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EFFECTIVE EXCHANGE RATES AND MERCHANDISE FLOWS – AN EMPIRICAL ANALYSIS OF POLISH FOREIGN TRADE

Summary: The author attempts to analyse links between merchandise flows in Polish foreign trade and the evolution of nominal and real exchange rate of zloty. As it turns out, the relations between the variables look similar like in theory although not in an entirely clear way. Essentially, however, the strengthening of zloty inhibits exports and stimulates imports, while reducing the income from the sale of goods abroad and increasing spending on imports results in the depreciation of Polish currency. Conducted econometric analysis indicates such connections; however, it is fraught with a large margin of error. On the other hand, the analysis of correlation coefficients suggests a positive relation between exchange rate and the size of trade, which, however, results to a large degree from a close link between the volume of imports and exports.

Keywords: exchange rate, foreign trade, merchandise flows.

1. Introduction

The scale of international flows of commodities is a variable which level is determined by a variety of factors and their influence has been widely studied in economic literature. The most important determinants are, one can consider, for example, progressive liberalization of trade, changes in price structures (including raw materials costs), directions of economic policies (fiscal, monetary and trade ones) conducted by countries, levels of interest rates, elasticity of demand and supply, labour productivity, international capital flows etc. At the forefront is the level of the exchange rate, which is considered to be one of the most significant factors influencing the turnover of goods in international trade.

Exchange rate fluctuations can cause significant changes in the profitability of imports and exports, and thus alterations in their levels. This dependence is observed also in Polish foreign trade¹. Therefore, the object of this paper is to attempt to define

¹ By the notion of “Polish foreign trade” the author understands the whole exchange of commodities (and services) between domestic entities and the entities located abroad (regardless of whether the border is customs or just administrative one). Definitions of exports and imports were adopted by

– on the basis of empirical data – the connection between the value of Polish zloty and the size of foreign merchandise trade, including the direction of this link. The basic research questions in this regard are: does the growth of Polish currency exchange rate in fact – as it is suggested – contribute to the reduction of Polish exports and the increase of imports? Does the depreciation of zloty, in turn, result in the expansion of exports and the diminution of imports? What is the nature of reverse relation (trade and exchange rate)? What is the delay of these dependencies?

Employed research methods consist in the analysis of literature (in the field of the theory of exchange rate), the descriptive statistical analysis of empirical data and econometric modelling.

2. Theoretical background and the method of research

To indicate a basic, reciprocal relation between exchange rate and international merchandise trade, referring also to Polish foreign trade, certain assumptions should be made. Firstly, the floating exchange rate regime is characteristic of Polish economy, and the payment position should be considered under such conditions. The analysis will therefore ignore the impact of direct state intervention. Secondly, Polish foreign trade is settled mostly in foreign currencies. Changes in export and import flows, therefore, cause adjustments in the demand and supply of foreign exchange. In such conditions, the theory of exchange rate indicates the following relations linking the nominal rate with the flows of exports and imports (*ceteris paribus*):

1. A decrease in domestic currency exchange rate (depreciation) results in the growth of export revenues denominated in these means of payment, in an increase of import costs and, consequently, in pressure on exports boost and imports reduction.

2. Increasing exports and shrinking imports lead to a rise in the amount of foreign exchange flowing into the country, to a fall in the quantity of money going abroad and to the related appreciation of domestic currency.

3. Growing exchange rate of domestic currency (appreciation) decreases the cost of imports and the competitiveness of exports and leads to higher imports and diminished exports.

analogy. It is worth emphasizing, because some works can be found with the view – according to the author, mistaken – that only the exchange with non-EU partners deserves to be called foreign trade, imports and exports. This is justified by the nomenclature used in the European Union law: intra-EU trade is defined there by concepts of intra-Community acquisition and supply; notions of imports and exports are reserved for exchange with countries outside the EU. However, the automatic transfer of legal nomenclature to the theory of international trade – where in fact in most cases there is no qualitative difference in the trade with a partner from Spain, for example, and with a partner from Belarus (in both cases, it has always been known as exports or imports) – appears to be significant abuse. It may also introduce erroneous belief that in view of the open economy macroeconomics, trade inside an integrational grouping has a different nature than trade with countries located outside.

4. An increase in imports and the reduction of exports result in a drop in the amount of foreign exchange in the country, a related increase in their rates and the depreciation of the domestic currency².

Therefore, the impact of the domestic currency exchange rate for exports is essentially negative and for imports – positive. Inverse dependence, in turn, is opposite: the volume of exports positively affects the level of the exchange rate and import volumes – negatively.

