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The Impact of the PLN/EURO Exchange Rate Volatility on Polish Export to the Euro Area -- a Time Series Study

Abstract

Since joining the European Union in 2004, Poland has been considering adopting the Euro in place of the Złoty. Several Polish economists have argued that a common European currency would encourage increased growth of Polish exports to the euro area countries. This argument assumes that exchange rate uncertainty negatively influences export flows between Poland and the euro area. This study aims to investigate the relation between exchange rate volatility and trade flows over the past 20 years both for total export volume and export generated by eight industries. Based on the trade gravity model, an Autoregressive Distributed Lags model is created with volatility as the explanatory variable of interest. This study does not detect a statistically robust negative relation between volatility and export volume for the examined data, but a strong statistically significant relation between economic mass and export is found.

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1. Introduction

The impact of exchange rate volatility on trade started to be intensively researched after the 1971 breakdown of the Bretton Wood system – a currency regime where major currencies were pegged to the US Dollar, which was fixed to gold. The emergence of floating exchange rate regimes, where exchange rates are in principle determined by market forces of supply and demand, introduced a new element of risk and uncertainty for companies and financial institutions involved in cross border trading (Clark, Wei, Tamirisa, Sadikov & Zeng, 2004). A large part of the research conducted since then has been focused on the question of whether increased volatility of exchange rates and related uncertainty has a negative, neutral or positive impact on the companies' willingness to be involved in cross border trade.

This question has been particularly important for developing countries because of two reasons. Firstly, invoicing currencies, the currencies in which cross-border trade is conducted, continue to be predominantly USD, EUR (previously DM) and to lesser degree GBP, Yen (Matteo, Neiman & Schreger, 2019). Since macroeconomic conditions and policies of developing countries are less stable and predictable than those of developed countries, developing countries' exchange rates are subject to greater volatility. Thus, the impact of foreign exchange volatility on exports should be more pronounced in the case of these countries (Clark et al., 2004). Secondly, developing countries' financial markets do not readily offer inexpensive and comprehensive instruments, such as forward foreign exchange contracts, which would enable exporters to hedge their exchange rate risk arising from trade receivables and payables in a foreign currency.

Exchange rate volatility impacts companies involved in cross border trading via several channels, with the ultimate effect depending among others whether a given company is an exporter or importer, has debt in foreign currency, and extends or receives foreign currency receivables/payables (Vo, Vo & Zhang, 2019). Analyses are conducted to measure this response on an aggregated country level and industry level.

Various empirical studies have been conducted linking exchange rate volatility to export flows in certain specific industries or across various countries. An example of a global study is the IMF paper titled "A New Look at Exchange Rate Volatility" by Clark, Wei, Tamirisa, Sadikov & Zeng (2004), which examines the susceptibility of global trade to currency volatility. Some economists, on the other hand, tend to focus on disaggregated industry data. For instance, Serenis and Tsounis (2015) examine how the chemicals, beverages, and tobacco industries respond to currency volatility.

This paper focuses specifically on Poland – a country that is developing quickly and catching up with its western and central European neighbors – and examines both aggregated and disaggregated data. Through an Ordinary Least Squares regression, Polish exports to the Euro area (19 countries as of 2015) is analyzed as a whole and by looking at 8 individual industries in the 2000 – 2019 time period. This leads to the following research question:

Research Question: What is the impact of exchange rate volatility on the Polish export volume to the euro area?

1.1 Relevance of Exchange Rate Volatility in the Euro Adoption Debate

In 2019, Polish total exports amounted to around 236bn EUR, while export to the EU (27 countries) amounted to 174bn EUR, and exports to countries of the Euro area reached 131bn EUR. (Eurostat, 2020) This means that the share of Polish exports to countries with the EUR as the home currency represented 56% of total exports and 75% of total export to European Union countries. Considering that the Polish GDP in 2019 was estimated to be of around 550 billion EUR in current prices (Eurostat, 2020), the export to the euro area is one of the most important drivers of growth of the Polish economy, please see Table.2 and Graph. 4 for illustration. Export to the Euro area, not the total EU market, was selected because of two reasons.

Firstly, although data about the currency of export invoicing for intra-EU trade is not available, the assumption that the Polish export to euro area countries is almost entirely invoiced in EUR seems sound. PLN is a fully convertible currency, but given that the access to instruments to hedge against PLN payables is limited, euro area importers are not willing to accept invoices issued in PLN. This tendency is characterized by the relatively low forex derivatives turnover rates in Poland, as shown in financial reports such as the Turnover in the Domestic Foreign Exchange and OTC Derivatives Markets (2019) issued by the Narodowy Bank Polski – the Polish central bank.

Secondly, in ongoing discussions about Poland adopting the euro, some argue that by replacing the PLN with EUR, monetary authorities will have no instrument to manage the currency used by Poland. Thus, the Polish government will not be able to support exports by depreciating the currency if needed. Proponents of this argument point to the situation of Greece after the financial crisis 2008-2009, as described in the book "Paradoks Euro" by Kawalec and Pytlarczyk (2016).

The results of my tests, which assess the impact of the PLN/EUR exchange rate volatility on Polish exports to the Euro area may be used in the discussion on the optimal currency regime in Poland. The data used covers a relatively long time period from 2000 till 2019. In this period, the PLN/EUR nominal exchange rate was subject to large volatility, especially in the early 2000 and during the 2009 recession. Therefore, the results of my tests may indicate whether this volatility had an actual impact on the volume of Polish exports to countries sharing the euro. If volatility has had a statistically significant impact on exports, a strong case can be made for the adoption of the euro.

1.2 Structure of the Paper

In the literature review, both the empirical findings and theoretical models are presented relating the role that volatility can play for exporters under various circumstances. Later, in the theoretical framework, the mechanisms through which volatility impacts trade are presented. In the data & methodology section, the data is visualized and discussed descriptively, while the relevant regression model and transformations are presented in detail. In the results section, the output of the OLS regressions is analyzed in conjunction with the hypotheses. The conclusion answers the research question and draws implications relevant for the Euro adoption debate.

2. Literature Review

2.1 Theoretical models of a Firm Exposed to Exchange Rate Volatility

The emergence of the floating exchange rate regime after the breakdown of the Bretton Wood system, with fixed exchange rates of major currencies, initiated the start of extensive academic research on the impact of foreign currency volatility on trade flows. The first studies on this subject were completed by Clark (1973) - in his academic article titled “Uncertainty, Exchange Risk, and the level of International Trade” - and by Ethier (1973) in “International Trade and the Forward Exchange Rate”.

While the study of Clark focused solely on the impact of exchange rates on exports, Ethier modeled the decisions made by a risk-averse firm for both the volume of goods imported and the size of the forward currency contracts purchased. Since this thesis analyses the exchange rate volatility impact on exports, a brief outline of Clark’s model will be presented. The main assumptions in his model are there is only one firm selling one commodity product with no market power, there is a single importing market, export flows are invoiced in the foreign currency and no hedging instruments are available. Additionally, there are no imported inputs, and therefore, if there is a depreciation of the local currency, the depreciation does not lower production costs. Clark also assumed that to maintain timely production flows, the firm could not alter its production process to respond quickly to swings of the exchange rate. Thus, the firm’s profits depend solely on the volatility of the foreign exchange rate. Given all these assumptions, Clark argues that if managers are averse to risk, an increase in volatility will lead to a reduction in output and consequently a reduction in exports.

Clark’s model was subsequently developed further by several researchers including Hooper and Kohlahagen (1978) using various measures to specify exchange rate volatility based on nominal exchange rates. These authors also concluded that there exists a negative relationship between volatility and exports. However, critics of this study pointed out that empirical results were based on nominal exchange rates and a very short time period after the emergence of global floating exchange regimes – two and a half years.

