The Effect of Exchange Rate Uncertainty on Poland’s Trade Flows

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Abstract
The aim of the paper is to investigate the effect of exchange rate uncertainty on bilateral trade flows between Poland and its major trading partners. For this purpose we employ extended trade gravity model approach. In the basic form of the gravity equation, trade volume between a pair of countries is modelled as an increasing function of their sizes (GDP) and a decreasing function of the distance between the two countries. Additional factors included in extended model are population, dummies for common border; membership in EU and EMU and proxy for exchange rate volatility. The measure of exchange rate volatility is estimated by standard deviation approach. This paper explores relationship between trade and exchange rate uncertainty using quarterly data over the period 1997:1 – 2012:2. In order to obtain the objective result, we use the panel data regression with 19 trading partners. Based on a gravity model that controls for other factors likely to determine bilateral trade, the results suggest that nominal exchange rate volatility of Polish zloty has a significant negative effect on bilateral trade over the sample period.

Key Words
bilateral trade, exchange rate, gravity model, panel data, volatility

Introduction
The intensity of Poland’s participation in the international trade is still at a relatively low level. Although the volume of Poland’s international trade has been increasing since the joining the EU in 2004, it is constantly characterised by a long term negative trade balance. The reducing of Poland’s negative trade balance has been largely affected by the foreign direct investment inflow since the companies with foreign ownership account for a substantial share in Poland’s exports. This situation makes Poland’s economy more vulnerable to any adverse changes in other economies.

Both, exports and imports, solidly depend on exchange rates and their development. According to Abeysinghe and Yeak (1998), policy prescriptions have generally assumed that currency depreciation stimulates exports and curtails imports, while currency appreciation is detrimental to exports and encourages imports. Generally is expected, that higher exchange rate volatility leads to higher transaction costs for traders and is followed by decrease of
foreign trade. Theoretical analyses of this relationship have been conducted by Hooper and Kohlhagen (1978), who argue, that if changes in exchange rates are unpredictable it means uncertainty about companies’ profits and reduces the benefits of foreign trade. Even if hedging in the forward markets were possible, there are limitations and costs which are especially considerable for small firms. Per contra, De Grauwe (1988) pointed out that the dominance of income effects over substitution effects on international trade can lead to a positive relationship between trade and nominal exchange rate volatility, because an increase in exchange rate volatility raises the expected marginal utility of export revenue and therefore can induce increasing of exports. According to latest studies made by Taglioni (2002) and Ozturk (2006), it can be stated, that the inverse effect of exchange rate volatility on trade flows, if it exists, is not large.

Findings differ across the studies as well for aggregation reason. In the IMF’s study (2004) on exchange rate volatility and trade flows can be found conclusion that there is no obvious negative relationship between aggregate exchange rate volatility and aggregate trade. When the research is turned to bilateral trade, we do find evidence that exchange rate volatility seems to more affect bilateral trade than the aggregate one. Evidence on the researched relationship between exchange rate volatility and trade flows is characterized as heterogeneous as the results tend to be sensitive to the choices of sample period, model specification, proxies for exchange rate volatility and countries.

The aim of the paper is to investigate the impact of exchange rate volatility on bilateral trade flows between Poland and its major trading partners. Panel data used in this study covers period from 1997 to 2012 and 19 trading partners. Hence, this study provides additional evidence on the effect of exchange rate volatility on trade flows in the context of emerging market after the most turbulent part of economic transformation. One aspect of this transformation was a transition from fixed exchange rate arrangement into a crawling peg and recently to a free-float regime. In addition, Poland is interesting objective to study because international trade serves as a major channel of economic integration within the Group of Visegrad countries or the EU as a whole, because usually, international trade tends to be a driver of the economy in countries neighbouring with economies with open trade regimes, high presence of multinational companies and large volume of re-exports. The fact that this example fits to Poland can be illustrated by increasing share of merchandise trade on Poland’s GDP. The latest data of the World Bank shows 76.8 % as compared to 36.5 % in 1997.
Gravity equation of foreign trade

To estimate the impact of exchange rate volatility on foreign trade in this paper is used a gravity model, which is a simple empirical model for analysing bilateral trade flows. Despite this approach was often criticized for insufficient theoretical foundations, this drawback has been eliminated in the recent years. The original gravity equation is based on Newton’s gravity law equation:

\[ F_{ij} = g \frac{m_i m_j}{d_{ij}^2} \]

where \( F_{ij} \) is the value of gravity force, \( m_{i(j)} \) is the weight of object \( i \) (\( j \)), \( d_{i(j)} \) represents the distance between the objects and \( g \) is the gravity constant.