In case of real exchange rate, which is additionally adjusted by changes in the purchasing power of currencies (by inflation rates), relations are similar and even stronger. Real depreciation implies an actual improvement of the competitiveness of domestic goods, export expansion and import deceleration. In turn, growth in exports results not only in the appreciation of domestic currency in nominal terms, but also in a decrease of the domestic supply of goods – at least in a short period, assuming full utilization of production capacity or difficult access to investment capital – and, consequently, in a rise of prices level and real appreciation³.

Since several currencies play an important role in Polish foreign trade (primarily euro, but also the U.S. dollar, zloty and other means of payment), a measure in the form of so-called effective exchange rate is used for the examination of dependencies. It is an exchange rate aggregate, calculated as a geometric mean of foreign currencies' rates, weighted by their shares in a representative for the given economy currency basket. The composition of the basket and the shares of currencies are determined on the basis of their importance in the foreign trade of the country – depending on the approach, basing on either their shares in trade settlement, or the importance of the issuer of a currency as a partner in the exchange. In order to make the analysis more readable, reverse exchange rates of foreign currencies (i.e. the amount of foreign currency per unit of domestic currency) are usually used and the numbers are given in relation to the level in the base period.

² W. Michalczyk, *Zależność pomiędzy poziomem kursu złotych a obrotami towarowymi w polskim handlu zagranicznym – analiza danych empirycznych*, [in:] *Problemy regionalne i globalne we współczesnej gospodarce światowej*, red. J. Rymarczyk, Wyd. Akademii Ekonomicznej, Wrocław, 2006, p. 258; W. Michalczyk: *Kształtowanie kursu walutowego jako narzędzie realizacji celów polityki gospodarczej*, [in:] *Wybrane problemy ekonomiczne czasów globalizacji*, red. W. Michalczyk, Wyd. Akademii Ekonomicznej, Wrocław 2007, p. 27; W. Michalczyk, *Realny efektywny kurs walutowy i jego związek z obrotami towarowymi w polskim handlu zagranicznym*, [in:] *Wybrane problemy gospodarki światowej pierwszej dekady nowego wieku*, red. W. Michalczyk, Katedra Międzynarodowych Stosunków Gospodarczych UE, Wrocław 2009, p. 15. Compare also e.g.: K. Zabielski, *Finanse międzynarodowe*, Wyd. Naukowe PWN, Warszawa 2002, p. 22-27; A. Budnikowski, *Międzynarodowe stosunki gospodarcze*, PWE, Warszawa 2003, p. 307-313; E. Chrabonszczewska, K. Kalicki, *Teoria i polityka kursu walutowego*, SGH, Warszawa 1996, p. 116-117; L.S. Copeland, *Exchange Rates and International Finance*, Addison Wesley, Wokingham, 1994, p. 19-30; A.R. Ghosh, A.M. Gulde, H.C. Wolf, *Exchange Rate Regimes: Choices and Consequences*, MIT Press, Cambridge 2002, p. 23-38; I.A. Moosa: *Exchange Rate Regimes: Fixed, Flexible or Something in Between?*, Palgrave Macmillan, New York 2005, p. 38-48.

³ W. Michalczyk, *Realny...*, p. 15.

This indicator comes in two forms: NEER – nominal effective exchange rate and REER – real effective exchange rate. The latter differs from the former – in the same manner as in the case of disaggregated, “normal” exchange rate – in additional adjustment by inflation rates of both currencies (by changes in their purchasing power) and in related more direct implications for trade competitiveness.

These measures for the PLN put in a formal way may look as follows:

$$s_t^{Ef} = \prod_{i=1}^n s_{t(i)}^{w_{(i)}} ; \quad s_t^{REf} = \prod_{i=1}^n \left(s_{t(i)} \times \frac{1 + p_{f(i)}}{1 + p_{ht}} \right)^{w_{(i)}} ; \quad \sum_{i=1}^n w_{(i)} = 1 ;$$

$$NEER_t = \frac{(s_t^{Ef})^{-1}}{(s_x^{Ef})^{-1}} ; \quad REER_t = \frac{(s_t^{REf})^{-1}}{(s_x^{REf})^{-1}}$$

where $NEER_t$ is the nominal effective exchange rate of PLN at the end of period t , $REER_t$ is the real effective exchange rate of PLN at the end of period t , s_t^{Ef} is the nominal effective exchange rate of the currency basket at the end of period t , s_t^{REf} is the real effective exchange rate of the currency basket at the end of period t , x is the base period indication, $s_{t(i)}$ is nominal exchange rate of the i -th foreign currency at the end of period t , $p_{f(i)}$ is the inflation in the i -th economy in period t , p_{ht} is the inflation in Poland in period t , $w_{(i)}$ is the share of i -th currency in the basket, n – the quantity of currencies in the basket and i – the number of a currency in the basket.