An interesting contribution to the theoretical consideration of the relationship between exchange rate volatility and trade was made by De Grauwe (1988) in the IMF paper “Exchange Rate Variability and the Slowdown in the Growth of International Trade”.

His study offers a comprehensive model, in which a business is active in both the local and foreign markets and has varying risk tolerance levels. The study points out that the final impact of currency volatility is related to the business owner’s level of risk aversion and that risk may not always lead to export reductions. An increase in currency risk, expressed as volatility in trade models, influences the exporter through both substitution and an income effect. The substitution effect lowers the willingness of the exporter to engage in foreign trade, which is seen as a risky activity contrary to, for instance, local sales. However, with greater risk, the expected utility of an exporter decreases. This decrease in expected utility from the exporting activity can be compensated for by allocating more resources towards exporting. Thus, if the income effect dominates the substitution effect, higher currency risk may be accompanied by greater general export levels, as presented in De Grauwe’s (1988) trade utility models. Such a result is contrary to the theoretical analysis presented by Clark (1973). Thus, on a theoretical level, credible economic theories have been presented with varying conclusions as to the final impact that volatility has on trade.

2.2 Past Empirical Research on Exchange Rate Volatility

The above presented theoretical studies that focus on the behavioral aspects of a firm engaged in international trade represent one line of academic research from the early ’70s. The other studies have been empirical in nature and aimed at examining the actual export data to establish a relationship between exchange rate volatility and exports. McKenzie (1999) reviewed most of the empirical studies and came up with the following conclusion presented on page 10 of The Impact of Exchange Rate Volatility on International Trade Flows: “The empirical literature contains the same mixed results as the evidence provided by the world trade data most commonly fail to reveal a significant relationship. However, where a statistically significant relationship has been established, they indicate a positive and negative relationship at random”. Therefore, McKenzie’s empirical literature review study reinforces the conflict between mixed theoretical results, as seen by the works of De Grauwe (1998) and Clark (1973).

McKenzie's study is important not only because he summarizes the results of most empirical research completed in the period 1973-2000 but also because he has specified several important issues when analyzing the relationship between exchange rate volatility and trade flows. These were: the inclusion of nominal versus real exchange rates, the duration of the data period, the type of trade flows (i.e. export vs. import, aggregate trade flows vs. industry trade), what explanatory variables should be included in trade equations, what estimation technique should be applied, and what measure of volatility should be used.

One of McKenzie's conclusions was that the failure to establish a causal relationship between currency volatility and trade was because most empirical studies used aggregate trade as the main dependent variable. He provided several suggestions related to certain changes in techniques of testing, among others recommending that the impact of exchange rate volatility should be tested by applying disaggregated export data instead of aggregated data. This suggestion leads to my first hypothesis.

H1: The volatility of the PLN/EUR nominal exchange rate has had no material impact on the aggregated and disaggregated export volumes of the Polish industries trading with the euro area.

After McKenzie's summary completed in 1999, the next impactful paper in this debate came from the IMF economists Clark, Tamirisa, Wei, and Sadikov (2004), who found no robust relationship between volatility and trade for the 186 studied countries in the 1970 to 2002 period. The basic premise of the gravity model in terms of GDP (i.e. a measure of economic mass) determining the level of trade holds for the studied period. In other words, the bigger the economic mass of the trading partner, the greater the trade level. According to the regressions from the above-mentioned IMF paper, the link between GDP and trade is stronger than the link between trade and volatility. Moreover, GDP as an explanatory variable is statistically significant, while volatility was not. I expect to see similar results when I examine individual industries as well as the total export level for Poland to euro area countries.

H2: Changes in the euro area economic mass have had a much bigger impact on Polish export volumes to euro area than exchange rate volatility.

There have not been many studies that focus solely on the impact of the PLN/EUR volatility on Poland's trade. In the study published in 2017 titled "Exchange Rate Volatility and Exports in the run-up to the EMU accession", Goczek and Mycielska analyzed the relationship between total exports of Poland, Czechia, Hungary and Romania and exchange rate volatility in the period 2000-2015. Aggregated and industry export data were used in conjunction with two measures of exchange rate volatility (i.e. standard deviation and GARCH). The main goal of this study was to verify whether the elimination of currency risk, once these countries adopted the Euro, would increase trade with the current euro area member countries. In other words, the elimination of currency volatility should have a positive impact on exports. In this study, Goczek and Mycielska (2017) use regression analysis with lagged terms to conclude on page 73 that "the elimination of the exchange rate volatility through euro adoption will not necessarily increase the export performance of the countries integrating with the Euro area."

This conclusion is evidenced by the lack of an independent statistically significant volatility variable. The testing results for sectors showed a statistically positive impact of exchange rate volatility on exports of food and live animals and a marginally significant positive impact on exports of beverages and tobacco. Other sector relationships are negative but statistically insignificant. One very interesting finding of this study is that the export of industries with more differentiated products is less sensitive to the variability of exchange rate than export from commodity-type industries, but again results are statistically insignificant. This leads me to my last hypothesis.

H3: The sensitivity of manufacturing industries to exchange rate volatility has been lower than the sensitivity of exports of commodity linked industries.

3. Theoretical Framework

3.1 Mechanisms Through which Volatility Impacts Export

In the literature review, existing academic models and empirical research regarding exchange rate volatility were compared and examined holistically. However, in this section, trade revenue uncertainty, the dominant mechanism through which volatility affects export volume, is discussed in detail. I also examine other complementary factors that influence the final impact of volatility on the actions of exporters.

In an environment where exchange rates are determined by the supply and demand of currencies, volatility of the exchange rates represents a source of uncertainty since exporters cannot predict future sales revenues in their local currency (Goczek & Mycielksa, 2017). In the case of Poland, the exporters' currency is PLN. In other words, if exporters do not hedge, with for instance a forward rate agreement or currency options, they face exchange rate risk in their operations that may impact their revenues and net profits. As explained in Tomanova (2013), this risk emerges when a given firm enters into an export contract with deferred payment, which is the norm in today’s trading environment. If the foreign currency, in case of this study the EUR, depreciates against the local currency - the PLN - the exporter will receive less amount of cash in local currency with an immediate impact on its financial positions as local currency costs remain unchanged. This form of uncertainty poses a material risk for exporters of those products, which require a sizable amount of capital expenditures. Even if in a later period PLN appreciates, uncertainty makes financial and operational planning processes very complicated and cumbersome to implement. The ultimate impact of exchange rate risk for an exporter will depend on a number of additional factors for a given exporter. A list of additional factors, as explained in McKenzie (1999), are described below.

How quickly a firm can adjust its production process to exchange rate fluctuations gives the firm the ability to adjust to uncertainty. By either reducing costs in the local currency or keeping stock of goods for a later sale occasion, a firm can decrease its exposure to currency risk.

European economies have differing levels of financial institutions' maturity. Firms operating in a less developed country will have worst access to cost-effective hedging transactions with the application of financial instruments, such as foreign currency forwards or options. Even if such instruments are offered, the costs involved in buying this type of protection against the exchange rate risk could be quite high and thus exporters are not always willing to buy such protection (Clark et al., 2004). Thus, greater access to inexpensive financial derivatives can reduce exchange rate risk.

If an export experiences an unfavorable currency shift, the firm may be capable of redirecting its goods onto the local market. Thus, if there exists local demand for the goods that were previously sold to a foreign buyer, the exporter may decrease export volumes, while maintaining revenue levels.

