimated is: $inv_t = \beta^{inv} + \beta^{inv}_{AR} \cdot inv_{t-1} + \sum_{i=0}^{11} \beta^{inv}_{wd,i} \cdot wd_{t-i} + \sum_{i=0}^{11} \beta^{inv}_{q,i} \cdot q_{t-i}$. Although the estimated parameters reflect the sensitivity of investment to foreign demand and real exchange rate, still these coefficients are fairly low. There are at least two reasons for this: (1) In order to ensure that GDP components sum up to GDP without any discrepancy, we add the change in inventories data to investment, that is heavily burdened with statistical problems and errors in Hungary. (2) The investment data comprise three types of underlying investment component realized by households, enterprises and government.

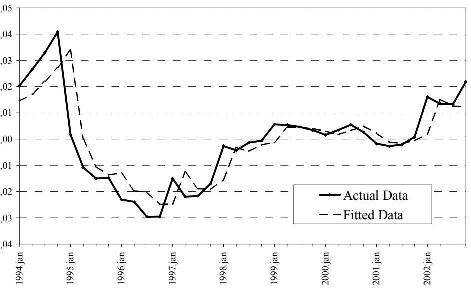
Unfortunately, these components have been following a completely different path in recent years: household and government investments have increased, while those of entrepreneurs have collapsed. These antagonistic developments extinguished at the aggregated level might be the second reason for the low parameters.

The form of the estimated behavioral equation of the export gap has been: $x_t = \beta^x + \beta^x_{AR} \cdot x_{t-1} + \sum_{i=0}^{11} \beta^x_{wd,i} \cdot wd_{t-i} + \sum_{i=0}^{11} \beta^x_{q,i} \cdot q_{t-i}$. The autoregressive coefficient of export gap is relatively high, and the gap is very sensitive to any change in foreign demand and real exchange rate as well. Over the long run, a 1 percent increase in foreign demand boosts exports by 0.70 percent, whilst every 1 percent depreciation in the real exchange rate lifts exports by 0.24 percent (in other words this is the real exchange rate elasticity of exports). The shape of the impulse response function reflects a sharp contrast: exports follow the foreign demand immediately, but the effect of a change in real exchange rate appears with long lag only.

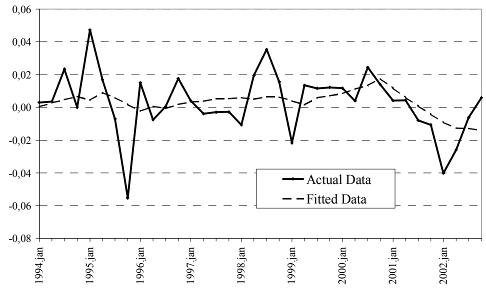
We have dropped the autoregressive parameter in the behavioral equation of the import gap, which is consistent to our approach that we model imports as a need for foreign goods arising from the rest of the GDP components: $m_t = \beta^m + \sum_{i=0}^{11} \beta^m_{c,i} \cdot c_{t-i} + \sum_{i=0}^{11} \beta^m_{inv,i} \cdot inv_{t-i} + \sum_{i=0}^{11} \beta^m_{g,i} \cdot g_{t-i} + \sum_{i=0}^{11} \beta^m_{x,i} \cdot x_{t-i} + \sum_{i=0}^{11} \beta^m_{q,i} \cdot q_{t-i}$. According to this, the sums of each estimated GDP component parameter can be interpreted as the marginal import contents. The sum of the parameters of the real exchange rate means the real exchange rate elasticity of imports. The effects of each GDP component on imports are pretty fast, as can be seen on the impulse response functions.

Graph A-9-12: The fit of estimations

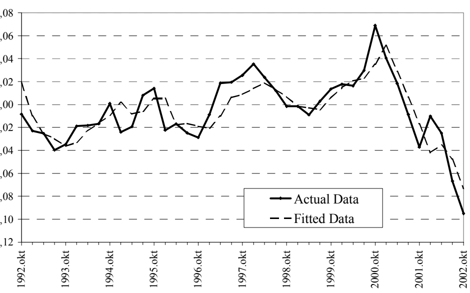
Consumption of households



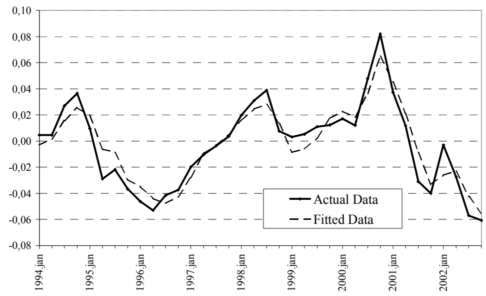
Investment



Export

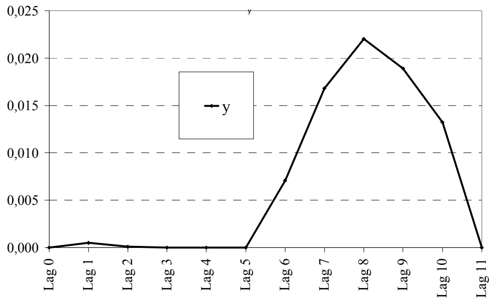


Import

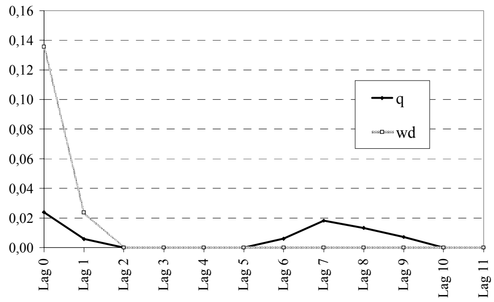


Graph A-13-16: The estimated distributed lag parameters

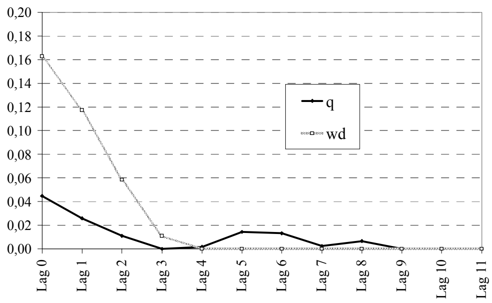
Consumption of households



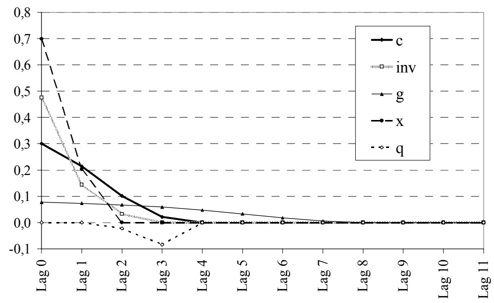
Investment



Export



Import



Graph A-17-20: Single-equation impulse response functions