To examine the relations between Polish foreign trade and the level of the exchange rate there were used NEER and REER calculated by Eurostat. According to this institution’s methodology, effective rates are calculated basing on the foreign trade structure within the broad group of as many as 41 countries, namely 27 European Union countries, Australia, Canada, the United States, Japan, Norway, New Zealand, Mexico, Switzerland, Turkey, Russia, China, Brazil, South Korea and Hong Kong. The base period of the index is the first quarter of 1999 and real rates used for the analysis are among others deflated by consumer price index (CPI)⁴. CPI has some faults, though (differences in the baskets of goods between countries or taking into account also the commodities and services not traded internationally), but it seems plausible enough, so the real exchange rate designated on its basis has an appropriate interpretational value.

In order to determine the connections between exchange rate and the size of exports and imports, the following research technique has been used:

1. Initial hypotheses were adopted that the zloty exchange rate affects the size of Polish foreign trade and that the rate-exports correlation is negative while the rate-imports one – positive. Such presumptions result essentially from the theoretical considerations and an observation that in a short period (such as monthly) the level

⁴ <http://epp.eurostat.ec.europa.eu>, 07.02.2010.

of exchange rate is affected, as it seems, by much more complex factors than these which influence the size of exports and imports. A supplementary hypothesis was also the existence of the reverse (trade affects the exchange rate), weaker dependence of the opposite nature, which might reveal itself with a certain delay.

2. The examined period was May 2004 – June 2009. At the time of the analysis, Eurostat published on its website the exchange rate data up to June 2009. As the beginning of the period May 2004 was adopted, because it was the time when Poland joined the European Union and there was a significant liberalization of trade with other member countries. Therefore, if the analysis involved the data for the earlier period, the image of interactions could be distorted (empirical studies show that the relations might look completely different then⁵).

3. Source data for the average monthly nominal and real effective exchange rate of PLN (<http://epp.eurostat.ec.europa.eu>) and for the monthly levels of merchandise exports and imports denominated in PLN, EUR and USD (www.nbp.pl) in the examined period were collected.

4. A descriptive analysis of changes in exports and imports against a background of the nominal exchange rate fluctuations, as well as the analysis of the evolution of the real exchange rate of PLN compared to the rates of other currencies in the region was conducted in order to formulate preliminary conclusions.

5. Correlation coefficients between exports/imports denominated in respective currencies and nominal/real exchange rate at different values of delay (from minus three months to plus three months) were calculated. The parameters of regression lines and their points of intersection determining equilibrium exchange rates were also estimated.

6. A simple linear model of relation between the nominal effective exchange rate and the values of exports and imports was formulated in two versions and its parameters were estimated in three variants: for trade denominated in PLN, EUR and USD; the coefficients of determination (R^2) were additionally calculated. The analysis was narrowed to the nominal rate only because of the volume limits of the paper and the similarity to the real rate nature of conclusions.

7. Correlation and regression coefficients and the model parameters estimators were analysed in order to determine the reasons of their formation.

Research results are presented below.

3. Nominal and real exchange rate against a background of foreign trade

The period after Poland's accession to the European Union is the time of rapid growth of turnover in foreign trade and of zloty's appreciation – both in nominal (Figure 1) and real terms (Figure 2). Upward trend for exports and imports lasted roughly until

⁵ W. Michalczyk, *Realny...*, p. 17.

the last quarter of 2008, when – due to the global economic and financial crisis – the volume of trade collapsed. Polish currency exchange rate responded to the negative trends in the global economy with slightly more advance, reaching its maximum in July 2008, and then rapidly falling down. When analyzing graphically presented dependencies, one can generally notice a positive correlation between the exchange rate variation and the scale of trade. Also for shorter periods it is evident that the signs of exchange rate increments are in most cases consistent with the signs of changes in exports and imports. A significant exception may be the year 2004, when despite the periods of both increasing and declining trade volumes, Polish currency was continuously strengthening. This resulted, however, from a major increase in confidence in the Polish economy after the accession to the EU and related higher demand for zloty.