Based on this equation, the gravity model of trade analogous describes the force of gravity and explains the flow of trade between a pair of countries as being proportional to their economic “weight” (national income) and inversely proportional to the distance between them. The model has a lineage that goes back to Tinbergen (1962) and Pöyhönen (1963), who specified the gravity model equation as follows:

\[ X_{ij} = \delta \frac{GDP_i^\beta \cdot GDP_j^\beta}{D_{ij}^\theta} \]

where \( \delta, \beta \) and \( \theta \) are the parameters of the modified equation, \( X_{ij} \) is the bilateral trade between countries (dependant variable), \( GDP_{i(j)} \) represents income of respective trading partner \( i(j) \) (independent variable), \( D_{ij} \) is the distance between these two countries (independent variable) and \( \delta \) is constant.

Trade theorists have found the model to be consistent with theories of trade based upon models of imperfect competition and with the Hecksher-Ohlin model. For example Carrere (2005) points out its microeconomic foundation. The gravity equation can be formally derived within an imperfectly competitive set up with increasing returns to scale and firm-level product differentiation as well as within a perfect competition setup with product differentiation at the national level. Countries with a larger economy tend to trade more in absolute terms as they have larger demand, respectively supply. Higher distance depresses the bilateral trade as it represents higher costs for transportation, higher shipment time, and higher costs for searching trading opportunities or it can be used as proxy for cultural difference.

The basic gravity equation is frequently extended to incorporate other factors stimulating or reducing of bilateral trade flows. As an additional determinant of trade there is often used a population size of respective countries. Generally coefficient for country
population is expected to be positive, since bigger market in the recipient country is expected to demand more goods. And population of the export country is expected to be able to supply more as the population grows in size. Recent models also include many dummy variables that can affect transaction costs. For example common border, language or memberships in custom union are supposed to decrease transaction costs and to promote trade (Arricia, 1998). Therefore inserting these variables in the model we obtain:

\[
X_{ij} = e^{\beta GDP_i + \beta GDP_j + \beta \text{pop}_i + \beta \text{pop}_j + \sum_d \text{dum}_d + \epsilon_{ij}}
\]

where \( \text{pop}_{ij} \) stands for population of country \( i(j) \) participating in bilateral trade and \( \text{dum} \) represents dummy variables in addition to equation (Arvas, 2008).

**Extended gravity model with exchange rate volatility**

To analyse effects of exchange rate volatility on international trade flows of Poland we employ an augmented gravity model equation. In this paper we express bilateral trade flows as a function:

\[
X_{ij} = \alpha GDP_i^{\beta_1} GDP_j^{\beta_2} \text{pop}_i^{\beta_3} \text{pop}_j^{\beta_4} D_{ij}^{\beta_5} e^{\gamma \text{V}(ER)_{ij}} \prod_d \text{dum}_d \gamma_d + u_{ij}
\]

where additional factor \( ER_{ij} \) is the spot exchange rate and \( \text{V}(ER)_{ij} \) is its volatility, \( \alpha, \beta_k, \gamma_l \) are the unknown parameters of the model, \( u_{ij} \) is the error term. In order to add the exchange rate volatility into the equation, we follow Tichý (2007) and Baldwin et al. (2005) who pointed out that this relationship is not linear but convex and to avoid error due to rounding during data transformation, the volatility is used in exponent. Common border; membership in EU and EMU are incorporated in variable \( \text{dum} \).

