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**EXTERNAL FACTORS  
IN CZECH DISINFLATION  
(DYNAMIC ANALYSIS)**

**VP č. 35  
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The views and opinions expressed in this study are those of the author  
and are not necessarily of the Czech National Bank



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After the monetary turbulence in May 1997, the Czech National Bank (CNB) decided to abandon the exchange rate band and to let the Czech koruna float freely. Later in December 1997, the CNB adopted direct inflation targeting. The experiences with this type of monetary policy have been summarised in the booklet, *Inflation targeting in transition economies: The case of the Czech Republic*, edited by the CNB and the IMF in March 2000.

In this paper, one aspect of inflation targeting has been scrutinised – the impact of both internal and external factors on the inflation rate. **The starting point for this study is the extended Phillips curve (PC) models.**

In the introductory part of the paper<sup>1</sup>, some possible extended PC models from the literature are presented and discussed.

In the following part (section 2), possible candidates for explaining the movement of the inflation rate are enumerated using monthly data. The data are grouped into four categories – production, wages, domestic prices and external influences. Unit root tests reveal that monthly data, used mainly in the form of year-on-year changes, are integrated of order 1, hence their first differences are stationary. A look at the cross correlograms of net inflation and the explanatory

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<sup>1</sup> The views and opinions expressed in this study are those of the author and are not necessarily those of the Czech National Bank. I would like to thank J. Arlt, A. Derviz, T. Holub, J. Hošek, H. Janečková and M. Mandel for their invaluable comments. Any remaining inadequacies are, of course, mine alone.



variables indicate the clearly decisive role of external factors in influencing the time pattern of the inflation rate.

The main reason for utilising monthly data is to study more profoundly the correct temporal linkages between the variables. Therefore in section 3, the interim multipliers from some distributed lag models (finite and polynomial distributed lag models) are calculated and compared for net inflation as well as for import prices.

The more sophisticated part of the dynamic analysis (more equation systems) deals with the kit of tools from the vector autoregression (VAR) analysis – the impulse response functions and variance decomposition applied to the equations with import prices and the nominal effective exchange rate.

In the final part of the paper, some conclusions from the analytical parts are drawn, and the results are compared with those of some studies from abroad.

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# 1 Introduction

The Phillips curve can be interpreted very generally as the “triangle” model of inflation (Gordon, 1997) – a label summarising the dependence of the inflation rate on three basic determinants: inertia, demand and supply with the inflation expectations as the fourth possible determinant:

“The term Phillips curve is used here to cover models that directly relate nominal price or wage inflation to some measure of excess demand or real disequilibrium, conventionally measured as either an unemployment or an output gap” (Economic models at the Bank of England, 1999, p. 77).

This traditional definition stresses the original meaning of the PC – to capture shifts along the curve and to offer politicians a trade-off between the inflation rate and the unemployment rate in the short run. Later, possible shifts of the PC due to changing expectations and supply factors enriched the presentation of the PC models, and the extended versions were formulated.

The extended PC model suitable to our purposes can be written as follows:

$$p_t = A(L)p_{t-1} + B(L)p_{t+1}^e + C(L)(y_t - y_t^*) + D(L)X_t \quad (1)$$

On the left side of the equation, we have the inflation rate  $p_t$  (other potential candidates are nominal wages, real unit labour costs, etc.), whereas on the right side

we have past inflation  $p_{t-1}$ , expected<sup>2</sup> inflation  $p_{t+1}^e$ , the output gap  $(y_t - y_t^*)$  and predetermined variables  $X_t$  that help predict future inflation. Three lag polynomials  $A(L)$ ,  $C(L)$ ,  $D(L)$  and one forward polynomial  $B(L)$  should help to reveal the correct temporal linkages between the variables on the right side and the inflation rate on the left side.

Many types of PC models in the literature are special cases of this general model. Especially in American literature, the linchpin of virtually every model is the “output gap” as the main factor influencing the inflation rate. Monetary policy in this “large, closed economy” should influence the magnitude of the output gap through the movement of the interest rate.

**In a small, open economy changing from a command-type economy to a full-fledged market economy, the importance of an output gap after the elapse of a few years only is very difficult to judge.** What is worth mentioning here is the partial conclusion from a paper by Aгенor and Hoffmaister.

“The stylized facts may be suggesting that as developing countries mature into more advanced countries, business cycle factors may tend to exert greater influence on the labour market and wages, making inflation more consistent with an output gap model of inflation.”, 1997, p. 27.

Hence, the impact of an output gap on inflation will probably be felt more in the Czech Republic after the elapse of at least two business cycles.

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<sup>2</sup> Modelling expectations is not an easy task. With monthly data, the choice is between adaptive expectations based on the CPI and the extraction of inflation expectations based on the yield curve. The surveys have been conducted since May 1999, and hence, their series is very short. As concerns the yield curve, Matalík and others assert, “At present the future level of inflation cannot be predicted using the yield curve spread (Pribor) as inflation expectations are mainly influenced by actual inflation development.” Finance a úver, 8/1999, p. 465.

Sobczak (1998) has used in Spain as a proxy of inflation expectations interest rate differentials with Germany, which should reflect differences in inflation expectations between the two countries. Assuming as a first approximation that inflation expectations have been roughly constant in Germany during a certain period, then changes in spreads should reflect changes in Spain’s inflationary expectations.

The experiments with a twelve-month moving average of past CPI inflation rates in the Czech Republic (expectations proxy in the adaptive expectations framework – see Lardaro, 1993, p. 112) offered as the “best” equation:

$$n_t = -0.15 + 2.48 \text{ cpiex}_{t+1} + 1.18 \text{ cpiex}_{t+2} + 0.69 \text{ cpiex}_{t+6}$$

t=-2.97    5.75                    2.68                    1.76

$R^2_{\text{bar}} = 0.49$       LM test (F=0.46 P=0.64)

Haldane (1997) presented a standard expectational forward-looking PC model (the second and third item in equation 1). Ball (1999) preferred an open economy PC model with the change in the exchange rate as a special item on the right side. The Bank of England (1999) has, in addition to the output gap, an unemployment gap on the right side as well. The Israeli model (Djivre, Ribon, 2000) has captured the effects of supply shocks by using the lagged growth rate of nominal wages and the rate of change of the dollar price of intermediate goods. Isard and Laxton (2000) in their model of the Czech economy have put import prices (with the weight of one quarter) as the first item on the right side of the PC equation (the weight of three quarters has been given to expected inflation). This list of models could go on and on.

For the purposes of this paper, what is worth noting is that

“... the current unemployment gap is only one of many explanatory variables in the PC equation. The presence of lags of the inflation rate in the equation suggests that inflation may decelerate because expected inflation is falling, even if the unemployment rate is below the natural rate of unemployment. Similarly, if there have been favourable supply shocks, inflation in the future may decelerate even though the unemployment rate is well below the natural rate.”, Estrella, Mishkin, 1999, p. 409. This last sentence describes very succinctly the development in the Czech Republic during the last few years.

Sobczak's paper (1998) investigates the causes of the recent disinflation in Spain. In his standard Phillips curve model, three major aggregate shocks could explain the fall in inflation: an adverse demand shock that raises unemployment, a positive supply shock resulting from relative price adjustments or structural improvements in the labour market, or a credibility shock associated with a strong commitment to participate in the EMU, which lowers inflationary expectations.

The emphasis on impulse responses (from a generalised VAR) is evident in Agenor and Hoffmaister (1997) examining the short-run links between money growth, exchange rate depreciation, nominal wage growth, the output gap and inflation in some middle-income developing countries.

McCarthy (1999) examines the impact (the pass-through) of exchange rates and import prices on domestic prices in selected industrialised economies. The empirical model is a VAR (impulse responses and variance decompositions) incorporating a distribution chain of pricing (three stages – import, producer and consumer).

In summary, the disinflation could be explained by three major aggregate shocks in extended PC models: an adverse demand shock that raises unemployment, a positive supply shock resulting from relative price adjustments or structural improvements in the labour market and, last but not least, a credibility shock that lowers inflationary expectations. **PC models incorporate some theory but are largely data determined.** Hence, our accent is on the use of the all-important information stemming from monthly data in order to focus **on the dynamic links between the measures of inflation on the one hand (net inflation, occasionally adjusted inflation) and the explanatory variables on the other.** The fourth item on the right side of equation (1) is more general than primary supply shocks and includes any predetermined variables other than the output gap and inflation that help predict future inflation.