The ability of a firm to control costs and adjust to exchange rate risk depends on the type of goods that are exported. Goods that constitute an integral part of a firm's global supply chain may be unaffected by currency swings. A supply chain link may not have any other alternatives outside of the currently imported foreign parts. However, commodity export or exports of manufacturing products with a significant content of cost related to commodities will be susceptible to exchange rate changes. An example of such a product could be the export of gasoline or fertilizers.

Exchange rate volatility impacts all companies involved in cross border trading – although as it has been written above not necessarily in the same magnitude. Therefore, it is adequate to analyze trade flows for a given country or industry on an aggregated level as a sum of individual firms' exports. The theory that allows the analysis of trade flows on a macro level is called the gravity theory of trade.

3.2 Gravity Theory of Trade

This paper's goal is to estimate the statistical relation between volatility and polish export levels to the Euro area. However, volatility is clearly not the only factor that will influence the export level. In order to avoid the issue of the omitted variable bias, more explanatory variables are introduced. The most widely applied approach in modeling trade flows is using the gravity model. The fundamental idea behind the model is that countries with greater economic mass will tend to import more internationally because with a greater aggregated wealth of its population, a can country can afford to buy more goods from abroad. In addition, countries that are further apart will experience greater costs in order to trade with one another. Thus, countries closer to each other should be more willing to engage in trade. The fundamental idea behind the trade gravity model, first adapted by Jan Tinbergen (1962), comes from a physics equation relating the gravitational pull that certain mass objects have on each other. Outside of mass and distance, other variables (such as trade barriers) have been added that explain other trade frictions that hamper growth. The traditional gravity model can be shown more formally, with the following equation from Jame's Anderson (2011) working paper "The Gravity Model":

$$T_{ij} = \frac{(Y_i)^a (Y_j)^b}{(D_{ij})^c} \quad (1)$$

Tij describes trade volume between two countries (foreign and home). Y described the economic mass of HOME and FOREIGN, while D represents the distance. Variables a, b, and c capture the effect of other trade impediments, such as language, cultural differences, trade unions, etc.

4. Data & Methodology

4.1 Datatype and Sources

For the paper, I have exclusively relied on time-series data from Eurostat and the Eurostat's guidelines on SITC nomenclature. Eurostat represents the statistical office for the Directorate-General of the European Commission and has the leading statistical information on the members of the European Union (Eurostat, 2020). The time period of my study starts from January of 2000, which represents the first month when trade data between Poland and the euro area is available for the 10 SITC nomenclature industries. The study ends in the December of 2019, meaning that in total 240 time points are investigated. The data collected for all variables is transformed into ln format. This is done so that percentage changes can be investigated and so that data is smoother, leading to a lower chance of outliers. Monthly data is used because this is the shortest time period when the key variables from the Gravity model can be obtained.

4.2 SITC Industry Transformation

As seen in Section 7.1 of the Appendix, I combine both SITC 6 – 8 industries in order to narrow down on the total manufacturing export. By using a complete manufacturing indicator, I can better address the third hypothesis. Also, together SITC 6 – 8 are the most important export industries, making up together around 70% of total trade to the Euro area. Moreover, from the manufacturing sector, the most important industry is SITC 7 (Machinery and transport equipment), accounting for around 39% of Polish export to the euro area.

4.3 Regression model specifications

As mentioned previously, the gravity model is used to isolate the effect of volatility on trade. Jan Tinbergen's fundamental theory does not incorporate volatility as an explanatory variable. Thus, an augmented version must be used.

The gravity model has been formally developed by many researchers. In principle, the developments of these models were aimed at adding or specifying additional control variables, which would better explain changes in aggregate trade by the applying ordinary least square method (OLS). This paper applies a slightly different version of the gravity model used by Goczek and Mycielska (2017) - a paper focusing on the aggregated trade flows for several Eastern European countries. As in the model by Goczek and Mycielska (2017), there are three independent variables; economic mass (Y), the volatility of exchange rate (VOL), and competitiveness – a ratio of average export prices to average import prices (P). A general formula for the model is:

(2) $$EX_t = (Y_t)^a (P_t)^b (VOL_t)^c$$

Contrary to Jan Tinbergen's model, in this equation, economic mass is the euro area's GDP only. Poland's GDP is not included as I assume that local economic mass should not affect foreign demand for local goods, as argued similarly in Wong (2017). Distance is not included as a variable as in the case of Polish exports to the euro area, distance's impact on costs for exporters is minimal and constant. Also, other control variables used in fully developed models like trade unions, languages, or cultural differences are not taken into account because current Eurostat trade data cannot be differentiated with respect to these softer factors.

By taking the natural logarithm of both sides, I arrive at the following expression.

(3) $$lnEX_t = ln\ ((Y_t)^a (P_t)^b (VOL_t)^c)$$

This expression can be shown as a linear equation with an error term

(4) $$lnEX_t = aln(Y_t) + bln(P_t) + cln(VOL_t) \; + \varepsilon_i$$

To avoid non-stationarity, Dickey Fuller tests were run for all the variables. Please see Table. 4 in the Appendix for all the Dickey-Fuller tests. Based on the results of these tests, price ratio, export, volatility and economic mass were differenced.

(5) $$\Delta lnEX_t = a\; \Delta ln(Y_t) + \Delta\; bln(P_t) + cln(VOL_t) + \varepsilon_i$$

Based on previous research on trade, such as Vo, Vo & Zhang (2019), trade is often correlated with previous lagged terms. Moreover, the export may be correlated with previous GDP figures, as contracts are signed in advanced and past economic growth could incentive higher orders. Lagged terms of volatility are not investigated as volatility is already a rollingv average, which takes into account previous months. Lagged past price data is also considered as delivery may be set in advance with delivery next month – rather than now.

To determine the optimal lag length for this model, I use the AIC and BIC criteria, as done by Vo, Vo & Zhang (2019). The AIC, as seen in Table.5 of the Appendix, indicates that a leg length of three should be chosen for export, economic mass, and prices. This can be shown by the following final Autoregressive Distributed Lag Model, which employed the ordinary least squares (OLS) regressive method. This is the final model used to evaluate my research question and hypothesis.

(6) $$\Delta lnEX_t = \sum_{i=0}^{3} a_i\; \Delta\; ln(Y_{t-i}) + \sum_{i=0}^{3} b_i\; \Delta\; ln(P_{t-i}) + c\; ln(VOL_t) + \sum_{i=1}^{3} d_i\; \Delta lnEX_{t-i} + \varepsilon_i$$

4.4 Measure of Exchange Rate Volatility

Selecting this measure of volatility, we follow the approach taken in many papers including A New Look Exchange Rate Volatility and Trade Flows by Clark et al. (2004). A summary of other measures of exchange rate volatility is provided by McKenzie (1999).

In my thesis, I apply as a measure of exchange rate volatility the moving average of the standard deviation of the first difference of logarithms of the PLN/Euro exchange rate. This can be illustrated by the following moving average equation, where a volatility data point is calculated based on a data period of 12 months. End of month exchange rate data is used.

$$V_{t+12} = (\frac{1}{12}\sum_{i=1}^{12}(R_{t+i-1} - R_{t+i-2})^2)^{1/2} \quad (7)$$

R represents the ln nominal exchange rate, while m is the number of periods taken into account. In my case, m of 12 is taken into account – meaning that the standard deviation over a year is calculated. The moving average standard deviation functions in the following way. For instance, for December of 2019, I calculate the standard deviation based on 12 months from January till December of 2019. For November of 2019, I calculate the standard deviation based on 12 months from December of 2018 till November of 2019. These calculations continue until I have 228 observations for volatility. The first 12 months of 2000 do not have volatility figures as I require past data on a minimum of 12 months to make the volatility calculation.

