

The Phenomenon of Incomplete Exchange Rate Pass-Through to Prices in the Euro Area

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Abstract. The main aim of the article is to present the influence of exchange rate fluctuations on the price dynamic in the Euro Area. The knowledge concerning the level of exchange rate pass-through to prices allows assessing how exchange rates affect on inflation and monetary policy in given states.

The article consists of two parts. The first component deals with theoretical analysis of the phenomenon of incomplete exchange rate pass-through to prices, including reasons and factors determining the range of this phenomenon. In the next part of article, there is analyzed the range of exchange rate pass-through to prices in the Euro Area by using the Vector Autoregression Model (VAR). There are estimated coefficients of exchange rate pass-through to import, producer and consumer prices on the base of impulse response function. Then, there is made decomposition of the price index variance in order to assess the degree of price determination by exchange rate changes.

Keywords: Exchange rate; VAR model, inflation

1 Introduction

The exchange rate fluctuations and exchange rate pass-through to prices of home and foreign goods have essential consequences from the macroeconomic as well as microeconomic point of view. The depreciation of home currency makes direct and indirect results for the whole economy. The direct results of depreciation appear in increase prices of imported semi-manufactured goods, which are used to home production, and in the growth prices of imported final products. However, the indirect results are increase of national demand on substitution goods in relation to import goods and increase of foreign demand on export goods. Consequently, all results of depreciation mentioned above lead to general growth of prices in the country [cf. fig. 1].

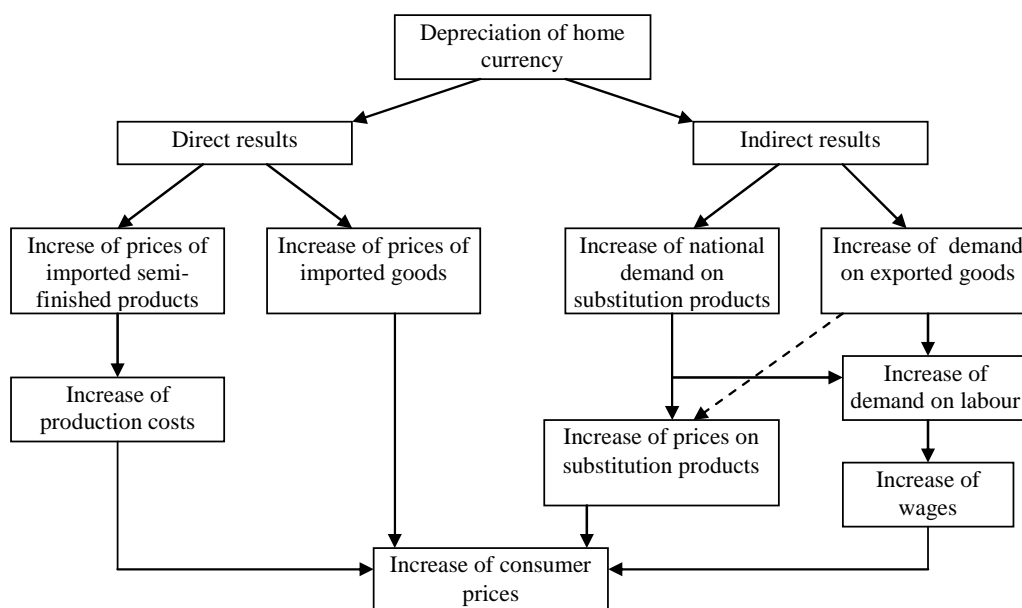


Figure 1 Macroeconomic effects of depreciation of domestic currency.

Source: (Hüfner and Schröder, 2002).

Reverse consequences result from appreciation of home currency in relation to foreign currencies. Appreciation of home currency leads to direct and indirect results for the economy. The direct effects of appreciation are the decrease prices of imported semi-products and decrease prices of imported final products. However, the indirect effects of appreciation are the decrease of national demand on goods, which are substituted to imported and decline of foreign demand on export goods. In consequence the indirect and direct results of appreciation of home currency lead to general fall of prices in a country [cf. fig. 2].

