



# Exchange rate pass-through to domestic prices

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*The effect of the exchange rate is considered to be an important factor affecting the Slovak economy. Its importance is also reflected by the QPM (Quarterly Projection Model),<sup>1</sup> which is used by Národná banka Slovenska (NBS) when preparing medium-term forecasts playing a key role in the decision-making regarding monetary policy settings. Due to the level of openness of the Slovak economy, it can be expected that the exchange rate will have an effect by means of the direct channel of prices of imported goods. The exchange rate is also part of the index of monetary conditions, which influence domestic prices by means of real economy. Adaptation of domestic prices to exchange rate changes is also important for the development of the balance of payment on current account.*

*From the view of NBS, the influence of the exchange rate on consumer prices is decisive, because the consumer price index is the primary indicator of price stability. Questions have emerged recently about which factors are the reason for the current low rate of inflation, above all in connection with the considerable appreciation of the Slovak koruna at the turn of the years 2006-2007. These questions are interesting and important especially in a period of discussions regarding the fulfillment of the Maastricht criteria, and above all in connection with their sustainable fulfillment.*

The objective of this analysis is to contribute to the partial understanding of the effect of the exchange rate on domestic prices. It is, however, vital to add that the presented results are only the first version of the analysis. Due to a missing analysis of the quantitative estimate of the influence of the exchange rate on prices, the first important step is to estimate the actual degree of pass-through of exchange rate changes to domestic prices (PTE). In most countries, the PTE is incomplete and frequently quite low. Despite an incomplete pass-through effect, however, the exchange rate can, as a determinant of domestic inflation, play an important role, if the shocks in the exchange rate are big or frequent. The Slovak koruna can serve as an example here, because it could have been exposed to frequent, unexpected shocks during the transformation process of the economy. Clarification of the importance of the influence of the exchange rate on changes of domestic prices using historical data can be potentially useful information also for assessing the development of the exchange rate. This argument can be partially used in the discussion regarding the considerable appreciation at the turn of the years 2006-2007, which was passed through to the prices only to a low extent. This situation can be also partially clarified by means of the estimated models for the prediction of inflation and they can be compared to actual values.

This analysis deals with three problems:

- What is the degree of the pass-through of exchange rates to prices of goods at various distribution levels – from the prices of imported

goods, over producer prices, up to consumer prices?

- Which role did the exchange rate changes play in the determination of inflation changes over the period under review (from the 1st quarter of 1999 to the 4th quarter of 2006)?
- The problem of the unclear effect of the considerable exchange rate appreciation at the turn of the years 2006-2007.

## METHODOLOGICAL APPROACHES TO THE PROBLEM OF EXCHANGE RATE PASS-THROUGH TO PRICES

In the first period, the influence of exchange rate pass-through to the prices of exported products was analyzed in the environment of the microeconomic model of the pricing issue from the view of a producer. Such models imply a situation where, in a perfect competition environment, prices are set at the level of marginal costs and each change of the nominal exchange rate must be reflected in full in the price of the exported goods. Such an approach justifies the interest of economists in testing purchasing power parity hypotheses, according to which the prices of identical tradable products in common currency are identical on various markets. However, this contradicts the observed reality, so that in general the economists agree that the prices of identical products are not identical and, in addition, they are not even constantly proportional, evidence of which is the weaker version of the purchasing power parity – the so-called relative purchasing power parity. This observation has motivated the economists to endeavor to explain the

<sup>1</sup> For more details see Gavura, Reľovský (2005).



functioning of market mechanisms involved in setting the price of identical goods on various markets, both in theoretical models and by means of empirical tests of the proposed theoretical solutions, as well as other possible factors determining the relation between the production and exported price.

Dornbusch (1987), who has considerably contributed to the further direction of the research in this area, argued that firms operate in an environment of imperfect competition, which enables them to react to a change in conditions on the target markets by changing the price of the products, as well as the margin. The exchange rate is one of the main factors affecting the development of prices of exported goods. Its influence on prices is called the pass-through effect (PTE) and the textbook definition says that it is the percentage change in the price of a good in the currency of the target market as a reaction to a one percentage change in the bilateral exchange rate.

The theoretical definition of the PTE is quite clear, but empirically it is quite difficult to separate the changes in prices of tradable goods as a result of the changes of exchange rates. The argument elaborated by Dornbusch (1987) formed the basis for the estimation of PTE. In the representative model of this type, the exporter is exporting products to foreign markets characterized by imperfect competition. That enables the exporter to set the prices above the level of their marginal costs (price discrimination) even on a long-term horizon. In such a case, the incomplete PTE is consistent with the assumption of a variable margin, when a part of the change of the exchange rate is absorbed by the producer in the margin. The degree of PTE depends then on the variability of the margin, which is determined by several factors.

Menon (1996) emphasizes, *inter alia*, the importance of the degree of substitution between domestic and imported goods and of the degree of segmentation or integration of the market. According to economists, the producers have a wider possibility for price discrimination, if their products are more differentiated, as well as if the markets are more segmented. Allowing for these opinions, individual works differ especially in the assumptions regarding the determination of the margin. The basic framework of the model is, however, more or less identical in all works.