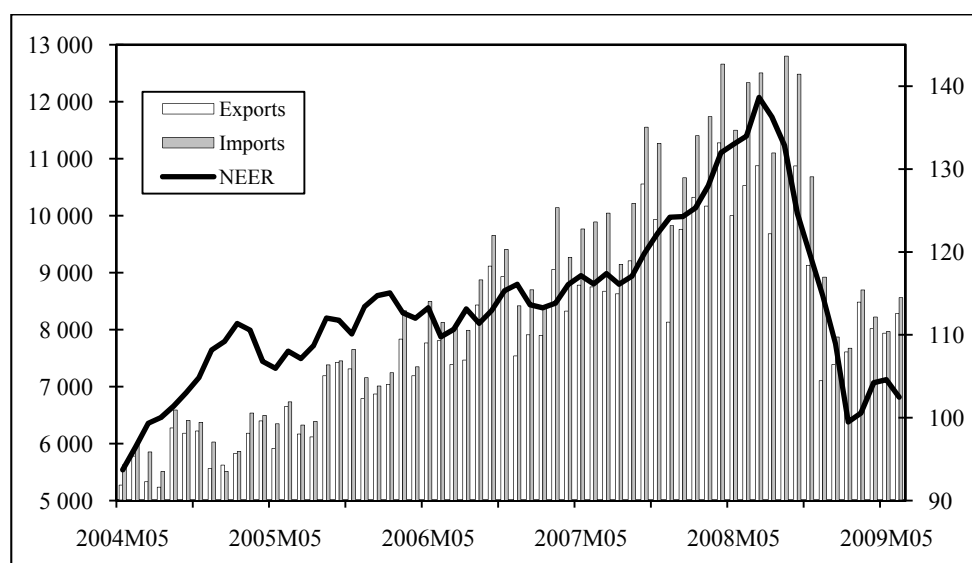


Figure 1. Exports and imports in mln EUR (left axis) and nominal effective exchange rate (right axis) in May 2004 – June 2009 in Poland

Source: own development based on data published by Eurostat (<http://epp.eurostat.ec.europa.eu>) and National Bank of Poland (www.nbp.pl).

Important observations arise also from an analysis of the real effective exchange rate of PLN against a background of other currencies in the region – Czech koruna, Slovak koruna (replaced in 2009 by euro), Hungarian forint and three currencies of Baltic countries: Lithuania, Latvia and Estonia (Figure 2). Stronger or weaker appreciation ongoing until the global crisis is typical of all these means of payment. At its base there is a phenomenon commonly known in economic theory as Balassa-Samuelson effect, appearing primarily in the countries at a low level of development

which integrate with the more developed economies. In the necessary simplification, its interpretation comes down to recognition that the reason of the nominal exchange rate appreciation in a developing country despite an inflation rate higher than in trading partners (i. e. contrary to the theory of purchasing power parity) is usually occurring rapid growth in labour productivity in the part of the economy which produces goods subject to increasing exports. Productivity growth is usually accompanied by wages expansion, which also spreads to sectors not increasing their productivity significantly and causes a rise in unit costs and selling prices. By contrast, persistent low prices in the sectors producing exported goods result in high competitiveness on the world market, a continuous foreign exchange inflow into the country and elevated nominal exchange rate of the domestic currency. Inflation higher than in trading economies, accompanied by nominal appreciation, results in the strengthening of the currency also in real terms⁶.

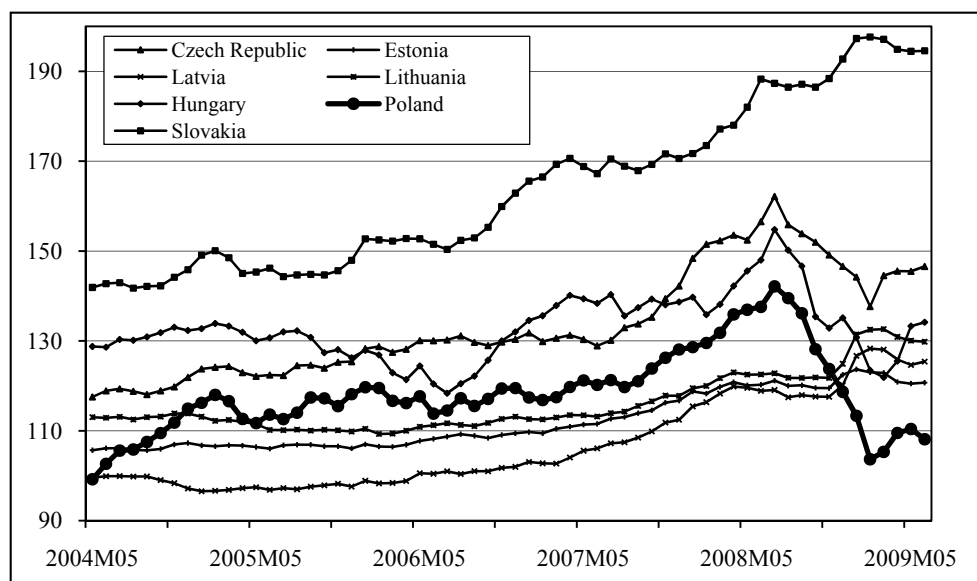


Figure 2. Real effective exchange rate in chosen East Europe countries between May 2004 and June 2009

Source: own development based on data published by Eurostat (<http://epp.eurostat.ec.europa.eu>).