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## 2 Basic data analysis

It should be kept in mind that the time series at our disposal are rather short. The analysed time span begins in 1995:1 and ends in 2000:12 (net inflation – the CPI adjusted for regulated prices and the effect of other administrative measures, e.g. increases in indirect taxes and abolition of subsidies – has been monitored in the Czech Republic since January 1995). The 72 monthly observations are slightly above the critical number of observations needed for a sophisticated time series analysis.

It is well known that for time series data, the process of selecting explanatory variables is complicated by the fact that one must identify not only the variables themselves, but also the correct temporal linkage between these variables and the dependent variable. A contemporaneous equation may be correct for annual data if the adjustment of the dependent variable occurs within one year. For either monthly or quarterly data, however, it may be necessary to include lags of the explanatory variables, and **focusing on these lags is the main purpose of this paper**. I would like to stress the importance of monthly data, because 24 quarterly observations represent too short of a time span for the analysis of distributed lags.

The explanatory variables have been grouped as follows:

- 1) Production (industrial output-iob-basic index, average month of 1995=100<sup>3</sup>, construction work-cw-year-on-year change, transport of goods-st-y-o-y and retail sales-rs-y-o-y)
- 2) Wages (the difference between the indices of average nominal wage in industry y-o-y and labour productivity y-o-y – wgap)
- 3) Domestic prices (industrial producer prices-ppi-y-o-y, agricultural producer prices-ai-y-o-y, index of market services-ms-y-o-y, construction work prices-cwp-y-o-y)
- 4) External influences (nominal effective exchange rate-neer, average month of 1995 = 100, import prices-imp-y-o-y, import prices group 3 – mineral fuels, lubricants – impe, world price index of foodstuffs and raw materials-wpi-y-o-y, producer prices in Germany – ppig-y-o-y)

Having applied the Hodrick-Prescott filter on the time series of industrial production, we have constructed the trend line of industrial production. The differences between actual and trend data have been labelled industrial output gap-iobgap (the gap could also be measured as a ratio, but the results would be the same). Of course, the usual notion of **the output gap**<sup>4</sup> refers to the gross domestic product, which has been monitored quarterly. Instead of trying to construct different

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<sup>3</sup> I would like to thank the Department of Industrial Production at the Czech Statistical Office for providing me with data for 1995.

<sup>4</sup> Using a simple Okun relation, the output gap and the unemployment gap are substitutes in advanced market economies. But for the Czech case, having used the disposable GDP data (1994:1– 2000:3), I reveal a very weak association for the whole period (contemporaneous correlations):

$$\begin{aligned} \text{ur} &= 5.19 - 35.09 \text{ GDPgap} \\ &\quad t=11.46 \quad -1.72 \\ \text{Rbar}^2 &= 0.07 \quad F=2.95 \quad (P=0.098) \end{aligned}$$

where the GDP gap has been calculated using the HP filter, ur is the unemployment rate. But for the period 1996:1–2000:3, the association is more promising:

$$\begin{aligned} \text{ur} &= 6.46 - 83.12 \text{ GDPgap} \\ &\quad t=16.37 \quad -4.57 \\ \text{Rbar}^2 &= 0.53 \quad F = 20.9 \end{aligned}$$

And for the period 1996:1–1999:1, the association is almost perfect:

$$\begin{aligned} \text{ur} &= 5.37 - 67.38 \text{ GDPgap} \\ &\quad t=48.43 \quad -15.18 \\ \text{Rbar}^2 &= 0.95 \quad F = 230.4 \end{aligned}$$

surrogates in a monthly frequency, we have decided to rely on industrial production only (the ratio of GDP has been hovering around 38% in the relevant period).

The notion of **the wage gap** is based on inflation accounting<sup>5</sup> with a caveat that data for industry (only these data are in a monthly frequency) serve as a proxy for the whole economy again as in the case of the industrial output gap. The wage gap has been regarded as one of the most important inflationary pressures.

**The nominal effective exchange rate** (calculated by weighting exchange rates with shares in trade turnover for 22 countries, which cover around 90% of the Czech Republic's foreign trade) has been used in the form of previous CNB Inflation Reports (e.g. January 1999). The increase means depreciation<sup>6</sup> and contributes to the increase in the inflation rate, because it is passed directly on to import prices. Hence, **we stress the direct exchange rate channel**, the direct one-off impact of import prices on the inflation rate. The second channel functioning through the real exchange rate has been studied with quarterly data and is not examined here.

Given this adjustment, the increase in all variables causes the increase in the inflation rate (the correlations are positive).

As indicated above, monthly data are mainly year-on-year changes.<sup>7</sup> Seasonal transformation has been made regularly by the Czech Statistical Office, and data are presented mainly in this form only. In the terminology of time series analysis, one speaks about seasonal differencing of order 1 with a span of 12 periods. As known in the literature, seasonal differencing *per se* does not ensure the stationarity of the time series.

Among others: "... the strong seasonality means that January-to-January and July-to-July changes are not so pronounced as the changes between June and July... the seasonal differencing did not eliminate the time varying mean. In order to

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<sup>5</sup> For different variants of inflation accounting, including the definitions of indices of both nominal and real unit costs, see Izák (2000), section 3: Inflation, wages and productivity.

<sup>6</sup> In this respect, I follow the tradition of some other authors. "A rise in the exchange rate means that foreign currency has become more expensive and therefore corresponds to a weakening, or depreciation, of the domestic currency", Romer D. (1996), p. 206 or "A fall in the exchange rate means that foreign exchange becomes cheaper. This is equivalent to an appreciation of the domestic currency", Visser H. (1995), p. 7.

<sup>7</sup> Sobczak (1998), having examined the disinflation in Spain from 1977 to 1987, uses on several occasions relative prices (the relative price of energy as the difference between y-o-y percentage changes of energy and that of inflation; the relative price of non-oil commodities; the relative inflation for industrial prices as the difference between an industry inflation rate minus the total PPI inflation rate).



impart stationarity into the series, the next step is to take the first difference of the already seasonally differenced data”. And further: “Often... s-differencing also removes a trend, but where the trend is nonlinear, first differencing of the s-differences may be necessary in order to make the series stationary... many series (for example, those with additive seasonality) can be transformed to stationary series by applying only seasonal differencing... However, in some situations, further nonseasonal (normally first) differencing is necessary. Such a procedure is required if there is multiplicative seasonality and (or) the nonseasonal component of the series is integrated of an order greater than one, which could be the case for a nonlinear trend.” Charemza, Deadman, (1997), p. 97–9.

Last but not least, one can not avoid mentioning that the targets for net inflation, as practised by the CNB, are also in form of year-on-year changes (e.g. for 2001 in a band of 2%–4%).