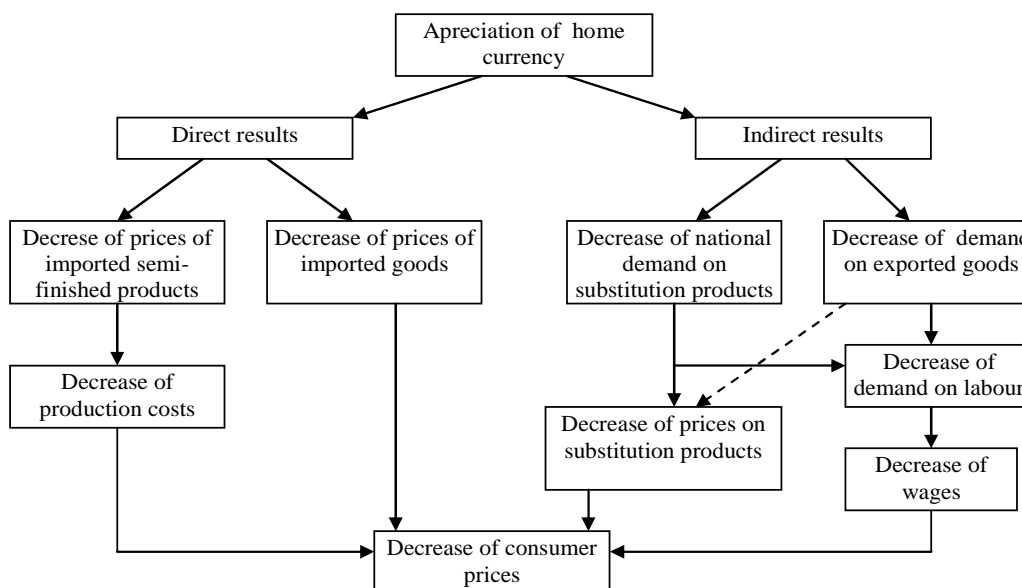


Figure 2 Macroeconomic effects of appreciation of domestic currency.

Source: (Hüfner and Schröder, 2002).

In economic literature, there are many different definitions of exchange rate pass-through to prices. From one side, many economists use definition, in which exchange rate pass-through defines how exchange rate changes are passed through to import prices (*sense stricto definition*) (Dwyer, Kent and Pease, 1993). On the other hand, other economists define phenomenon of exchange rate pass-through as a way, how exchange rate changes are passed through to all prices, both to producer prices (*PPI - Producer Price Index*) and to consumer prices (*CPI - Consumer Price Index*) (*sense largo definition*) (Ambler, Dib and Rebei, 2003).

For a long time the literature on the topic had assumed a complete exchange rate pass-through to prices in conformity with the law of one price and purchasing power parity. Only in the 1980s empirical analyses revealed that it is rather an incomplete exchange rate pass-through of into domestic and foreign prices which is a common phenomenon. The next studies concerning this issue confirmed prevalence of incomplete exchange rate pass-through to prices [see Appendix]. Such a situation is an effect of a specific market structure (perfect or imperfect competition), the occurrence of individualized products, activities of transnational corporations and the occurrence of different types of barriers in external trade.

One of the first economists analyzing the phenomenon of incomplete exchange rate pass-through to prices was Krugman as well as Dornbush. They came to a conclusion that pricing to market is an important factor determining deviations from the law of one price (Krugman, 1987; Dornbush, 1987). On the other hand, Taylor indicated also a different factor determining the degree of exchange rate pass-through to prices, which is inflation rate. He proved that a low inflation rate leads to a lower degree of exchange rate pass-through to domestic prices Taylor (2000). The situation is reverse in the countries of a low inflation rate (Choudhri and Hakura, 2001).