The volatility of the real exchange rate of PLN is very similar to the nominal one, and comparable to the variability of the Czech and Hungarian currencies' exchange rates. The latter similarity – especially in the period of 2008-2009 – probably results

⁶ Compare: J. Bilski, *Międzynarodowy system walutowy*, PWE, Warszawa 2006, p. 57-62; J. Świerkocki, *Zarys międzynarodowych stosunków gospodarczych*, PWE, Warszawa 2004, p. 185-186; W. Michalczyk, *Realny...*, op. cit., p. 12.

from the same in all three countries floating rate regime, which induces high sensitivity of the exchange rate to external shocks (and such was certainly the global crisis) and performing by it the role of negative exogenous trends absorber. The crisis stopped the appreciation in these three countries, what cannot be seen in other four analysed economies, where the nominal exchange rate in accordance with the regime rules is maintained more or less fixed.

Overall, therefore, the relation between the real effective exchange rate of PLN and the turnover of Polish foreign trade is in cases of both exports and imports, positive, too. This results from the fact that the real exchange rate variation is mainly conditioned by changes in the nominal rate and to a much lesser extent by differences in the rate of inflation (the correlation coefficient between these two types of exchange rate is as high as 99.65).

4. Correlation between exchange rate and the scale of foreign trade flows

A study of quantitative relations between the exchange rate and the Polish foreign trade turnover one should begin by analyzing the correlation coefficients between these variables. As it turns out, in cases of both nominal and real exchange rate, when denominating exports and imports in EUR and USD, i.e. in currencies in which Polish cross-border trade is mainly settled, the highest values of coefficients are obtained when the data come from the same month (Table 1). This indicates that the strongest influence of the exchange rate on trade and vice versa, occurs in a very short period. In case of the values in PLN, the correlation is the highest for the three-month delayed response of exports and imports. The rationale for this phenomenon may be greater strength of the exchange rate impact on trade than vice versa. It is also worth noting that the highest values of the correlation coefficient are for the data expressed in dollar. This may indicate the fundamental importance of this currency and its exchange rate in shaping trade flows and is consistent with the results of earlier research conducted by the author⁷. The sign of correlation coefficients is essential too. It is positive in each analysed case, which may suggest the existence of a positive relation between the exchange rate of zloty and the foreign trade turnover. To be consistent with the theoretical assumptions, in such a situation one should acknowledge that it is the exchange rate which affects import values, an increase (a decrease) of imports stimulates (inhibits) exports, and this consequently strengthens (weakens) the currency. However, the correlation coefficients analysis alone is not sufficient to confirm such a relation.

The presented graphical analysis of regression (Figure 3) is limited to euro due to the fact that Polish foreign trade is mainly settled in this currency and also because

⁷ W. Michalczyk, *Realny...*, p. 17.

of the volume limits of this paper. For the same reason the presentation of the graph for the real exchange rate was omitted.

Table 1. Correlation coefficients between monthly values of exports/imports and nominal/real effective exchange rate from May 2004 to March 2009 at different values of delay

Rate	Delay of the rate	PLN		EUR		USD	
		Exports	Imports	Exports	Imports	Exports	Imports
<i>NEER</i>	t-3	71.0%	78.0%	80.4%	82.8%	78.3%	79.8%
	t-2	70.0%	77.8%	84.2%	86.6%	83.4%	84.8%
	t-1	64.5%	73.3%	84.5%	87.0%	86.2%	87.4%
	t	61.1%	70.6%	84.5%	87.1%	88.5%	89.7%
	t+1	61.5%	69.4%	83.2%	84.9%	88.5%	88.8%
	t+2	61.4%	66.1%	79.8%	79.6%	85.5%	84.5%
	t+3	55.0%	58.8%	71.0%	70.5%	77.8%	76.5%
<i>REER</i>	t-3	67.4%	74.2%	77.9%	80.1%	76.3%	77.6%
	t-2	66.2%	74.1%	81.6%	84.1%	81.6%	82.9%
	t-1	60.1%	69.2%	81.5%	84.2%	84.1%	85.4%
	t	57.0%	66.7%	81.6%	84.3%	86.7%	87.8%
	t+1	57.7%	65.6%	80.1%	81.8%	86.4%	86.8%
	t+2	58.2%	62.7%	76.6%	76.4%	83.4%	82.3%
	t+3	51.7%	55.3%	67.4%	66.8%	75.2%	73.8%

Source: own calculation based on data published by Eurostat (<http://epp.eurostat.ec.europa.eu>) and National Bank of Poland (www.nbp.pl).

What should be noted, the regression lines for relations: export-exchange rate and import-exchange rate – for both nominal and real rates – have very similar inclination (they are almost parallel) and mentioned positive correlation between variables can be clearly seen. However, an occurring small difference in positions may be the evidence that exchange rate-exports and exchange rate-imports dependencies are opposite. Regression lines for both kinds of effective exchange rate have also very similar positions, which results from low inflation rates in Poland and in trading partner countries during the period and related to this fact, mentioned high correlation between nominal and real exchange rate.