**Figure 1**

**CPI, net and adjusted inflation  
(year-on-year changes)**

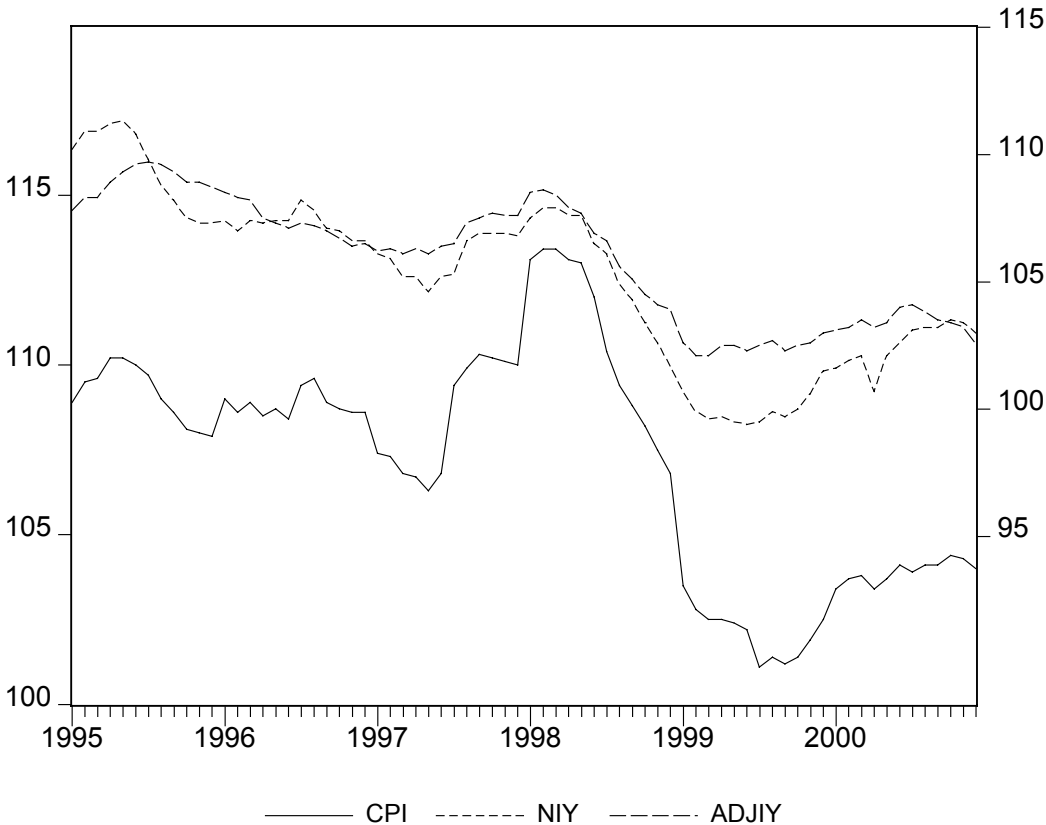


Figure 1 displays three measures of inflation showing the disinflation process since January 1995. What is worth mentioning is **the volatility of these indices during the whole examined period and during the period of direct inflation targeting**. Whereas CPI volatility is greater during the period 1998:1–2000:12 than in the period 1995:1–2000:12 (the coefficient of variation is 38.4%, respectively 31.4%), the opposite is true for both net and adjusted inflation. The coefficient of variation for net inflation is 26.5% in the period of direct inflation targeting (31.9% for the whole period). As expected, the lowest coefficient of variation has been calculated for adjusted inflation (19.4% in the period of direct inflation targeting and 22.8% for the whole period).

Table 1 displays the unit root tests (augmented Dickey-Fuller test, 2 lags, intercept) for the selected variables (adjusted inflation – adj – includes the prices of the non-food items of the consumer basket, excluding regulated price items).

**Table 1**  
**Unit root tests**

	adj	ni	ppi	ai	ms	cwp	wgap	iobgap	neer
level	-1.18	-2.08	-2.16	-2.39	-1.46	-0.55	-2.21	-2.25	-3.05
first difference	-2.62	-3.19	-3.14	-4.36	-5.62	-3.46	-4.87	-4.82	-4.49
	wpi	ppig	imp	impe					
level	-1.57	-2.27	-2.09	-0.78					
first difference	-2.78	-2.15	-3.77	-4.58					

*Note:* The 1% critical value is -3.53, The 5% critical value is -2.91 and the 10% critical value is -2.59. For the first differences of wpi, the Phillips-Perron test is -5.71 and ppig -7.17. For the level of iobgap PP = -5.36  
wgap PP = -3.41

**As the unit root tests indicate, all time series are nonstationary**, hence, the trend has not been removed by seasonal differencing, and further differencing is necessary to obtain stationary time series. Applying first differencing, the majority of stationary variables in this paper have the following form: e.g. for net inflation  $\Delta\Delta_{12}$  ni. Let me repeat to avoid any misunderstanding that year-on-year changes have been differenced only once.

At this point, two remarks are unavoidable. Firstly, the time span 1995:1–2000:12 is being treated as unique without taking into account the individual subspans. For example, we know that since 1999:10, the y-o-y changes of labour productivity in industry have been outpacing those of average nominal wages, which

is, in comparison with the previous period, a new feature in the development of the wage gap. If we look at the span 1995:1–1999:10 only, the co-movements of net inflation and the lagged wage gap are stronger than in the whole examined period. Secondly, we have mentioned correlations between net inflation and selected variables only, neglecting the interim links (e.g. imported energy prices→producer prices→adjusted inflation, the possible counter-effects of changes in world market prices and exchange rate movement, etc). For example, the correlations between iobgap and the producer price index are stronger than those between iobgap and net inflation. **The approach could be deployed for analysing these interim links**<sup>8</sup>, but this would lead us too far. A more profound analysis of these interim links is beyond the scope of this paper and has not been carried out here.

Cross correlations between stationary data belong to the useful tool kit of time series analysis in determining whether lags of different explanatory variables are related to the inflation rate or not. With 71 observations, lags of up to approximately 17 months are recommended for investigation (see Table 2), but in exceptional cases, even longer lags have been examined. Two standard error bounds are  $2/\sqrt{71}$  (the higher values are boldfaced). Only positive correlations are displayed. Looking at Table 2, one can assert:

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<sup>8</sup> For example, the regression between import prices and the nominal effective exchange rate:  $dimp_t = 0.559 dneer_{t-1} + 0.488 dneer_{t-3}$  with significant t-statistics and  $R^2_{bar} = 0.25$ . For a more in-depth study, see Holub (1999) – e. g. the differences between import prices from custom statistics used in my paper and import prices from a sample selection, which are in a monthly frequency since December 1997 only.

**Table 2a**

**Cross correlograms – net inflation**

	lags	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
A	iobgap	0.17		0.09	0.12	0.00	0.13	0.06	0.16		0.03				0.01							0.08				0.07			0.13		0.11		
B	wgap		0.06							0.19			0.10	0.09		0.10	0.17	0.02	0.22		0.15		0.14		0.12								
C	ppi	<b>0.61</b>	<b>0.29</b>	<b>0.32</b>	0.14	0.17	0.17	0.08	0.18	0.10	0.04																						
	ai	<b>0.37</b>	<b>0.31</b>	<b>0.28</b>	0.21	0.02																											
	ms	0.21		0.01		0.01	0.19				0.04	0.03	0.06	0.02	0.08		0.11																
	cwp		0.18	0.19	0.10	0.14	0.22	<b>0.24</b>		0.16	0.02																						
D	neer		0.21	<b>0.28</b>	<b>0.28</b>	0.18	0.14	0.12	0.03	0.18	0.13	0.18																					
	imp	<b>0.32</b>	<b>0.26</b>	0.18	0.23	0.17	<b>0.25</b>	0.12	0.15	0.07	0.19		0.07																				
	impe	0.23	0.11	0.08	<b>0.35</b>	0.01	<b>0.24</b>	0.15	0.18	0.08	0.21	0.15	0.15		0.11	0.06	0.03																
	wpi	<b>0.34</b>	0.19		0.20	0.05	0.07	0.07	0.13	0.18	0.07	0.05	0.19	0.02	0.01	0.14	0.06	0.21	0.11	0.14	0.03	0.10	0.07	0.10									
	ppig	<b>0.28</b>	<b>0.26</b>	0.07	0.15	0.16	<b>0.24</b>	0.04	<b>0.39</b>	<b>0.26</b>	0.12	0.17	0.10	0.05	0.10	0.03																	

**Table 2b**

**Cross correlograms – adjusted inflation**

	lags	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
A	iobgap	0.07			0.09			0.10											0.08	0.02	0.02	0.10	0.13	0.08	0.19	0.16	0.15	<b>0.25</b>	0.18	0.13	0.09			
B	wgap							0.07		<b>0.24</b>		0.02	0.01	0.15	0.03	0.04	0.17	0.12	0.17		0.19		0.12		0.05			0.03					0.09	
C	ppi	<b>0.67</b>	<b>0.38</b>	<b>0.26</b>	0.17	<b>0.24</b>	<b>0.24</b>	0.05	0.09																									
	ai	0.15	<b>0.23</b>	0.15	0.11			0.01							0.01				0.14															
	ms	<b>0.24</b>	0.07	<b>0.27</b>	0.02	0.16		0.01			0.09					0.06																		
	cwp	0.06	<b>0.28</b>	0.13	0.01	0.03	0.04			0.03		0.02																						
D	neer		<b>0.29</b>	<b>0.36</b>	<b>0.37</b>	0.16	0.09	0.20		0.14		0.09																						
	imp	<b>0.35</b>	<b>0.34</b>	0.22	0.16	0.07	<b>0.30</b>		0.13	0.02	0.06																							
	impe	0.18	0.18	0.11	0.23	0.10	0.10	0.19	0.11	0.07	0.15	0.10	0.14		0.01	0.04																		
	wpi	0.08	0.09		0.16	0.09	0.12	0.05	0.14	0.21	0.04		0.09	0.08	0.03	0.06	0.04	0.15	0.07	0.10														
	ppig	<b>0.26</b>	<b>0.24</b>	0.18	<b>0.26</b>	0.19	<b>0.28</b>	0.13	<b>0.28</b>	0.20	0.19	0.05		0.12																				

- a) The differences between the correlations of the explanatory variables and those of net or adjusted inflation are significant in some cases only (industrial output gap, agricultural prices, producer prices in Germany)
- b) The industrial output gap has influenced adjusted inflation stronger than net inflation as logically expected, but the impact is robust after a time lag of several quarters (17–29 months). One must again stress that capturing this effect in a transition economy<sup>9</sup> is not an easy task.
- c) The wage gap has influenced, of course, adjusted inflation stronger than net inflation (the robust lags are between 8 and 17 months) but again the impact is rather modest (statistically significant for adjusted inflation after the elapse of 8 months only). The explanation is beyond the scope of this paper – recall some of the facts from the models of income policy.<sup>10</sup>
- d) The impact of domestic prices is very quick and robust especially concerning producer prices. Also, the impact of agricultural prices on net inflation in the first lagged months is significant.
- e) By far the most important seems to be the impact of external factors. The correlations of net inflation with import prices are positive in all first nine months, and the impact of the import prices of mineral fuels and lubricants is felt even longer. The factors “behind” import prices in the domestic currency – the nominal effective exchange rate, world prices of raw materials and foodstuffs and producer prices in Germany – complete the picture. The impact is robust in the sense that correlation coefficients are positive in many subsequent years.