In an extensive review of the literature, Goldberg and Knetter (1997) give the general form of the equation implied by the theoretical model being described

$$p_i = \alpha + \beta E_i + \gamma X_i + \psi Z_i + \varepsilon_i \quad (1)$$

where  $p_i$  is the product price in the price of the import market,  $E_i$  is the nominal exchange rate,  $X_i$  is the proxy variable for producer costs and  $Z_i$  stands for further variables that can potentially help to explain the movement of prices.

Menon (1996) assumes that the producer margin is determined by the ratio of competitive products to the own production costs. He found out on the basis of the detailed structure of 40 product categories in Australia that the PTE differs considerably in the individual categories and reaches an average value of 75%. The influence of quantitative restrictions on imported goods dominates among the main PTE determinants. The author also emphasizes the selection of appropriate data and argues that the frequently used price indexes of imported goods (e.g. unit value indexes) are not the best proxy for imported prices. Therefore, Menon uses actual prices of imported goods in his work.

Campa and Goldberg (2002) also present the same direction of ideas. However, they extend the basic equation by adding time-lagged variables representing the dynamics of the adaptation process of prices. They model the margin of producers in the same way as Menon (1996). In their work, however, they emphasize that it is imperative to use correct data in the regression. In their opinion, it is absolutely necessary to include in the model all exogenous variables affecting the production costs. Otherwise it is impossible, according to them, to interpret economically the estimated coefficients, which in this case represent more or less only a mathematical statistical correlation. The average estimated PTE in a sample of 25 OECD countries is 61% on a short-term horizon, while it increases to 77% on a long-term horizon (1 year). The authors also deal with the issue of time stability of the degree of PTE. This issue came to the fore especially over the last 10 years, when several authors (e.g. Taylor 2000) document a fall in the degree of PTE. Campa and Goldberg (2002) in their work, however, do not reject the hypothesis of a stable PTE on a long-term horizon, while they obtain mixed results on a short-term horizon. The pass-through stability is even more marked at the disaggregated level of five product categories.

An extensive database enables the authors to perform a deeper analysis of the results reached. In the spirit of the last alternative explanations of the incomplete pass-through, they test if microeconomic or macroeconomic determinants play a greater role in explaining the partial influence of the exchange rate on prices. A prominent advocate of the macroeconomic factors, as the opposite of the microeconomic factors described in the introduction, is Taylor (2000), who ascribes the documented low (and decreasing) influence of the exchange rate on imported prices to monetary policy. In his opinion, the monetary policy regime aimed at maintaining a stable growth of prices has considerably contributed to a decrease of the influence of the exchange rate on prices. The grounds of this argument have a common basis with the microeconomic attitude – competition. According to Taylor (2000) strong competition in a low-inflation environment does not en-



able the producers to increase prices considerably, because increasing prices in a stable prices environment is unjustified and competitors would not follow them, which would entail a loss of market share. Taylor (2000) associates low inflation with low volatility and persistence of shocks. It is the reaction of producers to production cost shocks that determines the degree of PTE. If the shock is perceived as a short-term shock, the producers are willing to absorb it into their margin (due to competitive pressures). If, on the other hand, the shock is perceived as persistent, the producers have a tendency to pass it through to the prices. That means that the low-inflation environment (environment with low volatility and persistence of shocks) causes a lower degree of pass-through of exchange rate changes to prices. Campa and Goldberg (2002), however, find out that the macro determinants (openness of the economy, inflation level, volatility of the exchange rate and money supply growth) explain only a small part of the variability of prices. The micro determinants (elasticity of demand), on the other hand, are the core, the basis of the variability of prices. Likewise, the observed change in the degree of PTE at the aggregate level is explained by the authors by a change in the composition of imports, in contrast to Taylor's argument regarding the change of the monetary policy regime.

Goldberg and González Mínguez (2005) point out the possibility of endogenous variables in equation (1). In such a case, the estimated coefficients are biased and the actual degree of PTE can differ considerably from the estimated elasticity. One of the arguments of biased estimates is mentioned by Goldberg and Knetter (1997). The standard model like (1) assumes that marginal costs are the decisive factor of the price of the product. Therefore, empirical literature assumes that good variables exist for marginal costs. These variables, however, are often only indexes based on the wage costs of firms. The real (unobservable) marginal costs, however, include further influences, at least the influence of the exchange rate and the amount produced. The exchange rate as an argument of the cost function can be understood as a factor influencing the costs by means of imported production inputs. Likewise, the exchange rate can be interpreted as a cost factor – for the influence on the resulting price of the exported product. The authors Podpiera and Raková (2006) have also applied this interpretation. From the view of the exporter, the demand for his products on the foreign market increases in the case of a depreciation of the bilateral exchange rate. If the marginal costs are an increasing function of the amount of production, increased production entails an increase of the marginal costs. If the variable for marginal costs does not reflect this fact sufficiently, the variable contains a measurement error, which is negatively correlated with the exchange rate (a higher val-

ue of the exchange rate represents its appreciation) and positively correlated with the price  $pt$ . That causes a bias of the estimated elasticity towards lower values – underestimate of the PTE. Due to a possible endogeneity of the variables, Goldberg and González Mínguez (2005) consider the possibility of a multi-equation model as a possible solution to the problem. Based on cointegration tests of the variables, however, the authors conclude that the endogeneity of variables should not lead to biased estimates, and hence the resulting estimated model consists only of one equation of type (1). The authors thus estimate the PTE effect for the countries of the euro-area to be at the level of about 60% on a short-term horizon and about 80% on a long-term horizon. Like Campa and Goldberg (2002), Goldberg and González Mínguez (2005) have found out that the degree of pass-through differs in individual countries as well as industries.