After determining the parameters (equations) of the regression lines one can also attempt to calculate their points of intersection for each currency in which the trade value is denominated, and for both types of exchange rate – the real and the nominal (Table 2). In the case of values expressed in PLN, coefficient of determination R^2 is very low, which results in low reliability of the estimation. In addition, the designated values of equilibrium exchange rates are either negative or very improbable. But when the trade values expressed in EUR and USD are taken into account, the levels

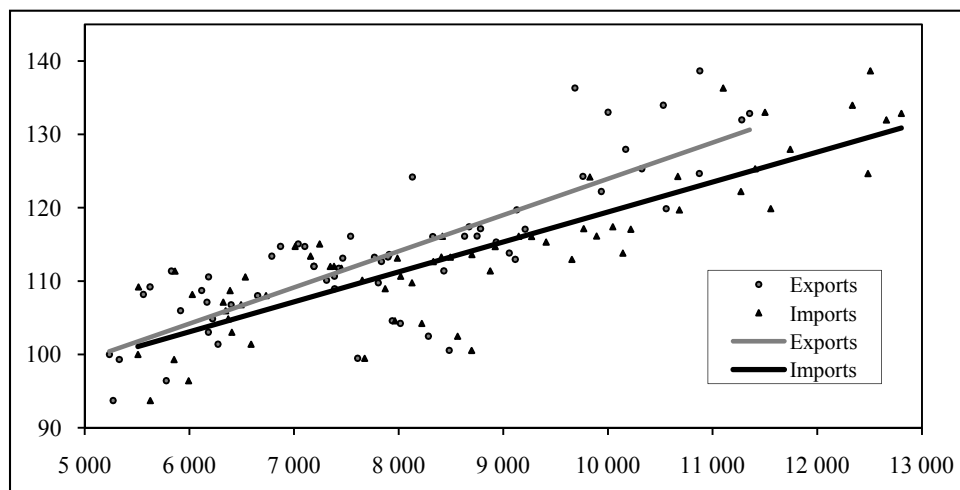


Figure 3. Point graph and regression lines for the correlation between exports/imports denominated in EUR and nominal effective exchange rate in the same month in from May 2004 to June 2009

Source: own development based on data published by Eurostat (<http://epp.eurostat.ec.europa.eu>) and National Bank of Poland (www.nbp.pl).

of these rates are as follows: in nominal terms – respectively 97.83 and 100.48, and with regard to the real exchange rate – 103.93 and 106.28. In June 2009 the actual values of these rates were: *NEER* – 102.49, *REER* – 108.12, and therefore they were 2-5% higher than the equilibrium rate. This may indicate the overvaluation of zloty.

Table 2. Parameters of regression lines and their points of intersection for correlation between exports/imports and nominal/real effective exchange rate in the same month from May 2004 to June 2009

Unit	Trade direction	<i>NEER</i>				<i>REER</i>			
		<i>a</i>	<i>b</i>	<i>R</i> ²	<i>NEER</i> *	<i>a</i>	<i>b</i>	<i>R</i> ²	<i>REER</i> *
bln PLN	exports	1.089	80.051	0.27	-480.78	0.942	89.273	0.23	322.20
	imports	1.084	77.476	0.42		0.953	86.553	0.38	
bln EUR	exports	4.936	74.572	0.67	97.83	4.445	83.149	0.62	103.93
	imports	4.083	78.592	0.73		3.684	86.707	0.69	
bln USD	exports	2.857	83.348	0.73	100.48	2.608	90.683	0.70	106.28
	imports	2.379	86.215	0.77		2.171	93.297	0.74	

The regression line's form is: $y = ax + b$, where: *y* – exchange rate level, *x* – exports/imports value. *NEER** and *REER** – equilibrium exchange rates determined by the point of intersection of the regression line for exports and the regression line for imports .

Source: own calculation based on data published by Eurostat (<http://epp.eurostat.ec.europa.eu>) and National Bank of Poland (www.nbp.pl).

To examine more accurately the interactions, which could also be distorted by mentioned possible correlation between exports and imports, an attempt to construct a simple linear regression model – describing the dependence between the exchange rate and the size of both exports and imports simultaneously – has also been made. The study has been narrowed to the nominal rate only, which, as mentioned before, was necessary because of the volume limits of the paper. It appears to be justified, anyway, by the similarity of analysis results for both nominal and real exchange rate shown so far.

The initial form of the model is as follows:

$$NEER_t = a_1 + a_2 Ex_t + a_3 Im_t + \varepsilon_t$$

where $NEER_t$ is the nominal effective exchange rate of PLN in period t , Ex_t is the value of exports in billion of units in period t , Im_t is the analogical value of imports, a_1, a_2, a_3 are the parameters of the model and $\varepsilon_t - a$ random variable.