To summarise, Table 2 shows how one type of monetary policy indicator influences the Czech monetary policy target after a certain period of time – the inflation rate in both forms (net inflation, adjusted inflation).

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<sup>9</sup> In this connection, I would like to quote K. Clinton: “Given the magnitude of the structural changes to the Czech economy, it would be implausible that potential output were simply a uniform rising trend”, (2000), p. 178.

<sup>10</sup> See Izák (2000), especially section 3.4: Wage and price inflation – microeconomic foundations and macroeconomics consequences where the combinations of the distribution of the “increment – the difference between an increase in the product in real terms and an increase in labour input” have been analysed with the help of numerical examples.

Among the factors “behind” the import prices, the exchange rate plays the most important role. Hence, the cross correlations between the inflation rate and the exchange rate must be examined more profoundly.

When examining the role of the exchange rate, one must distinguish first of all **the periods of different exchange rate regimes**. The following must be taken into consideration: a) the widening of the fluctuation band in February 1996 from  $\pm 0.5\%$  to  $\pm 7.5\%$  around central parity, b) cancellation of the fluctuation band and introduction of floating with reference to the German mark in May 1997.

The cross correlograms of the nominal effective exchange rate with both net and adjusted inflation (Table 3) show:

**Table 3**  
**Cross correlograms – nominal effective exchange rate**

		0	1	2	3	4	5	6	7	8	9	10	11	12
1995:1–1997:5	ni		0.10	0.01		0.10		0.07		0.06	0.04	0.02		0.04
28 obs.	adj	0.02	0.14	0.06		0.12		0.09		0.05				
1996:3–2000:12	ni		0.23	0.30	0.31	0.21	0.15	0.13	0.04	0.19	0.14	0.21		
58 obs.	adj		0.30	0.38	0.40	0.17	0.10	0.22		0.15			0.11	
1997:5–2000:12	ni		0.23	0.31	0.31	0.15	0.13	0.15	0.09	0.20	0.14	0.16		
40 obs.	adj		0.32	0.40	0.42	0.13	0.08	0.24	0.04	0.19		0.05		

- 1) In the period of the fixed nominal exchange rate 1995:1–1997:5, the lagged correlations were weak and statistically insignificant for both net and adjusted inflation, because in a country with fixed exchange rates, the exchange rate channel is not active (domestic interest rates adjust in such a way that the exchange rate remains unchanged).
- 2) In the periods of band easing (starting in 1996:3) and floating (since 1997:5), the lagged correlations look similar in both periods. **The stronger impact is on adjusted inflation in both periods**, especially in the first three months.

It is also worth noticing the cross correlations of both net and adjusted inflation with the nominal exchange rate expressed in USD and DEM (not shown here for brevity sake) in the three above mentioned periods.

As a brief summary:

- a) The impact of the exchange rate on both net and adjusted inflation is stronger in USD than that in DEM in all three time spans.

b) The impact is the strongest in the period 1997:5–2000:12, when floating was the official exchange rate regime.

Therefore, **as theoretically expected, the exchange rate regime has played a role in influencing the inflation rates.**

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### 3 Net inflation and import prices – distributed lag models

The positive correlation coefficients in several subsequent months between some lagged explanatory variables and the inflation rate turn our attention to constructing models which could attempt to explain the variation of the inflation rate over time. In distributed lag models of the type:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \dots + \beta_s X_{t-s} \quad (2)$$

the values of the parameters  $\beta_0, \beta_1, \dots, \beta_s$  reflect the relative importance of each of the lagged values of  $X$ . That is, the  $\beta$ s can be interpreted as the weights which can be attached to each of the current and previous levels of  $X$ .

According to Table 2, we might expect different influences of lagged explanatory variables on the inflation rate. For example, the correlation coefficients of the wage gap are positive only after a certain elapse of time, the coefficients of the nominal effective exchange rate are peaking at  $\beta_2$  and  $\beta_3$  and declining thereafter, the coefficients of producer prices in Germany are positive until the lag of 14 months (net inflation), etc. Hence the cross correlograms in Table 2 indicate that **the use of distributed models makes sense for some variables only – for the variables with a sustained positive impact on both inflation rates during several subsequent months.**



The well known problems preventing the straightforward estimation of the parameters  $\beta$  can be summarised in three groups: a) the length of the lag, b) the degrees of freedom, and c) a high degree of multicollinearity.

As concerns the first problem, both the cross correlograms and the statistical identification methods can help us in settling the problem of lag length. Only one selected explanatory variable, along with a sufficient number of observations, helps in overcoming the second problem. The most complicated is the third problem. The modelling of economic dynamics using finite distributed lag (FDL) models is acceptable with a caveat that individual coefficients can be estimated imprecisely due to multicollinearity.<sup>11</sup>

There are a number of estimation methods which can, to a certain degree, overcome the above-mentioned problems, but all involve making specific assumptions concerning the pattern of the  $\beta$ s over time. In what follows, we compare the multipliers from FDL and polynomial distributed lag models (PDL). The polynomial (Almon) method requires *a priori* specification of both the lag length and the functional form that generates the  $\beta$ s.

The single equation for net inflation and import prices in the form of a FDL model is:

$$\Delta\Delta_{12} ni_t = \alpha + \sum_{i=1}^9 \beta_i \Delta\Delta_{12} imp_{t-i} \quad (3)$$

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<sup>11</sup> But "...it may not be a problem at all. Often, interest centers not on the individual coefficients but on their sum...which measures the long run effect on y of a given change in x. Even when the individual  $\beta$ 's are estimated very imprecisely, their sum may be estimated with sufficient precision", Davidson, Mac Kinnon, (1993), p.673. On the other hand: "If we can characterize the lag structure for the coefficients of interest, such as strictly increasing or decreasing, or rising at first then falling, we can circumvent these problems and estimate the lag distributions with a relatively small number of parameters. This entails approximating the shape of the lag distribution with a polynomial, then incorporating the information into the general lag equation we wish to estimate", Lardaro, (1993), p. 552.

A look at Table 2 reveals that the geometric lag formulation (Koyck) is limited here, because it hypothesises a declining set of lag weights. It could be applied to agricultural prices only (the regular decline in the first three periods). The model is:

$$dni_t = -0.086 + 0.2455 dni_{t-1} + 0.0426 dai_t$$

t = -1.38    2.14    2.44

$$R^2_{bar} = 0.16 \quad DW = 2.29 \quad F = 7.72$$

with a declining set of coefficients :  $\beta_0 = 0.0426$ ,  $\beta_1 = 0.0105$ ,  $\beta_2 = 0.0026$ ,  $\beta_3 = 0.0006$ .

The coefficients<sup>12</sup> of this model are compared with those of a PDL model in Table 4 (the selection criteria have preferred a PDL model of order 2).