Goldberg and González Mínguez (2005) also point out another fact occurring in the literature in recent years. The PTE in imported prices differs from that in the consumer prices, the difference not being caused only by a smaller weight of the tradable goods in the CPI consumer basket (Consumer Price Index). Other factors causing this difference include the frequently mentioned influence of distribution costs on the final price for consumers. Another factor can be monetary policy, which reacts to the current (expected) development and damps inflation pressures, caused by a depreciation of the exchange rate, by a more strict monetary policy, which, through nontradable goods, compensates for the increase in the prices of tradable goods.

A single-equation model (1), or a VAR (Vector Autoregression) model, if the variables are endogenous, can be, of course, used to estimate the PTE, be it to imported prices or to consumer prices. If we want to explain better the different influence of the exchange rate on the prices of tradable goods at the various distribution stages, it is more appropriate to set up an integrated multi-equation model, which solves the potential problem of endogeneity of variables and at the same time enables a different reaction of the prices to exchange rate changes. The different reaction is made possible, besides the direct influence of the exchange rate like with model (1), by the effect of prices at a certain level of the distribution chain to prices at the following level. This richer dynamics of the model has the potential to better explain the (different) reaction of prices at the individual stages of the distribution of goods.

Faruquee (2004) uses a synthesis of the micro-economic approach with the idea of differentiation of the reaction of prices in the distribution chain. The price equations of the model (import and export prices, producer prices and consumer prices) take the form of a simple mark-up model that has the exchange rate and employee compensations, serving as proxy variable for margin-



al costs, as input arguments. The model is completed by equations for the exchange rate and worker compensations. The model implies a relatively low (almost zero) PTE for import and consumer prices on the short-term horizon for the euro-area countries. As expected, on a long-term horizon the degree of PTE (to consumer prices) is higher, but still incomplete. The difference in the PTE to import and consumer prices is considerable and it marks the important role played by the retail sector and by distribution costs.

Ca'Zorzi, Hahn and Sánchez (2007) have also chosen the distribution chain approach in their work. As opposed to Faruqee (2004), however, they apply a model with weaker theoretical bases. The empirical specification of the model contains the influence on prices by means of real economy (supply shocks are approximated by an oil price index and the GDP represents the demand shocks), monetary policy (short interest rates), the exchange rate and the model is completed by three price indexes within the meaning of the pricing chain – import prices, producer prices and consumer prices. Using a set of countries from various regions of the world (including countries of Central Europe except Slovakia), the authors find that the data does not corroborate the generally prevailing opinion that the PTE is higher in developing countries. The authors also state that the degree of PTE in developing countries depends on the level of inflation as Taylor (2000) suggests. Openness of the economy, on the contrary, is not an important determinant of the variability of prices.

The same approach to the problem has been basically chosen by McCarthy (2000) and Hahn (2003). They explain changes in domestic prices (import prices, producer prices and consumer prices) by the influence of the supply side of the economy (oil price index), demand side of the economy (GDP gap), exchange rate and monetary policy (central bank's reaction function and the money demand equation). McCarthy (2000) deals with a couple of developed countries. His main conclusion is that the PTE is relatively low and the exchange rate (and shocks in import prices) plays a relatively small role in the explanation of the development of the aggregate consumer price index. These conclusions contradict the findings of Hahn (2003), who claims that external shocks (besides the exchange rate, he considers the shock in import prices and oil prices) explain a great part of the inflation variance. The conclusion about the decreasing influence of the exchange rate on prices within the distribution chain, however, is in line with the observations of McCarthy (2000).

## METHODOLOGY

The literature dealing with the issue of pass-through of exchange rate changes to the prices provides the unambiguous conclusion that the in-

fluence of the exchange rate on imported prices differs from the influence of the exchange rate on consumer prices. The microeconomic single-equation approach based on mark-up models thus does not have to be appropriate from the perspective of the needs of the central bank. The reason is the different degree of PTE in the imported and consumer prices. A mark-up model based on the explanation of the behavior of exporters during exchange rate changes has the potential to explain the change of prices in the first phase of goods distribution to the consumer – the import prices. In the following phases, however, the price of imported goods is also determined by other factors than marginal costs and producer margins. Burstein, Neves and Rebelo (2001) estimate that up to 40% of the final price of products are represented by distribution costs caused by domestic companies. In addition to the distribution costs, there are further factors that can affect the consumer prices of imported products.

For the estimation of the influence of the exchange rate on consumer prices, we have therefore used the model advocated by McCarthy (2000). He analyses the change of the price of imported goods in the distribution chain from the prices of imported goods, over producer prices, up to the final consumer prices; an exchange rate change having a symmetric impact on the prices. The logic of the model is described below.