After running a Dickey-Fuller test, non-stationarity could not be rejected. Although this volatility measure is a rolling average, I follow the empirical reasoning presented in Vo, Vo & Zhang (2019) and Serenis and Tsounis (2015) by differencing volatility to ensure stationarity for all variables.

4.5 Description of all Variables

A list of descriptive statistics for all variables used is provided in Table. 1. This aims to examine the characteristics and transformations of each variable relevant to the study, which includes examining some of the descriptive statistics.

Table.1 – Descriptive statistics used for regressions

	Average	**Std. Dev**	**Min**	**Max**
Export Group 0	447,496,777.46	267,495,420.98	84,847,191.00	968,654,185.00
Export Group 1	42,507,867.68	28,421,782.54	4,665,086.00	113,119,156.00
Export Group 2	149,792,392.58	78,375,206.35	35,064,621.00	322,238,265.00
Export Group 3	189,685,231.27	101,113,978.39	23,935,315.00	432,396,102.00
Export Group 4	30,005,179.21	17,246,813.16	5,299,577.00	75,721,613.00
Export Group 5	1,087,685,108.64	490,779,848.54	308,955,927.00	2,107,526,699.00
Export Group 6	4,639,866,421.69	1,995,969,501.20	1,599,665,398.00	9,325,825,002.00
Export Group 7	75,785,437.89	43,087,291.90	13,265,098.00	196,900,278.00
Total Export	6,662,824,416.42	2,968,326,623.77	2,113,838,982.00	13,109,538,138.00
Industrial production	103.04	4.48	93.30	115.90
Exchange rate	4.11	0.29	3.21	4.87
Price ratio Group 0	0.89	0.28	0.36	1.56
Price ratio Group 1	1.70	6.75	0.43	105.02
Price ratio Group 2	1.51	0.67	0.46	4.37
Price ratio Group 3	3.35	1.18	1.70	6.94
Price ratio Group 4	1.26	0.41	0.18	2.74
Price ratio Group 5	2.32	1.15	0.86	5.87
Price ratio Group 6	1.18	0.29	0.67	2.13
Price ratio Group 7	0.38	0.33	0.03	2.48
Price ratio	1.72	0.66	1.02	3.59
Volatility	0.02	0.01	0.01	0.05

Dependent variable – Export to the Euro area

Export in this study is defined as the total value of goods sold by Polish exporters to 19 countries Euro area. According to Eurostat, from 2015, there are 19 countries in the euro area. At the start of the 2000 period, only 11 countries were in the Euro area. However, the combined GDP of the 7 countries that joined after the 2000 period amounted to less than 2% of the GDP of the total euro area countries. Thus, these are very minor changes that should not change Poland's trade patterns. Moreover, before countries such as Cyprus and Malta adopted the euro, it is very likely that the invoiced trade currency would be the euro. Thus, although the euro area did change slightly during the course of the studied period, the trade data presented in Eurostat is compelling enough to answer the research question and evaluate the stated hypotheses.

Originally, Eurostat presents export data per 10 SITC nomenclature industries. However, in order to isolate the manufacturing sector for hypothesis 3, I grouped together 3 industries and referred to the newly organized industries simply by 8 Groups. Pleases see the industry composition chapter of the Appendix for a more detailed breakdown of the conversion from SITC into Groups defined for this study.

Table. 2 – Yearly Polish industry export to the Euro area (in millions of euros)

Industry	2000	2010	2019
Food and live animals	1,301.80 (4%)	5,537.21 (7%)	10,712.01 (8%)
Beverages and tobacco	96.86 (0%)	510.60 (1%)	1,121.99 (1%)
Crude materials	531.96 (2%)	1,781.77 (2%)	3,055.89 (2%)
Mineral fuels and lubricants	582.00 (2%)	2,542.40 (3%)	2,690.07 (2%)
Oils, fats and waxes	97.39 (0%)	261.07 (0%)	530.02 (0%)
Chemicals	4,645.76 (15%)	13,727.79 (17%)	22,834.43 (16%)
Manufactured goods	22,477.11 (75%)	54,596.34 (68%)	99,073.48 (70%)
Commodities and other transactions	279.80 (1%)	846.37 (1%)	1,155.92 (1%)
Total export	**30,012.68 (100%)**	**79,803.55 (100%)**	**141,173.82 (100%)**

Source: own calculations based on Eurostat data

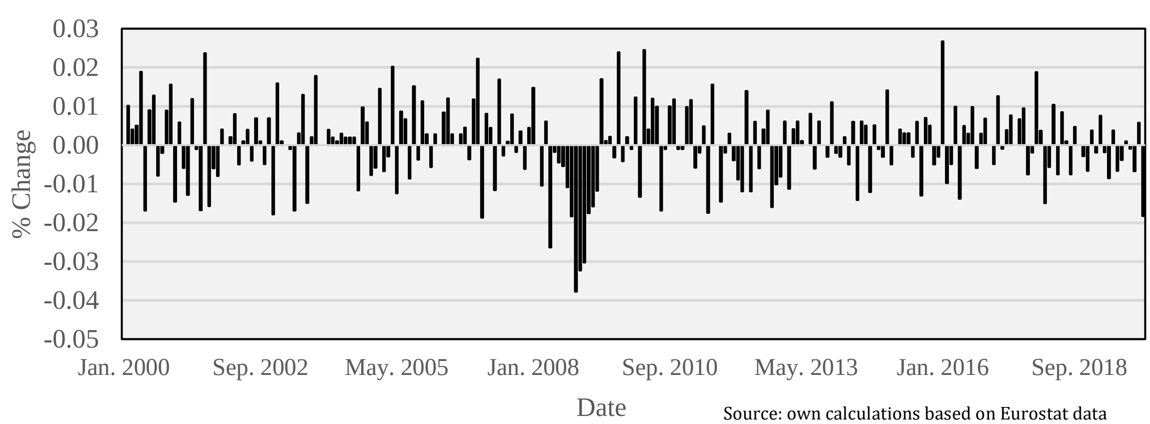
Total Polish export to the Euro area has grown by over 4 times from 2000 to 2019. However, the composition of Polish export has not changed a lot. Group 0 (i.e Food and Live Animals) have become more important than before by rising from 4% of total export in 2000 to 8% in 2019. Group 6 (i.e manufacturing goods) increased its export by over 3 times from 2000 to 2019, yet its relative importance decreased by 5%. All the other sectors exported rose by a similar percentage amount as the total, meaning that outside of groups 0 and 4, industry composition of total is almost the same.

The export levels were non-stationary according to Dickey-Fuller tests. After taking the first difference, another set of D-F tests were run and the hypothesis that the data is non-stationary could be rejected.