**Table 4**

<b>Net inflation, import prices</b>								
FDL					PDL			
1	2	3	4	5	6	7	8	9
variables	multipl.	t-stat.	cum. mult.	%	multipl.	t-stat.	cum. mult.	%
const.	-0.132	-2.41						
imp	0.105	4.23	0.105	21.3	0.087	4.38	0.087	19.1
imp <sub>-1</sub>	0.087	3.54	0.192	39.0	0.068	5.49	0.155	34.1
imp <sub>-2</sub>	0.026	1.01	0.218	44.3	0.052	5.58	0.208	45.7
imp <sub>-3</sub>	0.09	1.12	0.247	50.2	0.040	4.04	0.248	54.5
imp <sub>-4</sub>	0.049	1.90	0.296	60.2	0.032	2.92	0.281	61.8
imp <sub>-5</sub>	0.067	2.56	0.362	73.6	0.028	2.54	0.309	67.9
imp <sub>-6</sub>	0.025	0.96	0.388	78.9	0.028	2.77	0.337	74.1
imp <sub>-7</sub>	0.002	0.07	0.389	79.1	0.031	3.30	0.368	80.9
imp <sub>-8</sub>	0.031	1.22	0.420	85.4	0.038	3.04	0.406	89.2
imp <sub>-9</sub>	0.072	2.82	0.492	100.0	0.049	2.43	0.455	100.0

*Note:* FLD:  $R^2$  bar = 0.44 F = 5.69 (P=0.00)  
PDL:  $R^2$  bar = 0.42 Sum of coef. 0.455 T=6.59

**Long-run multipliers** (col. 4, col. 8, and last row) **are practically the same in both types of models, which enhance the credibility of these results.** They say that a one-unit increase in import prices, sustained indefinitely, increases mean net inflation, after the elapse of nine months, by about one half (0.492 in FDL, 0.455 in PDL model).

Interim multipliers (col. 2 and 6), their cumulative forms (col. 4 and 8) and their ratios on the long-run multipliers in per cent (col. 5 and 9) are a bit different, but the basic message is the same – **half of the total impact is exhausted after three months.**

<sup>12</sup> The coefficient  $\beta_0$  is the impact (short-run) multiplier. The coefficients  $\beta_1$  to  $\beta_9$  are the interim multipliers of order 1 to 9. For example, the coefficient  $\beta_3$  denotes the effect of a one unit change in import prices three months ago on the mean of net inflation in the current period, given all other lagged import prices (the interim multiplier of order 3). If a one unit increase in import prices is maintained indefinitely, the mean of net inflation changes by  $\beta_0$  (0.103 in the FDL model) in the initial period, by  $\beta_0 + \beta_1 = 0.187$  (column 4 in Table 4) – the two period interim (cumulative) multiplier, etc. The total impact of an indefinitely maintained one unit increase in import prices on the mean of net inflation is the sum of all multipliers (the equilibrium or long-run multiplier) – the last row in Table 4.



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## 4 Net inflation, the nominal exchange rate and import prices – impulse response functions and variance decomposition

Besides the dynamic multipliers from the FDL and PDL one-equation models, another, more sophisticated approach to studying dynamics is to determine how the variable in question responds over time to a shock in this variable and other variables. Vector autoregression (VAR) provides a means of letting the data<sup>13</sup>, rather than the econometrician, determine the dynamic structure of a model. One needs to specify the largest number of lags that are needed to capture most of the effects that the variables have on each other.<sup>14</sup>

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<sup>13</sup> In a similar study, Levy and Halikias (1997) note, "...the richness and unrestricted nature of the lag structure in VAR models provide a good safeguard against a host of econometric problems – notably spurious correlation and cointegration problems...despite this richer lag structure, the smaller number of variables typically employed by VAR models allow their efficient estimation over much shorter periods", p. 7.

<sup>14</sup> "...with monthly data, lags up to 6 or 12 months are likely to be sufficient...one wants lags long enough to fully capture the dynamics of the system being modeled...generally, one must trade off between having a sufficient number of lags and having a sufficient number of free parameters", Pindyck, Rubinfeld (1991), p. 354–5. In their modelling of the dynamics of the heating oil market, they have 109 monthly observations and  $3^2 \cdot 8 = 72$  parameters (3 variables, 8 lags). In my paper, there are 71 observations, and the highest number of parameters is 38 ( $2^2 \cdot 9 = 36$  parameters plus 2 intercept terms in a VAR model with import prices). It is evident that the number of observations precludes a VAR model with more variables if one stresses the richness of temporal links (see cross correlograms).

## 4.1 Net inflation and the nominal effective exchange rate

The nominal effective exchange rate plays the most decisive role of the factors “behind” import prices. Hence, special attention is given to the influence of this variable on net inflation. The unrestricted VAR in first differences (the selection procedure prefers a short lag – 2 months) is without a constant and has the following form:

$$\Delta\Delta_{12} \text{ni}_t = \sum_{i=1}^2 a_{1i} \Delta\Delta_{12} \text{ni}_{t-i} + \sum_{i=1}^2 b_{1i} \Delta\Delta_{12} \text{neer}_{t-i} \quad (4)$$

$$\Delta\Delta_{12} \text{neer}_t = \sum_{i=1}^2 a_{2i} \Delta\Delta_{12} \text{ni}_{t-i} + \sum_{i=1}^2 b_{2i} \Delta\Delta_{12} \text{neer}_{t-i} \quad (5)$$

VAR is here in first differences. As is well known<sup>15</sup>, only some of the coefficients are statistically significant. Typically they are not presented, and at this moment, we are not interested in these coefficients *per se*.

### Box 1: Identification problem

The starting point of the discussion of identification is a simple bivariate system, where for simplicity only, a first order VAR (the longest lag length being unity) is presented:

$$\text{ni}_t = b_{10} + b_{12} \text{neer}_t + \chi_{11} \text{ni}_{t-1} + \chi_{12} \text{neer}_{t-1} + \varepsilon_{\text{ni } t} \quad (1)$$

$$\text{neer}_t = b_{20} + b_{21} \text{ni}_t + \chi_{21} \text{ni}_{t-1} + \chi_{22} \text{neer}_{t-1} + \varepsilon_{\text{neer } t} \quad (2)$$

where  $b_{10}, b_{20}$ ...intercept terms,  $b_{12}, b_{21}$ ...feedback coefficients

$\chi_{11}, \chi_{12}, \chi_{21}, \chi_{22}$ ...autoregressive coefficients  $\varepsilon_{\text{ni } t}, \varepsilon_{\text{neer } t}$ ...pure innovations (or shocks).

<sup>15</sup> From a seminal paper by Sims, “The autoregressive coefficients themselves are difficult to interpret, and equivalent, more comprehensible information is contained in the MAR coefficients... Because estimated AR coefficients are so highly correlated, standard errors on the individual coefficients provide little of the sort of insight into the shape of the likelihood we ordinarily try to glean from standard errors of regression coefficients”, 1980, p. 18. More succinctly: “The vector moving average representation is an essential feature of Sims’ (1980)

In equations (1) and (2), we have described a structural VAR (sometimes called a primitive system). The structure of the system incorporates feedback since  $ni_t$  and  $neer_t$  are allowed to affect each other. If  $b_{12}$  is not equal to zero, then  $\varepsilon_{neer t}$  has an indirect contemporaneous effect on  $ni_t$ . Equations (1) and (2) are not reduced form equations since  $ni_t$  has a contemporaneous effect on  $neer_t$  and  $neer_t$  has a contemporaneous effect on  $ni_t$ .

After some algebraic manipulations (see Enders, 1995, p. 294), the VAR in standard form can be deduced:

$$ni_t = a_{10} + a_{11} ni_{t-1} + a_{12} neer_{t-1} + e_{ni t} \quad (3)$$

$$neer_t = a_{20} + a_{21} ni_{t-1} + a_{22} neer_{t-1} + e_{neer t} \quad (4)$$

What is important for our further analysis is to note that the error terms ( $e_{ni t}$  and  $e_{neer t}$ ) are composites of the two shocks  $\varepsilon_{ni t}$  and  $\varepsilon_{neer t}$ :

$$e_{ni t} = \frac{(\varepsilon_{ni t} + b_{12} \varepsilon_{neer t})}{1 + b_{12} b_{21}} \quad (5)$$

$$e_{neer t} = \frac{(\varepsilon_{neer t} + b_{21} \varepsilon_{ni t})}{1 + b_{12} b_{21}} \quad (6)$$

A critical point to note is that  $e_{ni t}$  and  $e_{neer t}$  are correlated (the correlation coefficient of residuals in our VAR model with 2 lags is -0.2336). Only in the special case in which  $b_{12} = b_{21} = 0$  (i.e., if there are no contemporaneous effects of  $ni_t$  on  $neer_t$  and no effects of  $neer_t$  on  $ni_t$ ), will the shocks be uncorrelated.