Transforming this function to log-linear form, we get an extended gravity model equation. This transformation helps to reduce skewness and heteroscedasticity and to stabilize variability:

\[
\ln X_{ij} = \alpha + \beta_1 \ln GDP_i + \beta_2 \ln GDP_j + \beta_3 \ln \text{pop}_i + \beta_4 \ln \text{pop}_j + \beta_5 \ln D_{ij} + \beta_6 \ln \text{V}(ER)_{ij} + \sum_d \gamma_d \text{dum}_d + u_{ij}
\]

**Data description**

The models are estimated by using quarterly data over the period 1997:1 – 2012:2. The dependent variable in the model is a volume of bilateral trade between Poland and its trade partner, which is given as a sum of export and import flows of respective country. Trade flows are obtained from the OECD statistics of international trade. The data are in current
prices and denominated in the US dollars. The countries selection is based on the share of total international trade turnover and their list can be seen in Tab. I.

**I: Country list for regression**

<table>
<thead>
<tr>
<th>Main trading partners of Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
</tr>
<tr>
<td>Belgium</td>
</tr>
<tr>
<td>Czech Republic</td>
</tr>
<tr>
<td>Denmark</td>
</tr>
<tr>
<td>Finland</td>
</tr>
<tr>
<td>France</td>
</tr>
<tr>
<td>Germany</td>
</tr>
</tbody>
</table>

Source: Author’s calculation

GDP for every country is also obtained from OECD statistics of national accounts, calculated by expenditure approach in millions of US dollars in current prices. Time series for population is acquired from Eurostat. Distance and common border between Poland and its trading partner are used based on GeoDist database made by Mayer and Zignago (2012). They made available the exhaustive set of gravity variables, in particular bilateral distances measured using city-level data. Exchange rates are obtained from OECD statistics of international trade and are the only variables on monthly frequency. The basic statistical description of data is stated in Tab. II.

**II: Data description**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln X_{ij} )</td>
<td>1178</td>
<td>19.30405</td>
<td>15.10395</td>
<td>22.94386</td>
</tr>
<tr>
<td>( \ln GDP_i )</td>
<td>1178</td>
<td>12.68463</td>
<td>9.729657</td>
<td>15.01207</td>
</tr>
<tr>
<td>( \ln GDP_j )</td>
<td>1178</td>
<td>13.16610</td>
<td>12.70339</td>
<td>13.64407</td>
</tr>
<tr>
<td>( nPOP_i )</td>
<td>1178</td>
<td>9.283552</td>
<td>6.035242</td>
<td>11.32105</td>
</tr>
<tr>
<td>( \ln POP_j )</td>
<td>1178</td>
<td>10.55209</td>
<td>10.54831</td>
<td>10.55948</td>
</tr>
<tr>
<td>( \ln D_{ij} )</td>
<td>1178</td>
<td>6.968083</td>
<td>6.247390</td>
<td>7.923146</td>
</tr>
<tr>
<td>( \ln V(ER)_{ij} )</td>
<td>1178</td>
<td>1.983096</td>
<td>0.327031</td>
<td>2.361932</td>
</tr>
</tbody>
</table>

Common border \((CB)\) = 1, if trading partner shares a common border with Poland; = 0 if not

EU member \((EU)\) = 1, if trading partner is a member of EU; = 0 if not

EMU member \((EMU)\) = 1, if trading partner is a member of EMU; = 0 if not

Source: Author’s calculation
Measuring of exchange rate volatility

To measure the exchange rate volatility in this paper standard deviation of the first difference is used, based on monthly average nominal exchange rates of the period of 1997:1 to 2012:6. We employ following formula:

\[ \sigma(ER)_{ij} = \sqrt{\frac{\sum_{m=1}^{n} (ER_{i,m} - ER_{i,t})^2}{n}} \]

In this paper is used nominal exchange rate, as nominal and real exchange rates tend to move closely together and the choice is not likely to the econometric results. As literature review made by Auboin and Rutha (2012) states, the probability that the variability of nominal exchange rates did not translate into that of the real exchange rate would be small, occurring only during exceptionally high periods of domestic inflation. In empirical studies, both variables are generally tested. In addition, using nominal exchange rate avoids bias from changes in price levels via spurious correlation.