Independent variable – Economic Mass

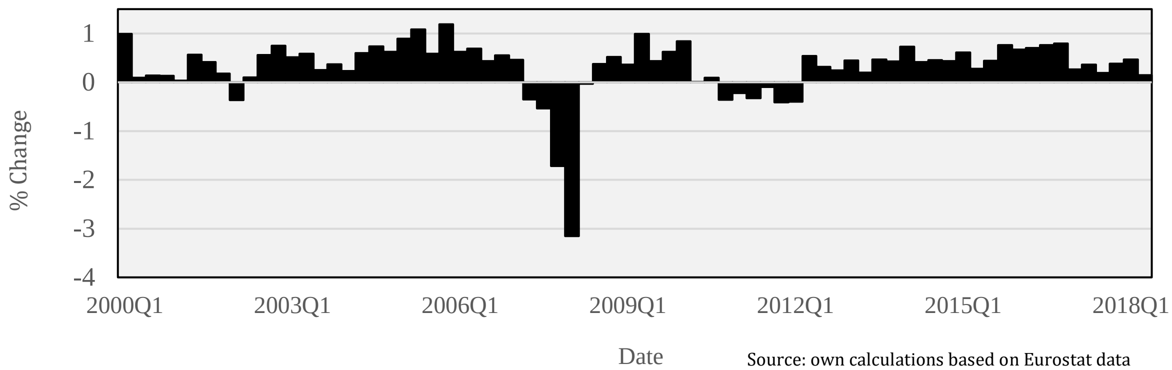
GDP represents the Gross Domestic Product of a country. GDP is a key variable in Gravity models, such as the one presented in Mathias, as it represents the economic mass of a country in the Gravity model. Using the definition of Eurostat, GDP represents the sum of the economy's gross value added and taxes less subsidies on goods and services. GDP is released once per quarter, yet my study looks at monthly changes in exchange rates. Thus, a normal form of GDP cannot be used. In line with the paper by Goczek & Mycielska (2017), I use industrial production as a monthly proxy for GDP. Although industrial production is an index, measuring the output of the manufacturing sector, the percentage change of the index is similar to the percentage changes in GDP. This is seen in Graphs 1 and 2, which are based on Eurostat data for industrial production and GDP. In order to examine monthly data, I could have extrapolated and broken-down quarterly GDP data into monthly data based on a set on assumptions, but that would have introduced a large bias since month-to-month percentage changes would be 0. By this estimation, a GDP proxy (i.e industrial production) released by Eurostat is more reliable than rough GDP estimations that I would have to complete by diving quarterly GDP into monthly changes. To ensure that industrial production fluctuations closely resembles GDP fluctuations, I provided a visual aid in the form of two graphs for industrial production change and GDP change. Instead of referring to Y as GDP in the final regression model, I henceforth refer to Y as foreign economic mass.

Graph. 1 - Euro area Industrial Output % change per Month



Source: own calculations based on Eurostat data

Graph. 2 - GDP % Change per Quarter



Source: own calculations based on Eurostat data

Contrary to the standard gravity model, I do not examine the economic mass of both the HOME and FOREIGN countries. I only examine the economic mass of the euro area as the FOREIGN country. This is because I am specifically focusing on the export levels from Poland to the euro area and not total trade. Like in the empirical trade paper o Vo, Vo & Zhang (2019), I assume that HOME's (i.e. Poland's) economic mass should theoretically not affect the demand that euro area region has for Polish goods.

The Industrial production (i.e proxy for economic mass) is a manufacturing index calculated by Eurostat. For the index, Eurostat selects one year as a base year and the results for the other years are interpreted as relative to that year. The base year for the industrial production is 2015, and the index is set at 100 with May data from 2015. The natural logarithm for each industrial production monthly data point is taken. Later, the difference between months of the logarithm is calculated to arrive at the monthly change in industrial production (i.e proxy for economic mass). Europe's economic mass has been on a positive trend for the last 20 years. Thus, using the augmented Dickey Fuller test, I check whether I can reject the statistical hypothesis of non-stationarity. Thus, to avoid a spurious regression with other non-stationary variables, I difference industrial production. The result of the Dickey-Fuller difference industrial production (i.e foreign economic mass) is shown in Table 4. Another augmented Dickey-Fuller test is taken, and we reject the hypothesis that the fist difference of GDP is non-stationary.

Independent variable - Volatility

To calculate the volatility of the PLN/EURO exchange rate, I first had to decide whether to use nominal or real exchange rates. I used nominal exchange rates since real exchange rates include the relative ratios of two economies and these relative price ratios are already incorporate into a different variable from the regression (i.e the prices ratio descried below). As seen in Table. 3 (see Appendix), the average PLN/EURO rate for the 2000-2019 period is around 4.1. At its lowest, the exchange rate was 3.35 in June 2008 and at its highest 4.7 in February 2009, indicating that currency has experienced a high level of variability during the financial crisis.

Independent variable – Price ratios

The price ratio as an approximation of competitiveness is included in the regression. Based on the data from Eurostat, I was able to find the average price of the exported good from Poland to the euro area per industry per month. I also found the average price of the imported goods from the euro area to Poland per industry per month. Later, a ratio between the import and export prices was taken for each industry. This can be shown by the following formula, where a high ratio means that Polish goods are expensive compared to Euro area ones.

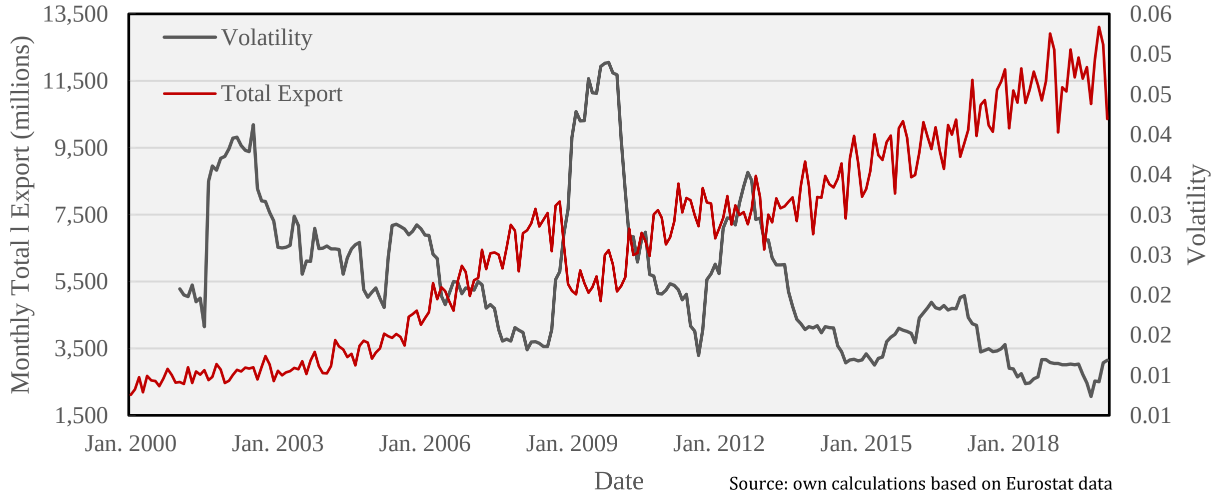
$$P_i = \frac{average\ export\ price}{average\ import\ price\ per}$$

After taking the Dickey-Fuller tests for all price data, and visualizing the price ratio data, I differenced the price level indices to avoid non-stationarity.

4.6 Graphical Representation of the Relationships

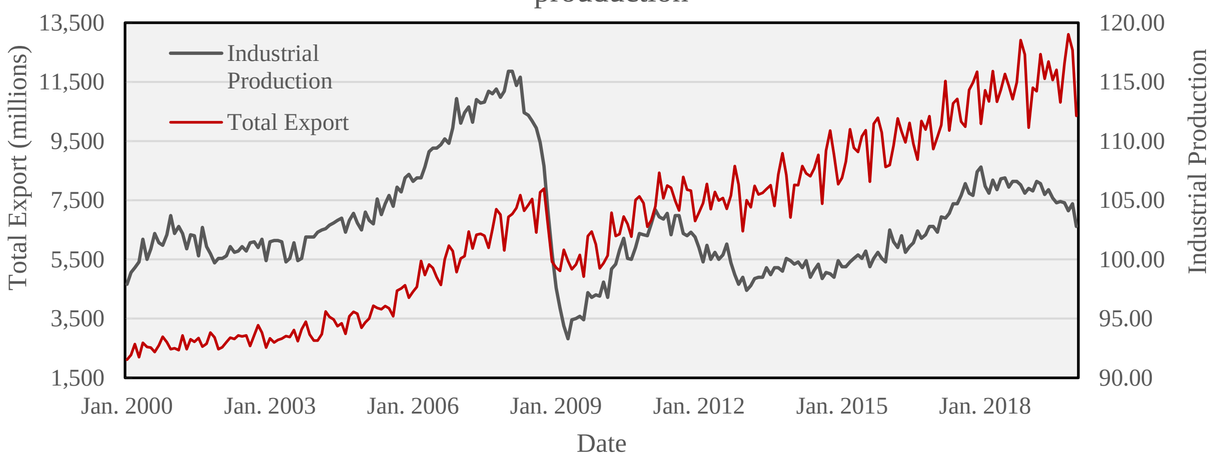
Before the results of the regressions are investigated, I would like to first describe the graphical representation of the relationships between currency volatility and monthly total export, industrial production and monthly total export, price ratio and monthly total export. The following 3 graphs include variables before differencing and before taking the natural logarithm.