What we obtain from EViews is the VAR in standard form (eq. 3 and 4) including both the correlation and covariance matrix of residuals. In our case in the text (net inflation and the exchange rate with a lag of 2 months) plus intercept terms, we obtain nine parameters ( $a_{10}$ ,  $a_{11}$ ,  $a_{12}$ ,  $a_{20}$ ,  $a_{21}$ ,  $a_{22}$ ,  $\text{var } e_{ni t}$ ,  $\text{var } e_{neer t}$ , and  $\text{cov } e_{ni t}, e_{neer t}$ ). However, the VAR in a structural form (eq. 1 and 2) contains ten parameters and is hence underidentified. We must restrict one parameter of a structural VAR.

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methodology in that it allows you to trace out the time path of the various shocks on the variables contained in the VAR system.”, Enders, 1995, p. 305.

Both economic logic and cross correlations in Table 2 say that the assumption  $b_{21} = 0$  is justifiable ( $ni_t$  does not have a contemporaneous effect on  $neer_t$ ). Both  $\varepsilon_{ni_t}$  and  $\varepsilon_{neer_t}$  shocks affect the contemporaneous value of  $ni_t$ , but only  $\varepsilon_{neer_t}$  shocks affect the contemporaneous value of  $neer_t$ . The observed values of  $neer_t$  are completely attributed to pure shocks to the  $neer_t$  sequence.

Decomposing the residuals in this triangular fashion is called a Choleski decomposition:

$$e_{ni_t} = \varepsilon_{ni_t} - b_{12} \varepsilon_{neer_t} \quad (7)$$

$$e_{neer_t} = \varepsilon_{neer_t} \quad (8)$$

It implies an ordering of variables. An  $\varepsilon_{neer_t}$  shock directly affects  $e_{ni_t}$  and  $e_{neer_t}$  but an  $\varepsilon_{ni_t}$  shock does not affect  $e_{neer_t}$ . Hence,  $neer_t$  is “prior” to  $ni_t$ .

The number of observations must be limited, because only since 1996:3 has the nominal effective exchange rate been allowed to move in a wider band (see sections above). Hence, the number of effective observations in a model with two lags is 58.

The relevant matrices are:

Residual correlation matrix

	ni	neer
ni	1	-0.2336
neer	-0.2336	1

Residual covariance matrix

	ni	neer
ni	0.1982	-0.1760
neer	-0.1760	2.8634

The correlation between the residuals is not negligible (-0.2336) indicating that the order of the variables is at the edge of significance for drawing the conclusions. It is crucial to note that the importance of the ordering depends on the magnitude of the mentioned correlation. As a rule of thumb, the correlation is deemed to be significant if the coefficient is higher than 0.2, which is roughly our case. But in our case with two variables only, the problems of ordering are rather simple. One is quite easily

able to change the ordering and compare the results.<sup>16</sup> But, for example, in a system with four variables there are  $4!$  (24) possible orderings, and things get enormously complicated.

The relevant standard deviations can be obtained from the residual covariance matrix, and they are  $\sqrt{0.1982} = 0.4452$  and  $\sqrt{2.8634} = 1.6922$ .

What we are interested in are the VAR tools characterising the dynamic behaviour of the variables. **The impulse response functions and variance decomposition** do that.<sup>17</sup> Together they are called innovation accounting and are useful tools to examine the relationships among economic variables. We consider the conceptual experiment of disturbing a system at equilibrium, injecting a shock (called the innovation) to the system by changing one of the errors for one period and then returning it to zero thereafter. The dependent variable (net inflation) will move away from, then return to, its equilibrium. The path whereby the variable returns to the equilibrium is called the impulse response (IRF) of the VAR.

Hence, we are interested in **the response of net inflation to an exchange rate shock**. Here the IRF for  $\varepsilon_{\text{neer } t}$  traces through the effect of a one standard deviation nominal exchange rate on current and future net inflation and the exchange rate. Our concern is the response of net inflation to one standard deviation shock in the exchange rate (Figure 2).

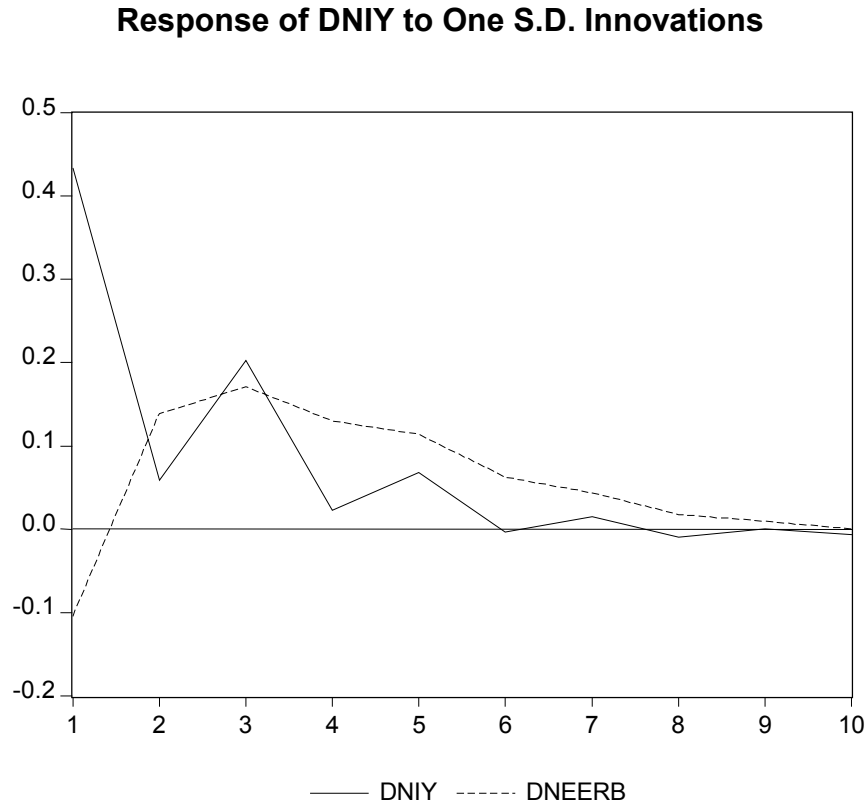
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<sup>16</sup> Agenor and Hoffmaister note, “A typically standard VAR analysis presents the impulse responses for an explicit ordering chosen by recourse to economic judgement and some effort is made to address the reader’s natural concern regarding the robustness of the results, mostly of discussing results for alternative orderings. However, analysis for all possible alternative orderings is only feasible for VAR systems involving a relatively small number of variables. Moreover, even with small systems, results associated with alternative orderings are not always devoid of ambiguities”, (1997), p. 7. In a similar way: “...results obviously depend on the ordering of variables, and some sensitivity analysis involving altering this ordering is often pursued”, Levy, Halikias, (1997), p. 9. And especially relevant for our case: “As a practical matter, how does the researcher decide which of the alternative decompositions is most appropriate? In some instances, there might be a theoretical reason to suppose that one variable has no contemporaneous effect on the other”, Enders, (1995), p. 310.

<sup>17</sup> For this type of policy analysis, VAR is written in moving average form (see chapter 11 in Hamilton (1994), especially 11.4, the impulse response function, and 11.5, variance decomposition). Returning to the classical writer, “The best descriptive device appears to be analysis of the system’s response to typical random shocks... The ‘typical shocks’ whose effects we are about to discuss are positive residuals of one standard deviation unit in each equation of the system. The residual in the money equation, for example, is sometimes referred to as the ‘money innovation’, since it is that component of money which is ‘new’ in the sense of not being predicted from past values of variables in the system”, Sims, (1980), p. 21.



**Figure 2**



The response is negative in the first period (negative correlation coefficient of residuals), and then is strong in the second period. The strongest response is exhibited in the third period, then dying out. **The responses are statistically significant until the fifth month.**<sup>18</sup>

Variance decomposition<sup>19</sup> breaks down the variance of the forecast error for each variable into components that can be attributed to both variables. In applied research, it is typical for a variable to explain almost all of its forecast error variance at short horizons and smaller proportions at longer horizons. Table 5 shows variance decomposition for net inflation.

<sup>18</sup> “Empirical evidence suggests that policy affects inflation through the direct exchange rate channel in about a year and through the output channel in about two years”, Ball, (1999), p. 129.

<sup>19</sup> In Agenor and Hoffmaister (1997), the variance of inflation is decomposed into shocks due to money supply, depreciation of the exchange rate, wages and the output gap. The percentage of variance associated with shocks to the exchange rate is, after the elapse of 1–2 quarters, between 26%–65%. With the exception of Korea, it has a decisive impact on the forecast errors of inflation.