Moreover, Osbat and Wagner (2006) suggest that the degree of exchange rate pass-through to prices depend on the degree of substitutability between foreign and domestic goods, the competitive structure in the industry in home and abroad, barriers to trade, import penetration and the relative market size.

In a recent paper that also examines extra-Euro Area manufacturing trade prices, Anderton (2003) also finds generally high (albeit not full) pass-through between 0.5 and 0.7, based on a single-equation approach.

The results of research conducted by Faruquee (2006) also show that the impact of an exchange rate shock on prices is relatively small in the Euro Area. According to these results, initially prices tend to be very sticky in response to depreciation in the euro effective exchange rate. Over time, the degree of exchange rate pass-through generally increases. Producer prices increase more than consumer prices, but the greatest response is in import prices. Twelve to eighteen months after the shock in exchange rate, import prices moves in the same proportion as the exchange rate, what suggests full exchange rate pass-through to prices in the long run.

Similar results of research obtained Campa, Goldberg and González-Mínguez (2005). They analyzed the exchange rate pass-through to prices across Euro Area countries and across product categories. They found evidence for a relatively high degree of exchange rate pass-through in the short run and even higher in the long run.

2 VAR model of exchange rate pass-through to prices

This article examines exchange rate change pass-through to prices in the Euro Area by means of the vector autoregression (VAR) model put forward by Sims (1980). This approach was used for the first time by McCarthy (1999) who analyzed the phenomenon of exchange rate pass-through to prices in the OECD (Organization of Economic Co-operation and Development) members. In the VAR method exchange rate pass-through to prices is surveyed with the use of a set of equations, which at the same

time eliminates the problem of exogenous explanatory variables. Then the assessment of the exchange rate effect on particular price aggregates in the model is isolated from the effect of other factors which the exchange rate may be correlated with.

The starting point for the model of exchange rate pass-through to prices in the Euro Area is an analysis of the so called distribution chain proposed by Blanchard. The distribution chain is a series of economic shocks (chain links) between which a cause and effect relation occurs over the same time unit in which the shock appeared Blanchard (1982). Obviously this type of approach must be revised and in the VAR model an appropriate lag length between variables must be taken into account because in economy there is no immediate cause-and-effect relation and the result always occurs with some lag in relation to the moment at which a given economic shock appears. In the analyzed VAR model, the distribution chain looks as follows.

Equation 1 Distribution chain

$$s \rightarrow \text{imp} \rightarrow \text{ppi} \rightarrow \text{cpi} \tag{1}$$

where:

s – exchange rate;

imp – import price;

ppi – producer price index;

cpi – consumer price index.

Next stage of the investigation is a measurement of the strength of the exchange rate pass-through to domestic prices. The so-called impulse response function is used to this purpose, that is a function of a given price aggregate (import prices, producer prices, consumer prices) response to an impulse resulting from exchange rate change. The index of exchange rate pass-through to prices after the period t is defined by the following equation Cholewiński (2008).

$$PT(z)_t = \frac{\sum_{i=1}^k \Delta z_{t-i}}{\sum_{i=1}^k \Delta s_{t-i}} \tag{2}$$

where;

Δz_{t-i} – change of given price index (import price, producer price, consumer prices), in the period from „ $t-i$ ” to „ t ”;

Δs_{t-i} – change of exchange rate, in the period from „ $t-i$ ” to „ t ”.

Changes in a given price aggregate equal the values of the impulse response function of the analyzed aggregate to the exchange rate shock, and changes in the exchange rate equal the impulse response function of the exchange rate to the exchange rate shock. Shock occurrence is connected with each of the distribution chain links. However, only in the case of the first chain link (exchange rate) the original shock occurs and in subsequent links the shock results from the transmission of shocks in the former links. Hence, the shock occurring in subsequent chain links can be decomposed into an autonomous part (occurring in a given chain link) and the one transmitted from earlier links. Chain link decomposition is accomplished with the use of Cholesky decomposition matrix. Establishing the strength of the shock transmission is crucial to analyze the phenomenon of exchange rate pass-through to prices in a more detailed way.