Graph. 3 - Polish export to the Euro area and exchange rate PLN-EURO volatility



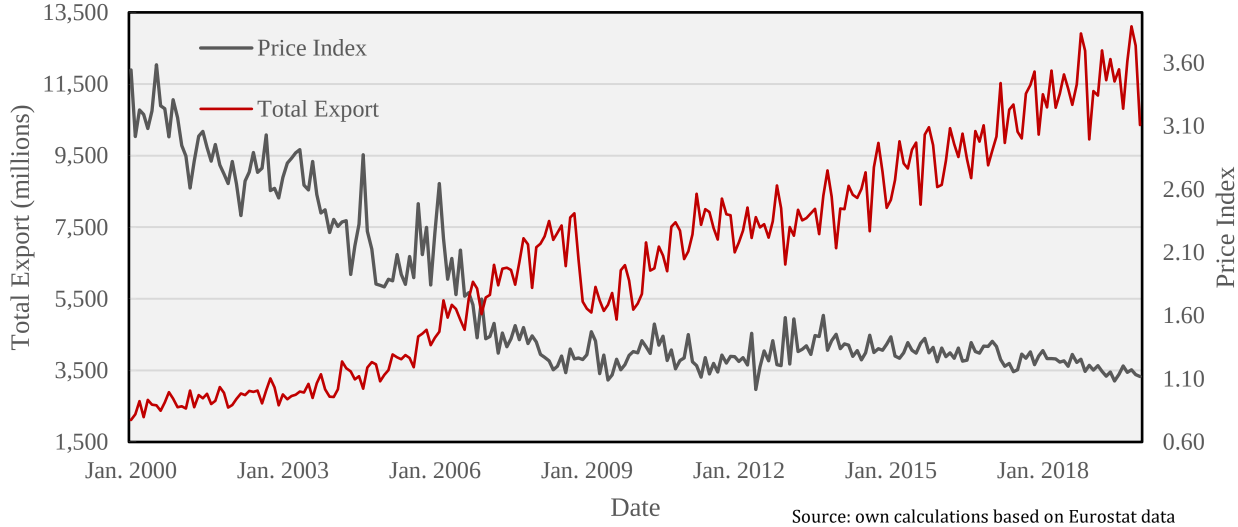
Source: own calculations based on Eurostat data

Graph. 4 - Polish export to the Euro area and Euro area industrial prouduction



Source: own calculations based on Eurostat data

Graph. 5 - Polish export to the Euro area and Price Ratios of Polish export



Source: own calculations based on Eurostat data

As can be seen in Graph.3, Total export has been steadily increasing every year since 2000. There seem to exist only two dips in monthly total export: during the 2008 Financial Crisis and a slight decrease in export in 2013. Almost every year, however, export has a tendency to fluctuate around a strong positive trend. Exchange rate volatility, on the other hand, does not seem to follow a clear pattern. Exchange rate volatility has three major spikes in 2002, 2009 and 2014. These are also the years export growth slows down relative to the previous years. Volatility is lowest in the recent period 2017 – 2020, which coincides with the highest levels of export. A rough negative relationship between volatility and total export seems to be present.

From Graph. 4, the euro area industrial production trend resembles the Polish total export trend more so than exchange rate volatility to total export. Until the 2008 recession, both industrial production and total export are increasing at a very similar rate. After 2008, both indicators dip in 2009 and 2013 and slowly recover from 2013 to 2017. Euro area industrial production does not display the same short-term swings as Polish total export. There seems to exist a strong positive relation between industrial production in the euro area and total Polish export in the long term.

Lastly, from the Graph. 5, we see that the prices ratio has been on a clear downturn over the last 20 years, which is now platooning at around 1.1. As stated in the data section, the price ratio exhibits the relative average export price to the average import price. Thus, in the year 2019, Polish exports were roughly as expensive as Polish imports. However, the average Polish export was more expensive than the average Polish import. This is a puzzling phenomenon as Poland was not a developed country in the early 2000th. This requires a further investigation outside of this study. Based on the data applied to calculate the prices ratio, it looks like there is a negative relation between the price ratio and the total export. It would indicate that the relative improvement of the price competitiveness has been contributing to increase in the rate of growth of total monthly export.

5. Results

5.1 EURO-PLN Volatility Impact on Export of 8 Industries

The relevant regression results are presented from Table. 6 to Table. 14 in the Appendix. In 5 out of 8 industries, the coefficients of the regression are negative, indicating that higher volatility is matched with lower levels of export growth. This is in line with the theoretical implications in Clark (1973), who theorizes that volatility should negatively affect export. None of the coefficients are very large; the lowest coefficient is -0.22, while the greatest is 0.24. These industry volatility coefficients (i.e the impact on exchange rate) are lower in absolute value than the coefficients of both prices and industrial production.

For the total export regression, there is a small negative relation of -0.08, which means that ceteris paribus an increase in volatility of 1 percent leads to a 0.08% decrease in rate of growth of total export revenue. For all the volatility coefficients, including the total export level, the coefficients are not statistically significant at the 10% level. This gives us enough information to evaluate hypothesis one:

The volatility of the PLN/EUR nominal exchange rate has had no material impact on the aggregated and disaggregated industry export values of the Polish industries trading with the Euro area.

We cannot reject Hypothesis 1 as there is no indication of a statistically significant relationship between volatility and exports. The results of this study are in line with the results of study conducted by Goczek and Mycielska (2017), A rough negative relationship is spotted on an aggregate export level, but with a relationship that is not robust and with a relationship that is weaker compared to other economic factors.

5.2 Industrial Production Impact on 8 Industries

As shown in the regression results presented in Table. 6 to Table. 14, for industrial production, 3 lags of the variables were taken into account. In terms of total export, all differenced economic mass and 3 lags of differenced economic mass were significant at the 10% level. Differenced economic mass had a very high coefficient of 1.2, while the lags were not this large but still larger than the coefficients of volatility. This means that when economic mass growth increases by 1%, export growth should increase by 1.2%. There is a statistically significant positive relationship between economic mass and the level of export by Poland to the Euro area. There is also a statistically significant relation between all the three lagged terms of economic mass and export. However, these results are not the same for disaggregated data.

For all categories, except “Food and Live Animals” (Group 0), “Beverages and Tobacco” (Group 1), and “Crude Materials, inedible, except fuels (Group 2)”, the industrial production coefficients are statistically significant. Outside Group 2, at least one lagged term or differenced economic mass is statistically significant. In general, the further the lag of industrial production is the smaller the impact on export. Also, the size of the coefficient of differenced economic mass is around 2 for the majority of the industries. Although differenced Economic Mass is not always statistically significant, the variable is never negative, indicating that all industries seem to be affected by the large macroeconomic phenomenon. Hypothesis two states that:

Changes in the Euro area GDP have had a much bigger impact on the export levels of the studied industries than exchange rate volatility

This hypothesis cannot be rejected as clearly economic mass has a positive relation to export that is more robust and greater in magnitude than the relation between volatility and export. This result also corroborates the findings from the IMF study by Clark et al., (2004).