**Table 5**  
**Variance decomposition for net inflation (nominal exchange rate)**

1	2	3	4
Period	S.E.	DNIY	DNEERB
1	0.445235	94.54021	5.459786
2	0.470092	86.39150	13.60850
3	0.539615	79.63141	20.36859
4	0.555539	75.30450	24.69550
5	0.571130	72.66513	27.33487
6	0.574525	71.81245	28.18755
7	0.576366	71.41895	28.58105
8	0.576702	71.36217	28.63783
9	0.576776	71.34388	28.65612
10	0.576815	71.34770	28.65230

Variance decomposition exhibits the expected jumps in the proportions of the standard errors of the forecast for net inflation that can be attributed to shocks in the nominal effective exchange rate (see column 2 in Table 5). The contribution of the nominal effective exchange rate “jumps” from 5.5% when forecasting net inflation for one month to 13.6% when forecasting for a horizon of two months, 20.4% when forecasting for a three month horizon and 24.7% when forecasting for a four month horizon. **In the subsequent months, the contribution of the nominal exchange rate to the forecast variance of inflation has been changing negligibly.** When we change the ordering, the results are changed only slightly and the time pattern is practically the same.

## 4.2 Net inflation and import prices

The cross correlogram (Table 2) has indicated that the time pattern for **the influence of the import process on net inflation** is rather different than that for the exchange rate. It is spread over a longer time horizon (the correlation coefficient for a lag with nine months is quite high, so the selection of a proper lag length has suggested the choice of a longer lag – see Box 2).

## Box 2: Selection of the proper lag length

The cross correlogram has suggested the proper lag length in this case to be around nine months. Firstly, we test the nine- and eight-lag specifications with the same number of 61 observations. The determinant residual covariances are 0.470365 for a model with nine lags and 0.697989 for a model with eight lags. Then  $61(0.697989 - 0.470365) = 13.89$ . The degrees of freedom are  $2^2(9-8) = 4$ . The 5% critical value for a  $\chi^2(4)$  variable is 9.49. Since  $13.89 > 9.49$ , the null hypothesis is rejected and a nine lag specification seems acceptable. Also, the Akaike information criterion (AIC) and Schwarz criterion (SC) are lower for this specification (AIC is 6.17 for a model with nine lags and 6.43 for a model with eight lags, and SC is 7.48, respectively 7.61).

But one cannot avoid mentioning that there are some complications in this type of selection. According to Sims (1980), p. 17, the above used likelihood ratio test should be modified to take into account a small-sample bias. He would recommend in our case to use  $[61 - (1 + 2*9)] = 9.56$ . This figure is slightly over the above-mentioned critical value, hence the selection of a nine-month lag length has been again confirmed.

Secondly, maybe a longer lag length – ten months – would better capture the dynamics. To compare models with lags of nine and ten months, one must lower the number of observations to 60 to keep the same number of observations for both models.

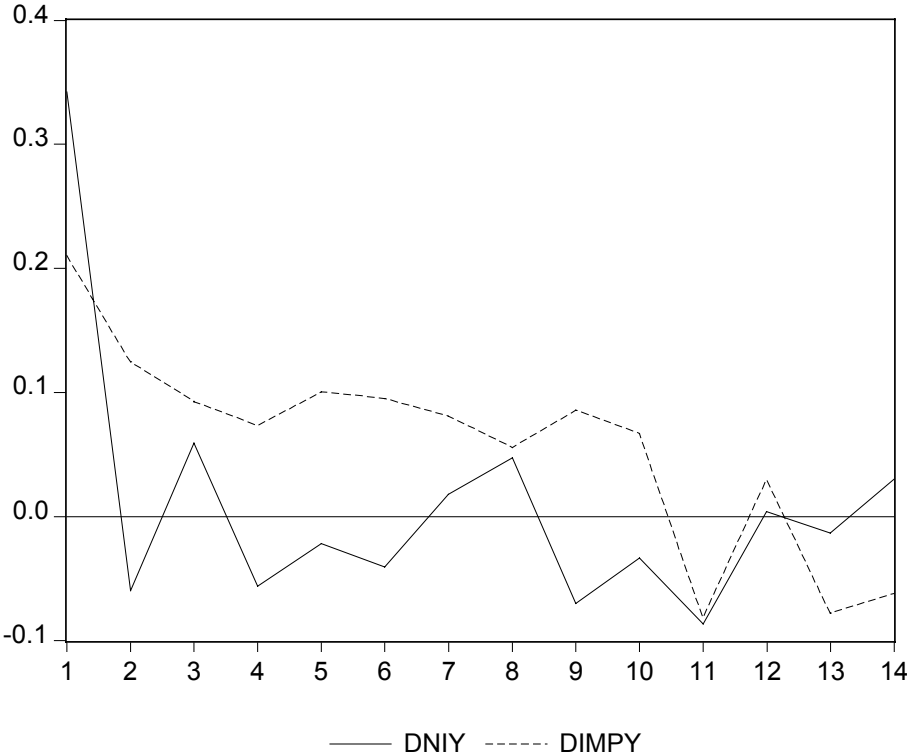
Using the determinant residual covariances from these models, we get  $60(0.47683 - 0.441941) = 2.09$  and taking into account Sims' qualification  $[60 - (1 + 2*10)] = 1.36$ . In both cases, the model with nine lags is again preferable. Last but not least, the AIC and SC in a model with nine lags are 6.20, respectively 7.53 and in a model with ten lags 6.26, respectively 7.73, which supports our definitive choice – a model with a nine-month lag.

The natural ordering of variables is: import prices, inflation. What we call the import price innovation is assumed to disturb the net inflation instantly, according to the strength of the contemporaneous correlation of the net inflation residual with the import price residual while the net inflation residual is only allowed to affect the import price residual after the initial period. The response (Figure 3) is the strongest in the first period (0.208 with  $t = 4.34$ ), and statistically significant effects are exhibited in the second period (0.131 with  $t = 2.63$ ) while dying out (in the sixth period 0.11 with

t = 2.06). We can conclude that **the effects of a shock to import prices are the strongest in the first period, and after the elapse of ten periods, approach zero.**

**Figure 3**

**Response of DNIY to One S.D. Innovations**



The relevant matrices are:

Residual correlation matrix			Residual covariance matrix		
	ni	imp		ni	imp
ni	1	0.5137	ni	0.1642	0.4137
imp	0.5137	1	imp	0.4137	3.9490

The correlation of errors is high, hence the ordering of variables is important.

Variance decomposition of net inflation (Table 6) gives in the second column the standard errors of the forecast for horizons of one month, two months, etc. until the end of the forecast horizon (here 14 months). For the one-month forecast, the standard error is just 0.4053, the standard deviation ( $\sqrt{0.1642} = 0.4053$ ). For the two-month forecast, the standard error is higher (0.4310) because it includes the effects

of uncertainty over the one-month forecast of import prices. The third column of Table 6 shows the percentage of the net inflation forecast variances that can be attributed to shocks in net inflation alone. The fourth column shows the percentage of the net inflation forecast variances that can be attributed to shocks in import prices. We are especially interested in this column. If the model is used to make a one-month forecast of net inflation, 26.4% of the forecast variance will be attributable to import price shocks (for a two-month forecast 32.6%, for a four-month forecast 41.6% with only a slower increase in subsequent months).

A partial conclusion is that **the importance of import price shocks is concentrated within the horizon of one to five months while dying out in the following months.**

**Table 6**

**Variance decomposition for net inflation  
(import prices, import prices – group 3 )**

1	2	3	4	5	6	7
Period	S.E.	DNIY	DIMPY	S.E.	DNIY	DIMPEY
1	0.405271	73.61406	26.38594	0.400802	88.87766	11.12234
2	0.430997	67.42642	32.57358	0.410552	88.12055	11.87945
3	0.442145	65.59232	34.40768	0.422893	88.62035	11.37965
4	0.452319	63.91654	36.08346	0.448463	79.87595	20.12405
5	0.462218	61.51498	38.48502	0.456232	77.44254	22.55746
6	0.476886	58.43236	41.56764	0.468325	73.79957	26.20043
7	0.481230	57.39451	42.60549	0.474526	72.95791	27.04209
8	0.484997	56.89481	43.10519	0.477126	72.18081	27.81919
9	0.493879	55.24262	44.75738	0.482012	72.44426	27.55574
10	0.501168	55.01979	44.98021	0.504032	71.47349	28.52651
11	0.512428	54.05437	45.94563	0.522719	73.42123	26.57877
12	0.513165	53.90318	46.09682	0.527723	73.38934	26.61066
13	0.518636	52.83488	47.16512	0.542380	74.44224	25.55776
14	0.522999	52.14189	47.85811	0.546792	73.66348	26.33652