A foreign producer sets the prices of their products on the basis of marginal costs and the required margin. The prices of these products imported to the domestic market are then converted to the domestic currency using the exchange rate. In the simplest case, the price of goods could be converted according to the current market exchange rate – in such a case, we would have a full PTE. In general, however, this is not the case visible on the markets, because the exchange rate change can affect both the change of marginal costs and the change of the margins. There are several reasons for this. A part of the production inputs can come from foreign suppliers, which influences the total production price. On the other hand, the margin is an instrument, by which the producers can control their market share and thereby can attempt to absorb the exchange rate change in the margins. The price of imported goods in the domestic currency can be resistant, in part, to changes in the exchange rate also due to contracts of rather long-term nature entered into between the importers and their foreign suppliers.

In a second phase, the prices of imported goods are reflected in producer prices. At this stage, however, the degree of PTE should decrease as compared to the first phase, because products at the output of producers already contain a considerable part of value added stemming from domestic environment (e.g. labour) and the imported production input represents only a small part of the final output. Since, in the first



phase, we do not consider the prices of imported energies, the prices of energies can also determine a part of the final price in that phase of goods distribution to the ultimate buyers – the consumers.

In the last phase of goods distribution (goods market for end consumers), the prices are, to a considerable extent, influenced by the prices of imported goods and producer prices. At the same time, we can assume that the final prices are also influenced by further factors such as demand pressures. The arrival of large chains of stores and the gradual growth of the number of hypermarkets is also likely to have had a damping impact on the growth of consumer prices. We have found no satisfying proxy variable for the estimate of the influence of hypermarkets, therefore it is possible that the exchange rate effect and the influence of the hypermarkets on prices overlap each other, so that the actual PTE can be somewhat smaller than estimated by this analysis.

We have explained the basic features of a model, having the potential to explain the influence of an exchange rate change on prices in various phases of distribution to the end consumer, in the preceding parts. We have also indicated certain structural restrictions, which however are ignored in the basic model and we use them only after formal tests have confirmed that they are justified.

The model consists of seven variables. The indirect channel of the exchange rate through a change in the production costs and margin is controlled by means of export prices of producers, supply shocks (secondary influences of energy price changes) are approximated by the oil price, and the output gap represents demand pressures. The nominal exchange rate, import prices, producer prices and consumer prices are the most important part of the model. The model in a reduced form can be formally written in the form:

$$Y_t = B_0 + \sum_{i=1}^n B_i Y_{t-i} + e_t, \quad (2)$$

where  $Y_t$  is the vector of seven endogenous variables,  $B_0$  is the vector of constants,  $B_i$  are coefficient matrices for lagged variables and  $e_t$  is the prediction error.

The advantage of this approach is the ability to demonstrate the dynamic trajectories of the variables as a reaction to a shock in one of the variables by means of impulse-response functions. At the same time, we can observe the potentially differing influence of the exchange rate in the individual price indexes (import, PPI, CPI). Finally, yet importantly, it also solves the problem of endogenous variables.

However, the term pass-through of exchange rates is not precisely defined, either. An appreciation/depreciation of the exchange rate does not naturally manifest itself in the prices during a couple of precisely given periods (quarter, month).

It just the opposite – we expect that the exchange rate change manifests itself in the prices during a certain time period. In this analysis, the influence of exchange rates is given on the time horizons of 1 quarter (immediate effect), 4 quarters and 8 quarters (long-term effect). In this perspective, the PTE is defined as the cumulative effect of the change of the exchange rate to the price level at the given moment of time over one to two years.

## DATA

We use quarterly data in the analysis – the period from the 1st quarter of 1999 to the 4th quarter of 2006, which corresponds to the period of the floating exchange rate regime.

From the analysis we have left out energies, whose reaction to an exchange rate change is usually considerably different from the reaction of other products. Consumer prices are therefore represented by core inflation<sup>2</sup> on the basis of CPI<sup>3</sup>. Producer prices are represented by the PPI manufacturing index. Two alternative indexes, the unit value index<sup>4</sup> (UVI) and the implicit import deflator<sup>5</sup>, are available for import prices proxy. Demand pressures on the domestic market are represented by the output gap, which is taken from the medium-term forecast of NBS (MTF-2007Q3). Supply shocks are approximated by the oil price in USD. The primary objective of this analysis is to estimate the influence of the bilateral SKK/EUR exchange rate, but the analysis is supplemented with a model with the effective exchange rate, where the shares of the imports of the individual trade partners represent the weights for the computation of the effective index. The index of export prices of foreign producers has been used analogously – the export price index of the euro-area is supplemented by the effective index of export prices.

Euro-area countries, the most important trade partners, have participated in the overall imports in 1999 – 2006 with almost 50%. The effective indexes are based on 4 trade partners – the euro-area, the Czech Republic, Hungary and Poland – which represents almost 70% of the total volume of imports to Slovakia. Table 1 shows the definitions of variables, their source and the designation used for the individual variables in the following.

