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Abstract

The paper investigates potential effects of euroization on the economy of Poland. It develops an empirical framework to provide estimations of the euro adoption costs arising from a loss of exchange rate regime as a macro-stabilization tool. The paper quantifies how a replacement of zloty with the euro, and thus the elimination of exchange rate would affect output fluctuations in Poland. Our analysis of the forecast error variance decomposition confirms that the real exchange rate served as an external shock absorber for Polish economy in 1990-2014. We find that external shocks on average explain up to 12-13% of the exchange rate variation and up to 5% in variation of Polish log-transformed output. We also find that over the past two decades the Poland's economy has become more resilient to external shocks, and thus it is reasonable to expect the cost of euro adoption to decline with further EU integration.

Keywords: euro adoption, real exchange rate, Poland

JEL classification: F31, F33, F41, F43, F47

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1. INTRODUCTION

Following the entry of the first wave of transition economies into the European Union (EU), questions about the post-accession monetary and exchange rate framework have moved center stage. The eastern enlargement of the EU heralded the enlargement of the European Monetary Union (EMU). Within a few years, the EMU could potentially grow to a size of 22 member states. Poland, a member of the EU since 2004 and our economy of focus, currently pursues an independent monetary policy. The government of Poland declared an objective to comply with the euro adoption criteria by 2015. At the same time, the Eurozone's debt crisis and the Greece recent threats to default caused Poles' interest to euro adoption to cool down, with nearly half of the population opposing to entry. The question remains a subject of a fierce political debate in the country.

Euro adoption will require an approval of at least two thirds of the Sejm (the Polish parliament) to make a constitutional amendment changing the official currency from zloty to euro. The opposition coalition leaded by the Law and Justice Party is against euro adoption, and the governing parties do not have enough seats in the Sejm to make this constitutional amendment. The former Prime Minister of Poland Donald Tusk proposed a referendum, yet according to polls, public support is against such participation. The former President Bronislaw Komorowski, Finance Minister Mateusz Szczurek and the Governor of National Bank of Poland (NBP) Marek Belka suggested to discuss euro entry after a parliamentary election scheduled to take place in October 2015.The appetite for potential accession to the euro zone appeared to be a reaction to Russia's annexation of Crimea in March 2014 and the territorial conflict of Poland's

eastern neighbor Ukraine. They see membership in the euro zone as an additional form of security, and the mechanism for Poland to strengthen its position in Europe[1].

In addressing the question whether a certain Central European country should officially euroize, we strongly believe it is important to correctly evaluate all the economic benefits and costs of *de jure* euro adoption as the sole legal tender, prior to committing to any political decision. From the economic perspectives, advocates of euroization suggest that adopting a strong foreign currency enables countries to facilitate financial integration, boost trade, and perform better in the domestic credit market by decreasing long-term real interest rates. Euroization eliminates inflationary pressure and thereby helps the currency and balance of payments, reduces the level and volatility of interest rates, and ultimately stimulates growth (Rose, 2000). In contrast, opponents of euroization cite problems associated with giving up a national currency. Schmitt-Grohe and Uribe (2001) identify three sources of cost related to euroization: loss of seignorage revenues, disappearance of a lender of last resort[2], and relinquished ability to conduct cyclical monetary policy. In addition, the one-time cost of currency changeover and rounding up prices might be high[3].

Our paper will focus on the cost of giving up a flexible exchange rate regime as a macroeconomic stabilization tool. In economies with nominal frictions, monetary policy can play an important role in stabilizing business cycles. To the extent that shocks affecting the euroized economy might be different from those affecting other Eurozone countries, with a probability of asymmetric shocks as well as heterogeneity rising, adoption of euro comes at the cost of higher

[1] Slowikowska and Sobczak (2014)

[2] However, as pointed by Calvo and Reinhart (2002), domestic banks can have access to liquidity through a variety of sources other than a printing press of the central bank. Therefore, euroization will not necessarily imply the loss of a lender of last resort, but a disappearance of one particular source of liquidity – central bank credit. Under euroization, the government loses its ability to inject liquidity into financial system through money creation during a banking crisis.

[3] For a complete overview of costs and benefits of euro adoption see Kierzenkowski (2010).

macroeconomic instability. Poland's economy remained relatively stable and continued to grow throughout the recent EU economic devastation, wrought by the debt crises and problems in Greece, Ireland, Spain and Portugal. Does it make sense for a country to speed up the euro adoption at the probable contagion of macroeconomic instability?