On the basis of the distribution model presented before, a VAR model was constructed which analyzes the phenomenon of exchange rate pass-through to prices. This model is a set of 4 equations and it looks as follows:

Equation 2 VAR model

$$\Delta s_t = \sum_{i=1}^k \gamma_{11}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{12}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{13}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{14}^i \Delta cpi_{t-i} + \varepsilon_{1t} \quad (3)$$

$$\Delta imp_t = \sum_{i=1}^k \gamma_{21}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{22}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{23}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{24}^i \Delta cpi_{t-i} + \varepsilon_{2t} \quad (4)$$

$$\Delta ppi_t = \sum_{i=1}^k \gamma_{31}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{32}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{33}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{34}^i \Delta cpi_{t-i} + \varepsilon_{3t} \quad (5)$$

$$\Delta cpi_t = \sum_{i=1}^k \gamma_{41}^i \Delta s_{t-i} + \sum_{i=1}^k \gamma_{42}^i \Delta imp_{t-i} + \sum_{i=1}^k \gamma_{43}^i \Delta ppi_{t-i} + \sum_{i=1}^k \gamma_{44}^i \Delta cpi_{t-i} + \varepsilon_{4t} \quad (6)$$

where:

s – seasonally adjusted logarithm of nominal, effective exchange rate index (2000 year = 100);

imp – seasonally adjusted logarithm of import price index (2000 year = 100);

ppi – seasonally adjusted logarithm of producer price index (2000 year = 100);

cpi – seasonally adjusted logarithm of consumer price index (2000 year = 100);

t – given period;

k – lag length (in quarter).

All the above mentioned time series have a quarterly frequency and they cover the period from the first quarter of 1998 to the fourth quarter of 2007. Logarithming of particular model variables aimed at elimination of possible regression between variables. Before the model structural parameters were estimated, it was necessary to isolate a seasonal factor from the time series. The occurrence of the seasonal factors in the time series could lead to difficulties in interpreting changes in a given phenomenon in the analyzed period. To eliminate the time series from seasonal fluctuations, the X12-ARIMA method was applied.

This paper analyzes the phenomenon of exchange rate pass-through to domestic prices of imported, production and consumer goods over a short period of time (after 1 quarter) and over a long period of time (after 4 quarters). For the purposes of the analyses, one lag period (one quarter) between explanatory variables was adopted. The choice of lag lengths is in line with results of the information criteria of the Akaike, Schwartz-Bayesian and the Hannan-Quinn models. According to these criteria, a model with one lag length is characterized by the biggest information capacity.

Before the VAR model estimation it was necessary to specify stationarity of the analyzed time series. To this purpose the Augmented Dickey-Fuller Test (ADF) was used. The last step of the analysis of time series was co-integration estimation. Having a set of integrated variables of order 1, a co-integration test was carried out according to the method put forward by Johansen (1988). The choice of the lag lengths for co-integration testing was made on the basis of the earlier mentioned results of the Akaike, Schwartz-Bayesian and Hannan-Quinn information criteria.

3 Exchange rate pass-through to import, producer and consumer prices in the Euro Area

In the period of 1998-2007 took place relatively significant changes of nominal, effective exchange rate of the euro currency as well as import, producer and consumer prices index in the Euro Area. The nominal, effective exchange rate increased above 26% from 1998 year to the end of 2007 year. In the same time import prices increased about 40%, producer prices went up about 25%, whereas consumer prices increased near 22% [cf. fig. 3].