Least squares estimators of model parameters, calculated on the basis of the source data, are (standard errors of estimates are given in parentheses):

- for EUR (coefficient of determination $R^2 - 0.75$, adjusted $R^2 - 0.74$):
 $a_1 = 84.411 (3.882)$; $a_2 = -4.688 (2.209)$; $a_3 = 7.728 (1.746)$
- for USD (coefficient of determination $R^2 - 0.78$, adjusted $R^2 - 0.77$):
 $a_1 = 90.249 (2.892)$; $a_2 = -3.029 (1.569)$; $a_3 = 4.815 (1.272)$
- for PLN (coefficient of determination $R^2 - 0.57$, adjusted $R^2 - 0.56$):
 $a_1 = 93.336 (5.927)$; $a_2 = -2.947 (0.647)$; $a_3 = 3.334 (0.514)$.

The signs of the estimated parameters indicate an existing negative relation between exchange rate and exports, and a positive one – with regard to imports. According to theoretical considerations, therefore, it is the exchange rate level which affects in a given month the size of the trade, not vice versa. It should also be noted that the relation is stronger with respect to imports.

Correlation coefficients calculated previously for imports and exports separately indicated a positive dependence of the exchange rate and trade values. As it turns out, this follows largely from a significant link between exports and imports. The model parameters ($|a_3| > |a_2|$) show that an equal increase (analogically: decrease) in exports and imports results in the strengthening (analogically: weakening) of zloty, and thus in a positive correlation between the exchange rate and the values of foreign trade flows (although in the model the sign of the parameter for the value of exports is negative; the model is therefore not coincidental). The relation between exports and imports is confirmed by the values of coefficients of correlation between them, which are very high in the analysed period: for PLN – 0.96, for euro – 0.98, and for USD – 0.99. This strong dependence (which comes down to approximate co-linearity) also results in the relatively high values of standard errors of estimates.

Some additional conclusions brings the expansion of the model with the impact of variables from the preceding period to the form:

$$NEER_t = a_1 + a_2 Ex_t + a_3 Im_t + a_4 Ex_{t-1} + a_5 Im_{t-1} + a_6 NEER_{t-1} + \varepsilon_t .$$

Then least squares estimators of parameters are equal to:

- for EUR (coefficient of determination $R^2 = 0.93$, adjusted $R^2 = 0.93$):
 $a_1 = 14.079$ (6.250); $a_2 = -1.985$ (1.385); $a_3 = 2.747$ (1.357);
 $a_4 = 1.121$ (1.216); $a_5 = -1.633$ (1.072); $a_6 = 0.853$ (0.071)
- for USD (coefficient of determination $R^2 = 0.94$, adjusted $R^2 = 0.93$):
 $a_1 = 17.620$ (6.306); $a_2 = -1.265$ (0.956); $a_3 = 2.037$ (0.916);
 $a_4 = 0.724$ (0.871); $a_5 = -1.187$ (0.751); $a_6 = 0.810$ (0.069)
- for PLN (coefficient of determination $R^2 = 0.93$, adjusted $R^2 = 0.92$):
 $a_1 = 8.834$ (6.008); $a_2 = -0.532$ (0.350); $a_3 = 0.410$ (0.353);
 $a_4 = 0.476$ (0.311); $a_5 = -0.355$ (0.276); $a_6 = 0.923$ (0.057)

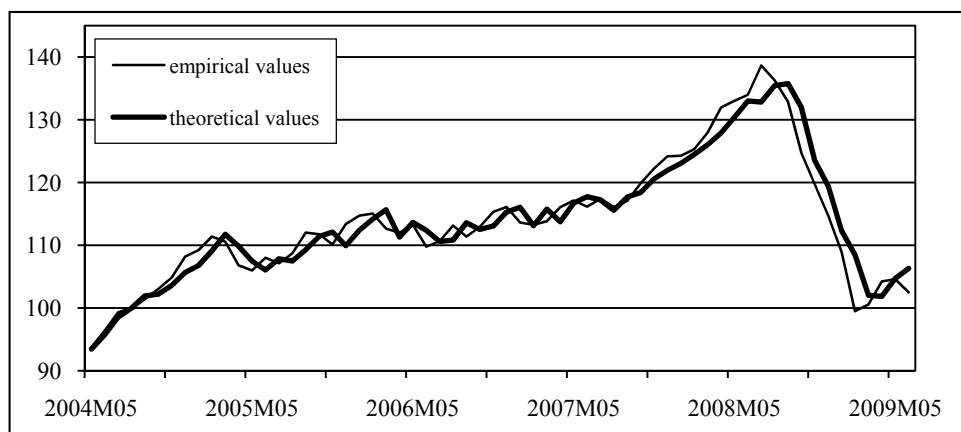


Figure 4. Fitting of the theoretical model for the trade denominated in EUR to empirical values of nominal effective exchange rate of PLN from May 2004 to June 2009

Source: own development based on data published by Eurostat (<http://epp.eurostat.ec.europa.eu>) and National Bank of Poland (www.nbp.pl).