We obtain a total of three alternative model specifications this way, which represent combinations of two import price indexes with a bilateral exchange rate, and a supplementing model uses effective indexes along with the import price deflator.

All variables (except the output gap) are converted to indexes, whose base is the average of 2000. Because some variables exhibit a seasonal character, we have added seasonal dummy variables to the model.

All variables except the output gap are nonstationary, their first differences being stationary. The output gap is stationary. The VAR model (2) can

2 Includes fuel prices, whose weight, however, is relatively low.

3 We have focused on the CPI instead of the HICP due to numerous methodological changes in the HICP definition during the period under review.

4 UVI – the unit value index is based on a Laspeyres index, in which the price level growth at time  $t$  against time 0 is computed as a change in the value of the representative basket of goods from time 0 between the given points of time.

5 The implicit import deflator is computed as the ratio of the nominal volume of imports excluding oil and natural gas imports in the given quarter to the real volume of imports excluding oil and natural gas in the same quarter.



Table 1 Definitions of variables, their source and designation

Variable	Proxy variable	Source	
Consumer inflation	CPI_core	Core CPI	ŠÚ SR
Producer prices	PPI_man	PPI manufacturing	ŠÚ SR
Import prices	Pmexe	Import prices deflator	ŠÚ SR and own calculations
	UVI	Unit value index <sup>4</sup>	ŠÚ SR
Supply shocks	Oil	Crude oil	Bloomberg
Demand shocks	GDP_gap	Output gap	NBS
Weights of imports according to countries		Shares of total imports	Eurostat and own calculations
Export prices	Export	Effective export prices deflator index	Eurostat and own calculations
	Export_EMU	Export prices deflator of the euro-area	Eurostat
Exchange rate	FX	Effective nominal exchange rate	NBS and own calculations
	FX_EMU	Bilateral SKK/EUR exchange rate	NBS

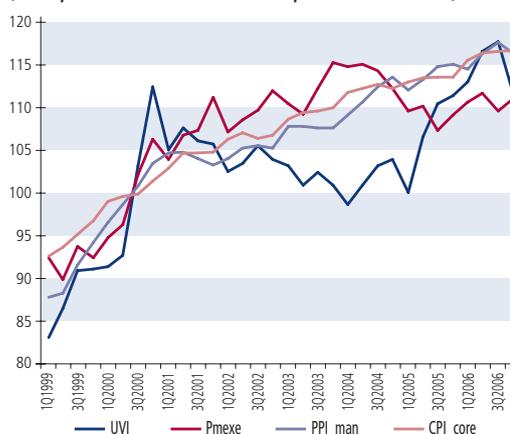
be thus estimated in the first differences of non-stationary variables.

**EMPIRICAL RESULTS**

The development of exchange rates approximately to the end of 2002 differs from their development in the second half of the period under review (1999-2006). While they have stagnated in the first half of the period, they have appreciated in the second half quite considerably. Table 2 demonstrates the different development on annualized changes for the whole period under review, as well as two intervals: first quarter of 1999 – third quarter of 2002 and fourth quarter of 2002 – fourth quarter of 2006. The price indexes increased during the period under review, which can be particularly seen in the case of producer and consumer prices, although their growth seems to have slowed down in 2001. That year, however, does not exactly coincide with the change in development of exchange rates. There has been a slightly unusual development with the UVI index, because its level was falling in 2001-2004. Such a development, however, visually reflects the development of the export prices indexes of foreign trade partners. The import price

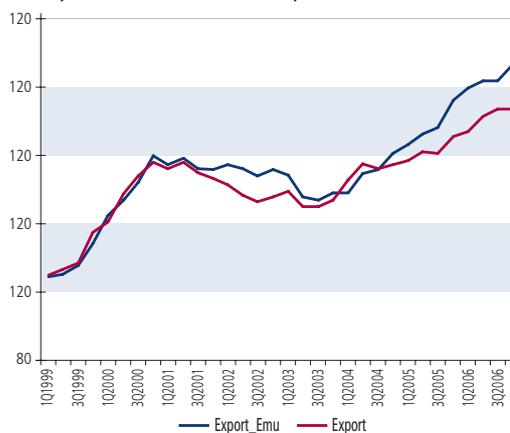
deflator, on the other hand, grew also during that period, its development, however, corresponded

Chart 2 Price indexes (1st quarter of 1999 – 4th quarter of 2006)



Source: Statistical Office of the Slovak Republic and own calculations.

Chart 3 Export prices (1st quarter of 1999 – 4th quarter of 2006)



Source: Eurostat and own calculations.

Explanatory notes:  
 FX\_EMU – SKK/EUR exchange rate,  
 FX – effective nominal exchange rate,  
 UVI – unit value index,  
 Pmexe – import prices deflator,  
 PPI\_man – producer prices,  
 CPI\_core – consumer prices

Chart 1 Exchange rate (1st quarter of 1999 – 4th quarter of 2006)



Source: NBS and own calculations.