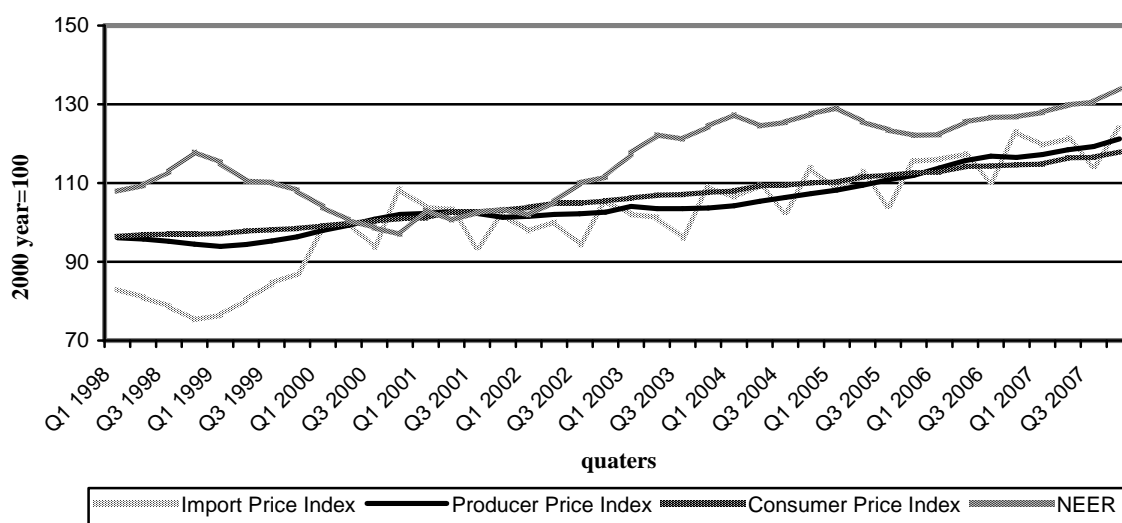


Figure 3 Exchange rate changes and price dynamics in the Euro Area the period of 1998-2007 [2000 year=100]

Source: *International Financial Statistics* (2008).

The point of departure of the analysis of exchange rate pass-through to prices in the Euro Area is an estimate of structural parameters of the VAR model. Results of the parameter estimate of the VAR model consisting of 4 equations are presented below.

Ordinary least squares (OLS) estimates using 40 observations 1998:1-2007:4, 1 quarter lag

Log. likelihood = 519,87175

Covariance matrix = 6,0426982e-017

Akaike Information Criterion (AIC) = -25,1936

Schwartz Bayesian Criterion (BIC) = -24,5180

Hannan-Quinn Criterion (HQC) = -24,9493

Test Portmanteau: LB(10) = 192,819 (df = 144, p-value 0,004120)

Table 1 Results of the parameter estimate of the VAR model – Euro Area Equation: s

	<i>Coefficient</i>	<i>Standard error</i>	<i>t-ratio</i>	<i>p-value</i>
s_1	0,444963	0,162884	2,7318	0,00970
imp_1	0,0826025	0,0941151	0,8777	0,38594
ppi_1	1,13399	0,850499	1,3333	0,19080
cpi_1	0,854656	1,55847	0,5484	0,58681

Equation: imp

	<i>Coefficient</i>	<i>Standard error</i>	<i>t-ratio</i>	<i>p-value</i>
s_1	-0,475831	0,27826	-1,7100	0,09587
imp_1	-0,297316	0,16078	-1,8492	0,07265
ppi_1	2,52361	1,45293	1,7369	0,09095
cpi_1	-3,53259	2,66238	-1,3269	0,19291

Equation: ppi

	<i>Coefficient</i>	<i>Standard error</i>	<i>t-ratio</i>	<i>p-value</i>
s_1	-0,0405024	0,0423777	-0,9557	0,34557
imp_1	-0,003186	0,0244859	-0,1301	0,89720
ppi_1	-0,128107	0,221275	-0,5790	0,56623
cpi_1	-0,245353	0,405467	-0,6051	0,54890

Equation: cpi

	<i>Coefficient</i>	<i>Standard error</i>	<i>t-ratio</i>	<i>p-value</i>
s_1	5,19482e-05	0,0199788	0,0026	0,99794
imp_1	-0,00464363	0,0115438	-0,4023	0,68987
ppi_1	-0,0327015	0,104319	-0,3135	0,75573
cpi_1	-0,49984	0,191156	-2,6148	0,01296

Source: Own calculations by using GRET.L.