### 4.3 Net inflation and import prices – group 3

The similar VAR model (nine lags) for import prices of mineral fuels and lubricants (group 3) has the matrices:

Residual correlation matrix		
	ni	impe
ni	1	0.3335
impe	0.3335	1

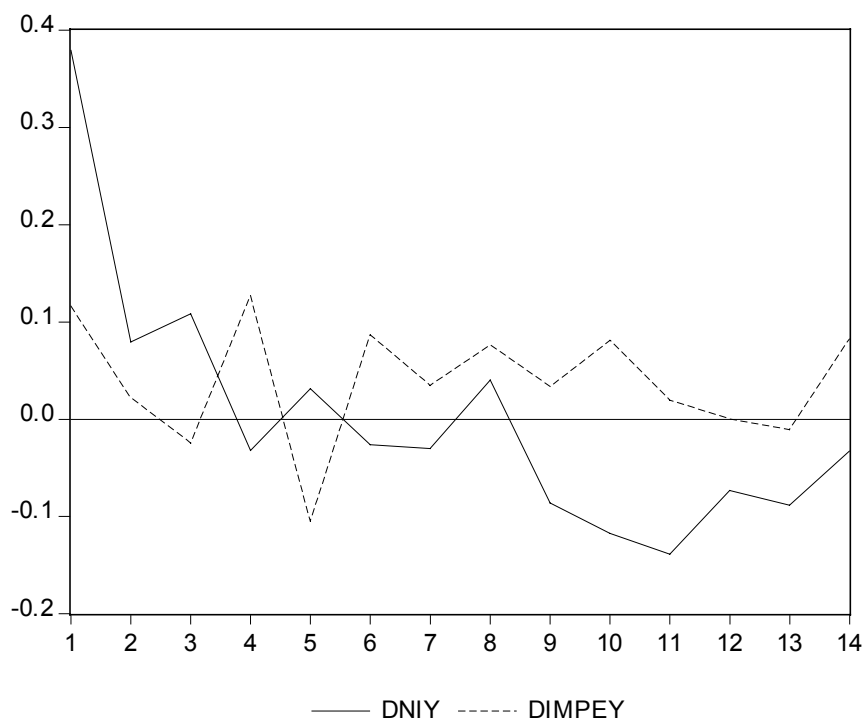
Residual covariance matrix		
	ni	impe
ni	0.1606	1.1149
impe	1.1149	69.5680

The correlation of errors is here lower than in the previous case, hence the change of ordering will lead to less distinct results.

Figure 4 shows the response of net inflation to a one standard deviation shock in import prices – group 3 in ordering: import prices – group 3. net inflation:

**Figure 4**

**Response of DNIY to One S.D. Innovations**



When comparing Figures 3 and 4, we can not overlook **the peaks after the lags of four and ten months** in Figure 4, where the important and statistically significant responses are lagged one month (impulse response is 0.13 with  $t = 2.70$ ), four months (0.14 with  $t = 2.72$ ) and also ten months.

Practically the same message is sent by variance decomposition (columns 5, 6 and 7 in Table 6). We can observe **the “jumps” of net inflation forecast variance** attributable to one import price – group 3 shock when forecasting for horizons of four and five months. After the elapse of ten months, the contribution of the import price shock – group 3 even slightly decreases. This is the specific feature of the reaction of net inflation to this very sensitive item of import prices.

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## 5 Concluding remarks and summary

The causes of disinflation may have different origins. According to Sobczak (1998), Spain's disinflation in 1996/97 can not be fully explained by the recession experienced in 1992/93 nor by a positive supply shock, even if both factors contributed to abate inflationary pressures. He comes to the conclusion that in Spain, as in Portugal and Italy, the fall in inflation is more likely to have resulted from **a credibility shock** associated with a strong commitment to be part of the EMU from the start and the implementation of fiscal policy consistent with that goal.

The analysis of four middle-income developing countries (Chile, Mexico, Korea, and Turkey) using VAR models in Agenor and Hoffmaister (1997) has shown different causes of inflation or disinflation. In all four countries, **a fall in the rate of depreciation of the exchange rate** leads to a reduction in inflation. **External shocks**, in particular oil price shocks, have played an important role in explaining the development of inflation in Korea.

In the Czech case, **the decisive impact of external factors on disinflation** is generally accepted.<sup>20</sup> For the reasons highly debated in the transition literature, the internal channels – credit channel and interest rate channel – are rather weak, and output gap measures must be regarded as questionable. Hence, the impact of the

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<sup>20</sup> “The exogenous reduction in inflation caused by the fall in world commodity and producer prices was called borrowed disinflation”, Šmídková, Hrnčíř (2000), p. 193.



direct exchange rate channel must be stronger and contributes to the importance of borrowed disinflation.

This study can be summed up as follows:

- 1) The temporal links between the inflation rate and a group of explanatory variables (industrial output gap, wage gap, domestic prices, external influences) have been scrutinised using monthly data (1995:1–2000:12). Monthly data (mainly year-on-year changes) are integrated of order 1, hence their first differences have been utilised.
- 2) From the four groups of factors, according to the cross correlograms, by far a decisive role seems to be played by the external factors. The correlations of net inflation with import prices are positive in all of the first nine months, and the impact of mineral fuels and lubricants (group 3) lasts even longer. From the factors “behind” the import prices in the domestic currency, i.e. the nominal effective exchange rate, world prices of raw materials and foodstuffs and producer prices in Germany, all exhibit similar correlations with net inflation.
- 3) Different exchange rate regimes have significantly influenced the correlations of the nominal effective exchange rate with both net and adjusted inflation. In the period of the fixed exchange rate, 1995:1–1997:5, the lagged correlations are weak and statistically insignificant. In the period of the widening band (starting in 1996:3) and floating (since 1997:5), the lagged correlations are stronger, especially when the explained variable is adjusted inflation. Hence, the exchange rate regime has played its expected role in influencing the inflation rates.
- 4) On the basis of evidence from the cross correlograms, the relations between net inflation as well as import prices are studied using distributed lag models. Multipliers from both finite distributed lag and polynomial distributed lag models (one-equation systems) are calculated and compared. For example, a one-unit increase in import prices, sustained indefinitely, increases the mean of net inflation after the elapse of nine months by about one half.
- 5) More sophisticated tools – impulse response functions and variance decomposition from the VAR models (two-equation systems) – serve for studying the dynamics and reveal the reaction of net inflation to the shocks in import prices, import prices – group 3 and the nominal effective exchange rate. The effects of a shock on import prices are the strongest after the elapse of one month then die out and approach zero after the elapse of ten months. For the forecast of

net inflation, the variance decomposition shows the increasing importance of import price shock until the seven-month forecast.

- 6) Special attention has been paid to import prices – group 3 (mineral fuels and lubricants). The impulse response function reveals the very strong impact of a shock on net inflation after the elapse of four and ten months, and practically the same “jump” message is sent by variance decomposition.
- 7) Out of the factors “behind” the import prices, a very important role is played by the exchange rate. The responses of net inflation to the nominal effective exchange rate are the strongest after the elapse of three months which corresponds to the anecdotal evidence at the Czech National Bank. Subsequently, the effects regularly die out. Variance decomposition confirms the short-run impact of an exchange rate shock on net inflation. After the elapse of five to six months, the impact on forecast errors in forecasting net inflation has essentially not increased.
- 8) Our results confirm the strong direct effect of exchange rate movement on import prices and thereafter on the inflation rate. The lags seem to be similar to those in other open market economies (e.g. the exchange rate channel of monetary policy via import prices in Australia takes effect with a lag of one quarter and has a stronger up-front effect on inflation than the output channel, Stevens, Debelle, 1995). Svensson (1995) notices that the direct exchange rate channel has a shorter lag than the other channels of monetary policy.
- 9) The main message to be drawn from the preliminary results of this paper, quoting L. Ball, is the following: “In an open economy, however, inflation targeting can be dangerous. The reason concerns the effects of exchange rates on inflation through import prices”, Ball, (1999), p. 128. And a remedy is also suggested by the same author: “...long run inflation should be the formal target variable. In practice, this could be done by adding an adjustment to calculations of ‘underlying’ inflation: the effects of the exchange rate could be removed along with other transitory influences on inflation”, p. 142. Another, less laborious approach consists of taking into account “caveats” that add flexibility in the case of external shocks.<sup>21</sup>

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<sup>21</sup> See Šmídková, Hrnčír (2000).



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