Table 2 Annual changes of individual variables (in %)

Period	Unit value index	Import price deflator	Producer prices	Core inflation CPI	Output gap	Oil	SKK/EUR exchange rate	Deflator of euro-area export prices	Effective nominal exchange rate	Effective index of the export price deflator
1Q1999 – 4Q2006	3.7	2.3	3.5	2.9	-1.4	20.8	-2.4	1.5	-1.5	1.2
1Q1999 – 3Q2002	6.4	4.5	4.9	3.7	-1.7	22.7	0.2	1.6	1.6	1.2
4Q2002 – 4Q2006	1.7	-0.2	2.4	2.1	-1.1	19.3	-3.5	1.4	-3.0	1.2

Source: NBS, Statistical Office of the Slovak Republic, Eurostat, Bloomberg and own calculations.

Note: The table gives the annualized percentage changes of individual variables. The data for the production gap represents its average size.

more to the development of exchange rates, because its growth slowed down slightly in the period of exchange rate appreciation.

A comparison of the growth of the individual indexes in two periods indicates that the exchange rate could have played a role in the development of price indexes. Arranging the periods according to the size of the average exchange rate appreciation (fourth quarter 2002 – fourth quarter 2006, first quarter 1999 – fourth quarter 2006, first quarter 1999 – third quarter 2002) shows that the growth of import prices (UVI as well as Pmexe) keeps the order, given that in the period fourth quarter 2002-2006 (the strongest exchange rate appreciation) the growth of import prices reached the lowest rate. Over the entire horizon, the growth of import prices was somewhat faster and in the period from the first quarter of 1999 to the third quarter of 2002 their growth reached the highest rate. The same argument, albeit to a lesser extent, applies to producer prices. The situation is less unambiguous in the case of consumer prices. Nevertheless, we can state even for the consumer prices that the growth of consumer prices was higher in the first half of the period under review than in the second half, because the exchange rate appreciates considerably. We can also presume that the influence of the exchange rate decreases in the sense of the distribution pricing chain, as already described in the methodological part, when the difference of the growths of price indexes between the individual periods was more considerable at the beginning of the distribution chain, more so in the import prices than in consumer prices.

However, this development is facilitated also by further factors applied – the export prices and the oil prices. Demand pressures measured by the production gap are relatively small. The production gap is always negative and somewhat smaller in the second half of the period.

As mentioned already in the preceding part, the three estimated models will be identified in the following parts of the analysis according to Table 3.

Table 3 Identification of the models

	UVI – unit value index	Import prices
Euro-area	Model 1	Model 2
Euro-area + V4 countries	–	Model 3

Reactions of the price indexes to a shock in the exchange rate have been simulated using a Cholesky decomposition. The size of the shock was 1 standard deviation of the exchange rate. In the following tables, the cumulated reactions of the price level are normalized to a shock of size 1% of exchange rate depreciation. The first line contains the immediate reaction of the given variable, the second line the total change of the given index after 1 year from the depreciation of the exchange rate and the third line presents the cumulated changes two years after the shock.

The following findings can be presented based on reactions of price indexes:

1. The influence of the exchange rate on import prices depends on the index used. The immediate reaction to an exchange rate change in the case of the UVI index is about 100%, while it is considerably less in the case of the import prices deflator – 15%. Based on the UVI indexes, the PTE on import prices can thus be full.
2. Some 15% of the total exchange rate change gets into producer prices in one quarter. Both models indicate that the effect of an exchange rate change manifests itself only in the first period, because the cumulated reaction or producer prices after one (as well as two) years is approximately the same as after the first quarter – about 15%.
3. The pass-through of the exchange rate to consumer prices appears to be relatively resistant to the model choice. The immediate influence is negligible. The total effect is approximately 10%. The reaction of prices approaches this value as early as one year after the exchange rate change. The cumulated effect even increases slightly in the second year.
4. The influence of the exchange rate on prices in the distribution chain is falling. The PTE on import prices is almost full; it is less than 50% in the producer prices and about 10% in consumer prices.

The model using the effective exchange rate indicates a full PTE on prices of imported goods, like in the case of model 1. In the second and third phase of goods distribution, on the other hand, this model indicates a slightly higher degree of PTE. For producer prices, it indicates a longer lasting pass-through of the exchange rate change to producer prices, because about 15% of the ex-



**Model 1 Reactions of price indexes to an exchange rate shock using a Cholesky decomposition (in %)**

Period (quarters)	UVI	Producer prices	Consumer prices
1	1.14	0.16	-0.02
4	<b>1.07</b>	<b>0.12</b>	<b>0.09</b>
8	0.80	0.12	0.12

Source: Own calculations.

**Model 2 Reactions of price indexes to an exchange rate shock using a Cholesky decomposition (in %)**

Period (quarters)	Import prices	Producer prices	Consumer prices
1	0.15	0.13	-0.02
4	<b>0.16</b>	<b>0.08</b>	<b>0.09</b>
8	0.27	0.14	0.14

Source: Own calculations.

change rate change is reflected in the prices after one quarter, almost 30% after one year and this value approaches the value of 50% after two years. In the last phase of goods distribution, prices of consumer goods, the values are similar except for immediate reaction. One quarter after the exchange rate change, there is zero influence on the consumer prices, after one year it is more than 10% and after two years, the influence of the exchange rate change stabilizes at a level of about 20%.<sup>6</sup>

It is necessary to realize for these values that models based on the bilateral exchange rate do not imply an influence on prices that (considerably) differs from that of the model with the effective exchange rate, despite the numerically different expression of the exchange rate elasticity. The reason for this is a different speed of appreciation of the koruna against these two exchange rates over the period under review. While the koruna appreciated against the euro in the period first quarter of 1999 – fourth quarter of 2006 by 19%, it appreciated against the broader effective exchange rate only by 12%. That means that the seemingly lower degree of pass-through in the case of the bilateral exchange rate has approximately the same impact on the price level in absolute terms as the higher degree of pass-through in the case of an effective exchange rate.