Estimation of gravity model

As Arvas (2008) states, standard gravity models usually employ cross-section data to estimate trade patterns in a given year, or averaged data. We employ panel data regression to avoid the risk of choosing an unrepresentative year and to monitor unobservable individual effects between trading partner. This can provide additional insights to trading relationships. In addition using of panel data for estimation brings mostly significant relation between international trade and exchange rate volatility.

Before estimating ordinary least squares (OLS) based methods on panel data, it is needed to determine data set effects as random or fixed. The fixed effects are when the heterogeneity in the model is unobservable, but correlated with any variable included in model. The heterogeneity in random effects is also unobservable, but it is not correlated with any other variable. In this case we follow Tichý (2007) again. The Breusch-Pagan Langrage multiplier test is used and the test criteria is calculated from equation:

\[ LM = \frac{nT}{2(T-1)} \left( \frac{\sum_{i=1}^{n} \sum_{t=1}^{T} e_{it}^2}{\sum_{i=1}^{n} \sum_{t=1}^{T} e_{it}^2 - 1} \right)^2 \]

where \( T \) is the length of time series, \( n \) is the number of unit in cross-section dimension and \( e_{it} \) is a residuum.
Empirical results

The estimation of the Breusch-Pegan Lagrange multiplier test revealed random effects. Thus the extended gravity model is estimated by Generalized least squares for panel data. The dependent variable in the model is total trade turnover between Poland and its trading partners. We have included 19 cross-sections and 62 periods. Total panel observations are 1178. The value of adjusted R-squared in this model is 92.61%. The results of this estimation can be seen in Tab. III.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>lnPOP_i</td>
<td>0.260188</td>
<td>0.115524</td>
<td>2.252247</td>
<td>0.0245</td>
</tr>
<tr>
<td>lnPOP_j</td>
<td>-21.51528</td>
<td>1.948769</td>
<td>-11.04045</td>
<td>0.0000</td>
</tr>
<tr>
<td>lnGDP_i</td>
<td>0.651731</td>
<td>0.099215</td>
<td>6.568904</td>
<td>0.0000</td>
</tr>
<tr>
<td>lnGDP_j</td>
<td>1.779169</td>
<td>0.070401</td>
<td>25.27178</td>
<td>0.0000</td>
</tr>
<tr>
<td>lnD_ij</td>
<td>-1.292551</td>
<td>0.204634</td>
<td>-6.316417</td>
<td>0.0000</td>
</tr>
<tr>
<td>lnV(ER)_{ij}</td>
<td>-0.018150</td>
<td>0.005184</td>
<td>-3.501307</td>
<td>0.0005</td>
</tr>
<tr>
<td>EU</td>
<td>0.249139</td>
<td>0.030013</td>
<td>8.301059</td>
<td>0.0000</td>
</tr>
<tr>
<td>EMU</td>
<td>-0.143396</td>
<td>0.022194</td>
<td>-6.461127</td>
<td>0.0000</td>
</tr>
<tr>
<td>CB</td>
<td>0.563128</td>
<td>0.296643</td>
<td>1.898338</td>
<td>0.0579</td>
</tr>
<tr>
<td>C</td>
<td>220.8696</td>
<td>20.25225</td>
<td>10.90593</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Source: Author’s calculation

Except parameter of dummy variable common border, all estimated parameters are statistically significant. We can observe expected positive impact of foreign population, Poland’s and foreign GDP, membership in European Union. Per contra, there is confirmed supposed indirect relationship between trade volume, distance and volatility of exchange rates. Results show, that the population of Poland has negative instead of positive impact. The same direction of relationship is revealed with membership in European monetary union.

Conclusion

The aim of the paper was to investigate the impact of volatility of Polish zloty on bilateral trade flows between Poland and its major trading partners. For this purpose we employed extended trade gravity model approach. We included 19 trading partners into the panel data analysis and the results suggest that the nominal exchange rate volatility of Polish zloty has a significant negative, but weak effect on bilateral trade over the sample period. Therefore, the results indicate that an active exchange rate policy aimed to influence exchange rate
development is not supposed to promote any notable improvement of Poland´s international trade.

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**References**


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