Below one can see respective graphs of the impulse response functions of exchange rate, import prices and consumer prices to a one-time unit change of the exchange rate in the Euro Area [cf. fig. 4].

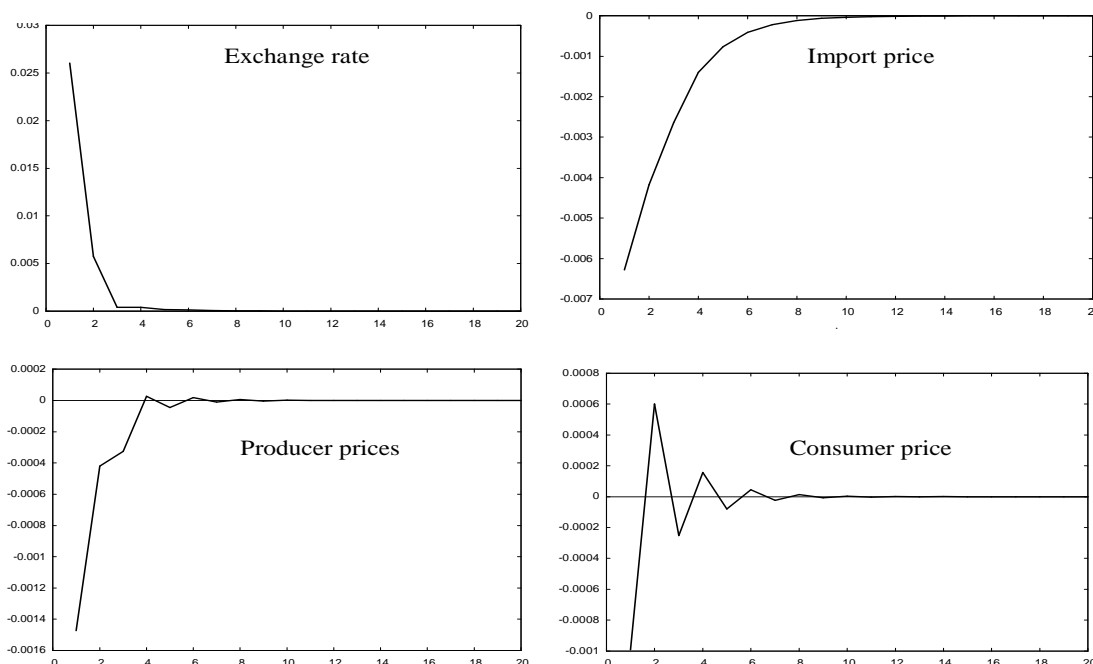


Figure 4 Impulse response function of exchange rate, import price, producer price and consumer price to a one shock in exchange rate

Source: Own calculations on the basis of *International Financial Statistics* (2008).

It is obvious that import prices respond more rapidly to changes in the exchange rates than producer and consumer prices Hüfner, Schröder (2002). The average level of exchange rate pass-through to import prices stand in the Euro Area at 53,9% in the short-term. However, after one year only 74,7% of exchange rate changes are passed through to import prices. Producer prices respond less to changes in the nominal, effective exchange rate. The average level of the exchange rate pass-through index to producer prices in the Euro Area amounts to 6,7% in the short-run. But, after one year only 7,2% of exchange rate changes are passed through. The least affected by exchange rates, both in the short- and long-term, are consumer prices. The average level of exchange rate pass-through to consumer prices reaches in the Euro Area 4,5% in the short-term. Anyway, after one year only 1,6% of changes in the exchange rate are passed through to consumer prices [cf. tab. 2].