Although impulse-response functions indicate the size of the effect of the pass-through, they do not tell much about whether and how the exchange rate changes were important for the fluctuation of domestic prices. If, for example, shocks in the exchange rate were relatively large or frequent, the exchange rate can be an important determinant of price level changes, although the PTE is relatively small. To clarify this importance, we have performed a decomposition of the variance of price indexes. The variance decomposition can be used to evaluate the individual

variables' share in total fluctuation of the given variable<sup>7</sup>, during the whole period under review. The following table summarizes this decomposition for all three models and for the period of 1, 4 and 8 quarters.

The exchange rate is an important determinant of UVI index changes, because it explains up to approximately one third of the total index fluctuation. Surprisingly, however, the exchange rate plays a negligible role in the case of changes of the import prices deflator. When determining the changes of producer prices, the exchange rate is present at about 10%, which is considerably less than in the case of the UVI index, but more than in the case of the import deflator, which also confirms the specific development of the deflator. The exchange rate's share of changes of core inflation is less than 10%, which reflects the smaller share of imported goods in the consumption basket. Overall, however, the exchange rate is able to explain a relatively small part of the fluctuation of consumer prices as well as producer prices, especially after taking into consideration the openness of the Slovak economy. These results indicate that the volatility of domestic prices (except imported prices) is not considerably determined by the volatility of the exchange rate. In other words, the appreciation of the exchange rate has had a relatively stable influence on domestic prices (we spoke about its size in the preceding part) and short-term shocks in the exchange rate did not influence domestic prices considerably.

**Tab. 4 Individual variables' share in total variance (in %)**

Period (quarters)	Model 1	Model 2	Model 3
	FX_EMU	FX_EMU	FX
	UVI	Pmexe	Pmexe
1	48	2	7
4	37	2	5
8	35	2	5
	PPI_man	PPI_man	PPI_man
1	9	11	14
4	5	7	7
8	5	7	6
	CPI_core	CPI_core	CPI_core
1	0	0	2
4	6	8	7
8	7	8	8

Source: Own calculations.

Explanatory notes: The lines show the percentage shares for the variance of the individual price indexes, which can be ascribed to exchange rate variance.

FX – effective nominal exchange rate

FX\_EMU – SKK/EUR exchange rate

CPI\_core – consumer inflation

PPI\_man – producer prices

Pmexe – import prices

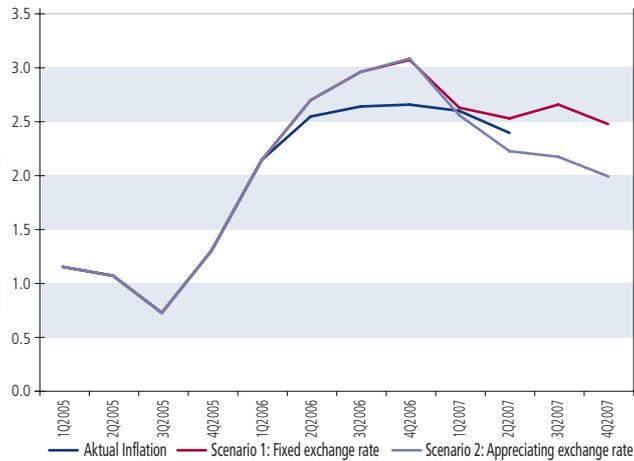
UVI – unit value index

<sup>6</sup> Due to a different reaction of consumer prices and producer prices to a change in the bilateral and effective exchange rate, the question emerges as to what is the appropriate way to compute effective indexes. While it is justified to weight export prices by means of the individual countries imports' shares (territorial structure), the exchange rates weighted in the same way do not have to correspond to the real shares of the given currencies in international trade. For this reason, model 3 has been estimated at the bilateral EUR exchange rate instead of the effective exchange rate (like in the original models). This change, however, has no considerable influence on the results of the impact of the exchange rate on producer and consumer prices.

<sup>7</sup> The decomposition of the variance of the fluctuation of variables is based on the decomposition of the fluctuation of the prediction error of the given variable, the fluctuation of the prediction error being in the limit identical with the variance of the given predicted variable. The prediction error variance can thus be used to evaluate the importance of the individual determinants when explaining the variable.