5.3 Most Affected Industries by Volatility

Below, in Table.2, I have attached a ranking of the most affected industries by volatility.

Table.2 – Susceptibility ranking of industries from all conducted regressions

Rank	Industry	Volatility coefficient
1	Manufactured goods	-0.22
2	Animal and vegetable oils, fats and waxes	-0.09
3	Mineral fuels, lubricants and related materials	-0.07
4	Crude materials, inedible, except fuels	-0.04
5	Food and live animals	-0.04
6	Commodities and transactions not classified elsewhere.	0.01
7	Chemicals and related products	0.23
8	Beverages and tobacco	0.24

The two most affected industries are “Manufactured Goods” and “Beverages and Tobacco”. Only 3 industries have a positive relationship with volatility. Three industries have a relation that is very close to 0: “Crude materials, inedible, except fuels”, “Food and Live animals”, and “Commodities and transactions not classified elsewhere”. This ranking is sufficient to answer hypothesis number three:

The sensitivity of the export of manufacturing industries to exchange rate volatility has been lower than the sensitivity of exports of commodity-linked industries.

We can reject this hypothesis as 6 other industries are less sensitive to volatility. Moreover, the total export value volatility sensitivity is -0.08, meaning that manufactured goods are more sensitive than the average export from Poland.

5.4 Prices Ratio Impact on Export

Like with industrial production, 3 lags of the calculated differenced price ratio were taken. For the total export regression, the price ratio, and its first, third lags are statistically significant at the 1% level. As shown in the regression Table. 14, Prices ratio has a very low negative impact on export of only -0.21, meaning that if the polish goods price growth increases by 1%, this would ceteris paribus lead to a decrease in the rate of growth of export by 0.21%. Such a result is consistent with a similar analysis conducted by Goczek and Mycielska (2017), where a cheaper export good is more sought after. Surprisingly, the first lag of price had a positive impact on export, meaning that if Polish prices grew a lot last month, this should lead to a slower growth rate in exports this month. However, these results are not the same for disaggregated data.

According to the regression results in Table. 6 to Table.14, in the case of Food and Live animals (Group 0) Crude materials, inedible, except fuels (Group 2), and Commodities and transaction costs (Group 7), the differenced prices ratio has a positive impact on export level. Both Crude materials (Group 7) and Commodities (Group 2) have a robust relation, while Food and Live animals is not statistically significant. For all other groups, an increase in the price variables seems to have a negative impact on export. Although there isn't a clear pattern for the lagged terms, it seems that in the majority of the cases at least one lag is significant at the 10% level. This intuitively makes sense as exporters may plan their trade ahead of time, and thus past prices may influence current trade.

5.5 Export Correlated with Past Lagged Terms

Starting with total export for Poland, all the lagged terms of export are statistically significant in explaining current export at the 1% level. Moreover, all lagged terms are negative, indicating that an increase in export growth last month should be matched by a decrease in export growth this month. This is consistent with the constant deviations around a trend that takes place for export, as seen in export graphs in section 4.6. For disaggregated data, an identical trend can be seen, where the first lag is always negative and statistically significant. The 2nd and 3rd lag are always negative, but not always statistically significant.

6. Conclusion

In this paper, I investigated the relationship between the volatility of the PLN/EURO exchange rate and the export levels to the Euro area of 8 Polish industries. This relationship was examined by incorporating volatility as part of the augmented Gravity Trade model. The gravity model, which is transformed into a linear regression, has economic mass, price ratio, and volatility as the main determinants of export.

The main results of this academic paper are the following. The first hypothesis that volatility does not influence export is not rejected. Neither for disaggregated data nor for aggregated data is volatility statistically significant in the regressions, although volatility for the aggregated database has a negative coefficient. Moreover, the coefficient that marks the relation between volatility and export is relatively low compared to the coefficients of other variables. Other variables, such as price, economic mass, or past lagged terms of export are far better predictors of export than volatility. In light of this, hypothesis two is not rejected. Economic mass changes positively influence the change in export and economic mass is statically significant both for aggregated and disaggregated data. As the economic mass coefficients are the largest, this economic mass-volatility relation is the strongest from all the independent variables. These results reinforce the economic idea explained by Jan Tinbergen (1962) in his gravity model that foreign economic mass is central to the demand for country home's export. Moreover, past lags of economic mass are also statistically significant. This implies that importers and exporters may plan their trade arrangements with a few months in advance, which is also supported by the fact that lagged price ratios are also statistically significant for the aggregated data and a few disaggregated cases.

Hypothesis three is rejected as the manufacturing sector does not seem to be less susceptible to volatility. Other industries showed lesser susceptibility with lower coefficients. Since all coefficients were also not statistically significant, a differentiation as to which industries are affected most by volatility cannot be sufficiently proved.

Therefore, in short, this paper does not uncover a robust relationship between PLN/EURO volatility and Polish export to the Eurozone from eight individual industries. Other variables, such as economic mass and price ratio are better in explaining trade patterns for Polish industries exporting to the euro area. Therefore, based on the evidence from my research, exchange rate volatility does not seem to be a strong argument in favor of the adoption of the Euro in Poland.

6.1 Limitations & Further Research

This study only applies only one measure of volatility: the moving average of the standard deviation. Although this is the most widely used tool in empirical papers looking at volatility, another popular alternative is to employ the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model to generate volatility figures based on exchange rates (McKenzie, 1999). By examining the same dataset with one more perspective on volatility, results could be further verified with a different technique.

Since this study is based on an augmented version of the gravity model, only a few independent variables were examined. It could be the case that other important economic factors not considered by augmented gravity models determine trade and are correlated with volatility, such as business confidence. Moreover, in the study, I examine the disaggregate industry-specific trade data always from the same perspective. The same independent variables (i.e economic mass, price ratios, and volatility) are examined for all industries. However, an industry, such as Food and Live Animals faces different economic conditions and regulatory frameworks than Machinery and Transport Equipment. Similarly, it may be the case that an industry, such as Machinery and Transport Equipment experiences time-specific economic shocks that only apply to this industry. For instance, a drop in the demand for diesel cars in the euro area may influence the export level of Machinery and Transport Equipment without influencing the volatility. Thus, to improve the time series analysis, specific for each industry variables could be constructed for each of the 10 SITC industries to account for unique time-varying industry shocks.

7. Appendix

7.1 Industry Composition

Industry breakdown used by the SITC - Standard international trade classification

1. Food and live animals
2. Beverages and tobacco
3. Crude materials, inedible, except fuels
4. Mineral fuels, lubricants and related materials
5. Animal and vegetable oils, fats and waxes
6. Chemicals and related products
7. Manufactured goods classified chiefly by material
8. Machinery and transport equipment
9. Miscellaneous manufactured articles
10. Commodities and transactions not classified elsewhere

Industry breakdown used in this study:

1 Food and live animals

2 Beverages and tobacco

3 Crude materials, inedible, except fuels

4 Mineral fuels, lubricants and related materials

5 Animal and vegetable oils, fats and waxes

6 Chemicals and related products

7 Manufactured goods

8 Commodities and transactions not classified elsewhere.

7.2 Tables and Regression Results

Table.4 - Dickey-Fuller tests for stationarity

Variable	Test statistic	P-value
Export Group 0	-1.26	0.65
Export Group 1	-2.44	0.13
Export Group 2	-2.10	0.24
Export Group 3	-2.39	0.15
Export Group 4	-2.81**	0.06
Export Group 5	-2.22	0.20
Export Group 6	-2.16	0.22
Export Group 7	-2.81	0.06
Total Export	-2.00	0.29
Prices ratio Group 0	-3.45**	0.01
Prices ratio Group 1	-6.76***	0.00
Prices ratio Group 2	-5.72***	0.00
Prices ratio Group 3	-3.80***	0.00
Prices ratio Group 4	-7.10***	0.00
Prices ratio Group 5	-2.63*	0.09
Prices ratio Group 6	-4.95***	0.00
Prices ratio Group 7	-7.36***	0.00
Prices ratio Total Export	-2.68**	0.08
Industrial Output	-2.02	0.28
Differenced Export Group 0	-22.47***	0.00
Differenced Export Group 1	-19.90***	0.00
Differenced Export Group 2	-19.49***	0.00
Differenced Export Group 3	-20.31***	0.00
Differenced Export Group 4	-23.22***	0.00
Differenced Export Group 5	-21.10***	0.00
Differenced Export Group 6	-20.12***	0.00
Differenced Export Group 7	-22.59***	0.00
Differenced Total Export	-20.33***	0.00
Differenced Volatility	-16.85***	0.00

Table. 5- Monthly lag determination using AIC and SBIC

Lags	AIC	SBIC
0	-14.47	-14.40
1	-19.33	-19.02
2	-19.75	-19.20
3*	-20.18*	-19.38*
4	-20.13	-19.09

Note: the asterisk marks the optimal lag length according to AIC and SBIC.

Table. 6 - Regression for Difference Group 0 Export

Variable	Coefficient
Volatility	-0.04
Δ Economic Mass	0.41
Δ Prices ratio for Group 0	0.02
1st Lag of Δ Group 0 export	-0.04
2nd Lag of Δ Group 0 export	0.78
3rd Lag of Δ Group 0 export	1.4
1st Lag of Δ Economic Mass	-0.46***
2nd Lag of Δ Economic Mass	-0.12
3rd Lag of Δ Economic Mass	0.03
1st Lag of Δ Prices ratio	0.07*
2nd Lag of Δ Prices ratio	0.1***
3rd Lag of Δ Prices ratio	-0.17
Constant	0.01

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 7- Regression for Difference Group 1 Export

Variable	Coefficient
Volatility	0.24
Δ Economic Mass	2.22
Prices ratio for Group 1	-0.05
1st Lag of Δ Group 1 export	-0.33***
2nd Lag of Δ Group 1 export	-0.28***
3rd Lag of Δ Group 1 export	-0.33***
1st Lag of Δ Economic Mass	0.62
2nd Lag of Δ Economic Mass	0.15
3rd Lag of Δ Economic Mass	0.39
1st Lag of Δ Prices ratio	-0.06
2nd Lag of Δ Prices ratio	-0.04
3rd Lag of Δ Prices ratio	-0.029
Constant	0.01

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 8- Regression for Difference Group 2 Export

Variable	Coefficient
Volatility	-0.04
Δ Economic Mass	2.2***
Prices ratio for Group 2	0.1***
1st Lag of Δ Group 2 export	-0.41***
2nd Lag of Δ Group 2 export	-0.21***
3rd Lag of Δ Group 2 export	-0.26***
1st Lag of Δ Economic Mass	1.38***
2nd Lag of Δ Economic Mass	1.55***
3rd Lag of Δ Economic Mass	1.00
1st Lag of Δ Prices ratio	0.06*
2nd Lag of Δ Prices ratio	-0.06*
3rd Lag of Δ Prices ratio	-0.09*
Constant	0.01

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 9- Regression for Difference Group 3 Export

Variable	Coefficient
Volatility	-0.07
Δ Economic Mass	2.16
Prices ratio for Group 3	-0.09
1st Lag of Δ Group 3 export	-0.28***
2nd Lag of Δ Group 3 export	-0.03
3rd Lag of Δ Group 3 export	-0.18***
1st Lag of Δ Economic Mass	-.2***
2nd Lag of Δ Economic Mass	0.03
3rd Lag of Δ Economic Mass	-0.18***
1st Lag of Δ Prices ratio	0.29***
2nd Lag of Δ Prices ratio	-0.09
3rd Lag of Δ Prices ratio	-0.11
Constant	0

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 10- Regression for Difference Group 4 Export

Variable	Coefficient
Volatility	-0.09
Δ Economic Mass	1.94**
Δ Prices ratio for Group 4	-0.01
1st Lag of Δ Group 4 export	-0.44***
2nd Lag of Δ Group 4 export	-0.27***
3rd Lag of Δ Group 4 export	-0.15**
1st Lag of Δ Economic Mass	1.16
2nd Lag of Δ Economic Mass	0.29
3rd Lag of Δ Economic Mass	1.54
1st Lag of Δ Prices ratio	-0.05
2nd Lag of Δ Prices ratio	0.03
3rd Lag of Δ Prices ratio	-0.02
Constant	0.01

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 11- Regression for Difference Group 5 Export

Variable	Coefficient
Volatility	0.23
Δ Economic Mass	1.68***
Δ Prices ratio for Group 5	-0.06
1st Lag of Δ Group 5 export	-0.51***
2nd Lag of Δ Group 5 export	-0.45***
3rd Lag of Δ Group 5 export	-0.33***
1st Lag of Δ Economic Mass	1.22*
2nd Lag of Δ Economic Mass	1.02
3rd Lag of Δ Economic Mass	0.92
1st Lag of Δ Prices ratio	-0.1***
2nd Lag of Δ Prices ratio	013
3rd Lag of Δ Prices ratio	0.04
Constant	0.01

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 12 - Regression for Difference Group 6 Export

Variable	Coefficient
Volatility	-0.22
Δ Economic Mass	2.16***
Δ Prices ratio for Group 6	-0.07
1st Lag of Δ Group 6 export	-0.51***
2nd Lag of Δ Group 6 export	-0.49***
3rd Lag of Δ Group 6 export	-0.54***
1st Lag of Δ Economic Mass	1.18**
2nd Lag of Δ Economic Mass	1.03*
3rd Lag of Δ Economic Mass	1.31**
1st Lag of Δ Prices ratio	-0.02
2nd Lag of Δ Prices ratio	-0.01
3rd Lag of Δ Prices ratio	-0.01
Constant	0.02

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 13- Regression for Difference Group 7 Export

Variable	Coefficient
Volatility	0.01
Δ Economic Mass	3.12**
Δ Prices ratio for Group 7	0.06**
1st Lag of Δ Group 7export	-0.41***
2nd Lag of Δ Group 7 export	-0.15*
3rd Lag of Δ Group 7 export	-0.03
1st Lag of Δ Economic Mass	-0.46
2nd Lag of Δ Economic Mass	1.19
3rd Lag of Δ Economic Mass	0.14
1st Lag of Δ Prices ratio	-0.05**
2nd Lag of Δ Prices ratio	0.06**
3rd Lag of Δ Prices ratio	-0.04*
Constant	0.01

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

Table. 14- Regression for Difference Group Export

Variable	Coefficient
Volatility	-0.08
Δ Economic Mass	2.13***
Δ Prices ratio for Total Export	-0.21***
1st Lag of Δ Total export	-0.54***
2nd Lag of Δ Total export	-0.44***
3rd Lag of Δ Total export	-0.5***
1st Lag of Δ Economic Mass	1.2**
2nd Lag of Δ Economic Mass	0.88*
3rd Lag of Δ Economic Mass	1.34**
1st Lag of Δ Prices ratio	0.07
2nd Lag of Δ Prices ratio	0.16**
3rd Lag of Δ Prices ratio	0.00
Constant	0.02

Note: *** represents statistical significance of 1%, ** represents statistical significance of 5%, and * represents statistical significance of 10%.

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