Table 2 Indexes of exchange rate pass-through to import prices, producer prices and consumer prices in the Euro Area

The number of quarter after shock	Import prices	Producer prices	Consumer prices
1	53,9%	6,7%	4,5%
2	67,2%	6,7%	1,4%
3	75,5%	7,3%	2,1%
4	74,7%	7,2%	1,6%
5	76,0%	7,3%	1,8%
6	75,4%	7,2%	1,7%
7	75,8%	7,3%	1,8%
8	75,6%	7,2%	1,7%

Source: Own calculations on the basis of *International Financial Statistics*, (2008).

The last step of the analysis is the residual component variance decomposition of subsequent price aggregates. This procedure specifies the contribution of the exchange rate shock affecting each of the price variables in accounting for the variances of the individual model variables (price aggregates) [cf. tab. 3, 4, 5].

Table 3 The error variance decomposition in the import price equation

The number of quarter after shock	Exchange rate	Import prices	Producer prices	Consumer prices
1	10%	90%	0%	0%
2	12%	82%	4%	3%
3	12%	80%	5%	3%
4	12%	80%	5%	3%
5	12%	79%	5%	3%
6	12%	79%	5%	3%
7	12%	79%	5%	3%
8	12%	79%	5%	3%

Source: Own calculations on the basis of *International Financial Statistics* (2008).

Table 4 The error variance decomposition in the producer price equation

The number of quarter after shock	Exchange rate	Import prices	Producer prices	Consumer prices
1	7%	2%	91%	0%
2	7%	3%	90%	1%
3	7%	3%	90%	1%
4	7%	3%	90%	1%
5	7%	3%	90%	1%
6	7%	3%	90%	1%
7	7%	3%	90%	1%
8	7%	3%	90%	1%

Source: Own calculations on the basis of *International Financial Statistics* (2008).

Table 5 The error variance decomposition in the consumer price equation

The number of quarter after shock	Exchange rate	Import prices	Producer prices	Consumer prices
1	14%	1%	40%	46%
2	14%	1%	42%	43%
3	14%	2%	42%	43%
4	14%	2%	42%	43%
5	14%	2%	42%	43%

6	14%	2%	42%	43%
7	14%	2%	42%	43%
8	14%	2%	42%	43%

Source: Own calculations on the basis of *International Financial Statistics* (2008).

On the basis of the data from the above Tables it can be noted that changes in the nominal effective exchange rate account for 10% of the price variances in the Euro Area in the short-run. In the long-run relative importance of exchange rate changes is greater. However, the effects exchange rate changes on producer price variances in the short- and long-term are significantly smaller. In the short-run as well long-run, ca. 7 % of producer price changes in the Euro Area can be accounted by a change in the nominal, effective exchange rate.

The role of exchange rate in accounting for consumer price variances in the short- and long-term is higher than in the case of import prices and producer prices. In the Euro Area less about 14% of consumer price changes can be accounted for changes in the nominal effective exchange rate in the short-and long-run.

4 Conclusion

The essay performed an empirical analysis of transmission mechanism of exchange rate changes to import, producer and consumer prices in the Euro Area. It was found, that there exists the phenomenon of incomplete exchange rate pass-through to import, producer and consumer prices in the short-run as well in the long-run.

The results of the conducted research are in accordance with theoretical arguments and indicate that in general the degree of exchange rate pass-through to prices declines across the pricing chain. It means that import prices respond stronger and faster to exchange rate shocks than producer prices and consumer prices. Mapping the results of this structural shock into an analytical framework helps recognize behavioral features that could help account for the nature of incomplete exchange rate pass-through in the Euro Area. Understanding of the economic behavior underlying restricted pass-through is an essential consideration for examining the implications of exchange rate changes and the role of monetary and exchange rate policy in the Euro Area.

5 Appendix 1

Table 6 Selected empirical analyses concerning the phenomenon of incomplete exchange rate pass-through to prices

Author	Used Data	Used investigative method	Main results
Kim (1990)	Quarterly import unit values of the U.S.	Varying parameter approach in the form of the Kalman filter	Sensitivity of import prices to exchange rate changes reduced in the 1980s, with considerable Pricing to Market activities.
Menon (1995)	Import prices of the Australian manufactured imports.	Johansen Maximum Likelihood procedure	The exchange rate pass-through is incomplete, around 66%.