The signs at the concurrent levels of imports and exports have not changed, but when it comes to the preceding period, the impact of exports is positive and of imports – negative. This is again consistent with theoretical expectations with regard to the influence of foreign trade flows on the subsequent exchange rate fluctuation. Standard errors of estimates arising from the interdependence of explanatory variables are still high. It is worth emphasizing, however, that the impact of the exchange rate from the preceding period is strong and of low estimation error, which indicates an important role of trends in the described phenomena. One should also note the high degree of fitting of the model to empirical data, which is implied by high coefficients of determination, and very similar shapes of model graph and observations graph (Figure 4).

5. Conclusion

The analysis of the correlation coefficients between the exchange rate and the volume of foreign trade showed rather a lack of delay in mutual dependency during the studied period. The research conducted earlier by the author showed a delayed reaction of the rate by up to six months⁸. A change in temporal relations could result from the consequences of the global crisis, which accelerated economic processes and initiated sudden concurrent adjustments in both the foreign exchange rates and the volume of international trade.

The correlation coefficients also indicate a positive relation of the exchange rate and both exports and imports. This phenomenon, contrary to theoretical assumptions, results primarily from the strong correlation between the values of trade flows. It is worth noting, however, that the method of pricing by exporters and importers and the elasticity of demand for goods in international trade may also be of great importance for the response of the trade value to exchange rate adjustments. In case of declining exchange rate (both nominal and real) the method of calculating prices in the global market (i.e. according to domestic or foreign prices, or intermediary solutions) will affect the scale of the decrease in selling prices denominated in foreign currencies, used abroad. In turn, the direction of change in the exports value in a foreign currency will depend on the strength of reaction of goods quantity acquired by foreign buyers to the fall in the offered price. In other words, when prices abroad are set on the basis of domestic prices and are subject to a significant reduction and when price elasticity of demand for exported goods is low, a fall in exchange rate of domestic currency may cause a simultaneous decrease in the value of exports denominated in a foreign means of payment.

On the other hand, a change in the value of imports expressed in the domestic currency may be positive in case of its depreciation, if importers set domestic prices primarily on the basis of foreign ones. Then, a fall in the exchange rate leads to a significant increase in prices of imported goods expressed in the domestic currency, and if demand is sufficiently rigid – also to a rise in the total value of imports. Thus, the impact of a decrease in the exchange rate on exports does not always have to be positive, and on imports – negative.

Econometric modelling of studied interdependencies indicated, however, that the main hypothesis adopted at the beginning – which comes down to the recognition of directions of shaping the trade by the exchange rate as consistent with the theory – may be judged true, as it is indicated by the respective signs of estimated model parameters. This relation is revealed, as it turns out, immediately, even in the same monthly period. In turn, the exchange rate responds to changes in international trade with a certain delay, at least one-month, while the direction of this reaction is also consistent with theoretical assumptions.

⁸ W. Michalczyk, *Realny...*, p. 17.

Therefore, the processes taking place in Polish foreign trade under the influence of exchange rate fluctuations, and vice versa, do not seem to differ substantially from the relations sanctioned by economic theory. It makes forecasting future states in the economy and explaining occurred phenomena much easier.

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KURSY EFEKTYWNE A PRZEPLYWY TOWAROWE – ANALIZA EMPIRYCZNA POLSKIEGO HANDLU ZAGRANICZNEGO

Streszczenie: Autor podejmuje próbę analizy powiązań pomiędzy przepływami towarów w polskim handlu zagranicznym a kształtowaniem się nominalnego i realnego kursu złotówki. Jak się okazuje, zależności pomiędzy zmiennymi wyglądają podobnie jak w teorii, choć w nie do końca jednoznaczny sposób. Zasadniczo jednak umocnienie złotego powoduje zahamowanie eksportu i pobudzenie importu, a zmniejszenie wpływów ze sprzedaży towarów za granicę oraz zwiększenie wydatków na import skutkuje deprecjacją polskiego pieniądza. Na takie powiązania wskazuje przeprowadzona analiza ekonometryczna, obciążona jednak dużym marginesem błędu. Z drugiej strony, analiza współczynników korelacji przemawia za dodatnią zależnością pomiędzy kursem a rozmiarami handlu, która wynika jednak w dużej mierze ze ścisłego związku pomiędzy wielkością importu i eksportu.