**Chart 4 Consumer core inflation  
(Model 1, 1st quarter of 2005 – 4th quarter of 2007)**



Source: Own calculations

In the recent past, the issue of the impact of a strong exchange rate appreciation at the turn of the years 2006-2007, when the considerable appreciation has not lead to the expected considerable decrease in inflation, frequently emerges. The estimated VAR models can be used to illustrate how inflation should react under such exchange rate development, if model relationships hold (the exchange rate has the same influence on prices as on average during the period under review). For that purpose, we have used the first model in the dynamic simulation; import prices are represented by the UVI index in the model.

The model has been used for the simulation of two scenarios. In the first scenario, the exchange rate was fixed over the entire period from the second quarter of 2006 at its level from the first quarter of 2006. The chosen simulated period represents the beginning of increased exchange rate volatility – the exchange rate depreciated in the second and third quarter of 2006 and appreciated considerably subsequently. In the second scenario, we have used the actual values up to mid-2007 for the exchange rate trajectory.

The model indicates in the initial simulation period that inflation should have been higher. Such a considerable deviation can be ascribed to shocks stemming from the actual data from the period before the beginning of simulation and persistence. The slight exchange rate depreciation in mid-2006 manifested itself in a slightly higher inflation in the scenarios involving actual exchange rate development (Table 5). In the next period, characterized by a considerable appreciation of the koruna, the inflation prediction based on the actual exchange rate development will shift to a considerable extent below the prediction based on a fixed exchange rate. These differences are expressed numerically in Table 5. According to the model, the difference between inflation in the case of the actual exchange rate and inflation in the case of a fixed exchange rate should be 0.3 percentage points in the second quarter of 2007, and this difference should culminate at the turn of the years when the time lags

should fully manifest themselves in the reaction of prices to an exchange rate change. It can be also seen from these simulations that the exchange rate appreciation effect might not have manifested itself yet in full and a part of the appreciation (the most considerable effect) can still manifest itself at the end of 2007.

According to the model, inflation in mid-2007 should be lower than it was in reality, and an additional decrease in inflation should follow in the following period, too. However, this should not be interpreted as a decrease in the pass-through degree, because other factors (shocks) also affected inflation in the same period. At the same time, it is also not possible to claim that the degree of PTE did not change. Recent information available to NBS does not indicate a considerable decrease in inflation due to the exchange rate in the near future. The deflection of the influence of the exchange rate on inflation from the average value during recent years can be due to the perception of the strong koruna appreciation as a short-term shock, therefore it has not been taken into account in the pricing process.

**Table 5 Difference between simulated inflation on the basis of scenario with the fixed exchange rate and the scenario with actual exchange rate development**

Obdobie	Model 1
3Q2006	0.00
4Q2006	0.01
1Q2007	-0.07
2Q2007	-0.30
3Q2007	-0.48
4Q2007	-0.49

Source: Own calculations.

## CONCLUSION

The degree of openness of the Slovak economy sets the stage for circumstances where the exchange rate plays a relatively important role in the determination of domestic prices. Due to the convergence of the Slovak economy, which partially happens by means of the long-term appreciation of the Slovak koruna, this question is one of the key questions of monetary policy.

The main objective of this analysis is to clarify the quantitative relationship between exchange rate changes and domestic prices. The chosen empirical approach uses a VAR model, which has a relatively general form in this project phase and treats the appreciation and depreciation of the exchange rate symmetrically. This approach enables to follow the dynamic reactions of the individual price indexes – the prices of imported goods, producer prices, consumer prices – on exchange rate changes. The estimated VAR models have been used to address three problems. The first problem is the estimate of the degree of pass-through of the exchange rate. The second prob-



lem is the evaluation of the effect of exchange rate changes on price level changes during the period under review. The last problem is the prediction of consumer price inflation by means of estimated models, conditional on the actual exchange rate development from the second quarter of 2006.

The basic finding of this analysis is that the long-term cumulated degree of pass-through to consumer prices (excluding regulated prices) is approximately at the level of 10 – 20%, and the immediate reaction of prices to an exchange rate change is negligible. The reaction culminates approximately after two years. Under the expected influence of the exchange rate on regulated prices<sup>8</sup>, the influence of the exchange rate on headline inflation is approximately the same as on core inflation. The degree of PTE to producer prices is higher and can reach a value of up to 50%. The import prices react to exchange rate changes immediately. The total degree of PTE, however, depends on the proxy of import price index used. The pass-through is full in the case of the UVI index. When the import prices deflator is used, on the other hand, the pass-through is only about 30%.

Inflation based on the individual price indexes and the exchange rate during the period under review has shown a relatively high volatility. Nevertheless, only a small part of the volatility of the consumer prices as well as producer prices can be ascribed to the exchange rate volatility. That suggests that the fluctuations of domestic prices are primarily caused by other factors, despite the considerable openness of the Slovak economy.

The estimated models have been used to evaluate the development of inflation in 2007 as a result of the exchange rate development in the years 2006 and 2007, during which a short-term exchange rate occurred in 2006 and a considerable appreciation of the Slovak koruna occurred at the end of 2006 and in the first months of 2007. This simulation indicates that if the effect of the exchange rate on prices from the previous years was maintained, inflation should be lower than it currently actually is. In other words, the potential for a decrease in prices of the imported goods created by the appreciation of the Slovak koruna has not been used to the same extent as during the preceding years.

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