Yang (1998)	Import and export price indices covering 2-,3-,4-digit industries in the manufacturing sector in the US.	Two stage single equation method	Exchange rate pass-through is incomplete, and is larger for the U.S. exports than for the U.S. imports.
McCarthy (2000)	Quarterly import, producer and consumer prices indices of nine developed countries	Stationary VAR model	Exchange rate pass-through is very small, and largest on import prices, second on producer prices and then on consumer prices. Pass-through is larger in countries with a larger import share and more persistent exchange rate shocks.
Kardasz, Stollery (2001)	Import price indices of 33 Canadian manufacturing industries at L-level of aggregation	Two-stage single equation estimation procedure	Exchange rate pass-through is small, averaging 25.5%. Pass-through elasticities vary a lot across industries.
Choudhri, Hakura (2001)	Monthly consumer price indices of 71 countries	Single equation model	For high inflation regimes, exchange rate pass-through is higher.
Hufner, Schroder (2002)	Monthly consumer price indices of the Euro area.	Vector error correction model	In response to a 10% depreciation of euro exchange rate, consumer price index tends to increase by 0.4% and complete after three years.
Olivei (2002)	Quarterly import prices that the BLS produces using the Standard International Trade Classification structure in the US.	Single equation model	Exchange rate pass-through are usually less than full and the hypothesis that pass-through is full in the long-run is rejected in all but three industries.
Hahn (2003)	Quarterly import, producer and consumer price indices in the Euro area	Stationary VAR model	Exchange rate pass-through to import price index, PPI and CPI are 50%, 28% and 8% for one year horizon, respectively. The speed of pass-through slows along the distribution chain of pricing.
Rowland (2003)	Monthly import, producer and consumer price indices in Colombia	Stationary VAR model and vector error correction model	Exchange rate pass-through coefficient of import prices is 0.48 after three months and 0.80 after one year. The pass-through rates of PPI and CPI are 0.28 and 0.15, respectively.
Faruqee (2004)	Monthly import and export unit value, PPI and CPI of the Euro area.	Stationary VAR model	After 18 months, exchange rate pass-through to export and import prices are about 0.5 and 1, respectively. Pass through to PPI and CPI are nearly 0.2 and 0.02, respectively.
Campa,Goldberg, Gonzalez-Minguez (2005)	Monthly import unit values across industries and countries in the Euro area	Single equation model	Average exchange rate pass-through by country and by industry within one month is 0.66 and 0.56 respectively; In the long run, the average rate is 0.8 across countries.
Ca'Zorzi, Hahn, Sanchez (2007)	Monthly import and consumer price indices, short-term interest rates and oil prices of 12 emerging markets in Asia, Latin America, Central and Eastern	Three alternative VAR models	The degree and the speed of exchange rate pass-through to import prices is higher than in the case of consumer prices. Moreover, the degree and the speed of pass-through are higher in emerging markets.

	Europe		
María-Dolores (2008)	Monthly import unit values of some New Euro Area members and one EU candidate country (Turkey) covering nine different product categories according to SITC classification.	One-equation model and vector error correction model	The exchange rate pass-through ranged from 0.09 to 2.92 in the short-run and from 0.10 to 2.24 in the long-run. The lowest value for exchange rate pass-through was in manufacturing sectors.
Bussière, Peltonen (2008)	Quarterly import, export, producer and consumer price indices for 41 countries - including 28 emerging market economies	Two, one-equation models	The elasticity of trade prices in emerging markets is sizeable, but not significantly higher than in advanced economies and is primarily influenced by macroeconomic factors such as the exchange rate regime and the inflationary environment, although microeconomic factors such as product differentiation also play a role. Export and import price elasticities tend to be strongly correlated across countries but pass-through to import prices declined in some advanced economies,

Source: Own study on the basis of Lian (2006).

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