Based on a vast body of evidence, we focus on two external shocks as principal sources of aggregate uncertainty in Poland: world interest rate and terms-of-trade. In addition to domestic rigidities, the estimated stochastic processes of these variables will serve proxy for the driving forces of business cycles in our model of the Polish economy in 1990-2014. After testing the co-movements between key macroeconomic series, such as output, real exchange rate, terms of trade, and world interest rates in Poland over the period of 1990-2014, we argue that our model is highly efficient framework for evaluating the cost of euroization that arises from a loss of stabilization mechanism. To gauge the relative importance of the shocks in the observed business-cycle fluctuations, we perform a variance decomposition analysis of the Polish real output and exchange rates series. We show that external shocks play an important role in a small open economy's output and exchange rate fluctuations both in economic and statistical sense. Namely, we demonstrate that 12-13% of the forecasting error variance of exchange rate and up to 5% of the forecasting error variance of Poland's output is explained by these external shocks. From the review of economic literature, it is our understanding that our approach to variance decomposition of output series explained by internal and external shocks offers the unique alternative pathway in quantifying euro adoption costs. The paper is of high relevance to policymakers not only in Poland, but in the other former centrally-planned Central and East European (CEE) economies that are interested in joining the EMU.

The reminder of the paper is organized as follows. Section 2 presents review of relevant literature. Section 3 provides an overview of the monetary and exchange rate policies in Poland over the past two decades. Next, the theoretical model of a small open economy is introduced in Section 4. It identifies the exogenous shocks that generate aggregate fluctuations in a transition economy and estimates their stochastic processes. Using the log-transformed macroeconomic data over the period of 1990-2014, Section 5 decomposes the Polish output volatility into external and domestic disturbances, and determines and numerically evaluates the ability of real exchange rate to act as a stabilization device. Finally, Section 6 concludes how the elimination of national currency would affect the Poland's economy, discusses policy implications and avenues for future research.

2. LITERATURE REVIEW

The traditional theory of optimum currency area proposed by Mundell (1961) and later expanded by McKinnon (1963) argues that an assessment about the costs and benefits of a monetary union is based on three criteria: asymmetry, flexibility, and openness (or integration). Within the Keynesian framework, assuming sticky prices and wages, Mundell (1961) argues that when entering a monetary union, countries that face large asymmetric shocks find it costly to lose their monetary and exchange rate policies. Mundell's (1961) arguments lead to skepticism about the desirability of forming a monetary union among countries that experience large asymmetric shocks.

With this in mind, what do we know about the empirical evidence on the degree of asymmetry and exchange rate absorption in the CEE countries, and in Poland in particular? Below, we would like to present a short review of literature exploring this question.

Recent empirical literature on business cycles in various emerging market economies emphasizes external shocks as the predominant source of aggregate fluctuations[4]. Unfortunately, only a few studies focus on the external shocks in the CEE economies, while producing contradictory conclusions. Addressing the question whether macroeconomic fluctuations in Central and Eastern Europe are connected with the fluctuations in Western Europe, Fidrmuc and Korhonen (2002) find a strong support to a correlation hypothesis between de-trended aggregate real output in Germany and aggregate output in a number of CEE transition economies. In contrast, analyzing the heterogeneity of national income structures and co-movements of inventory cycles, Buiter and Grafe (2002) find evidence that CEE business cycles are not synchronized with the EU15. Furthermore, Fidrmuc (2004) using the vector autoregression (VAR) framework shows that for the most accession countries the shocks are significantly more idiosyncratic with regard to the EU25 rather than with the EU15, and that labor market rigidities lower the correlation of business cycles between the EU and CEE economies.

In a similar tune, Korhonen (2003) finds that only about 10-12% of the variance in real aggregate output in Poland in 1993-2000 was attributed to innovations in euro area. However, Mackowiak (2006) by decomposing the sources of variation by origin in real aggregate output and aggregate price level in the Czech Republic, Hungary and Poland, finds that in 1992-2004 external shocks accounted for a sizeable fraction (about 52-72%) of the short-run variance of Poland's aggregate price level, and for about 20-30% in variations of real aggregate output.

[4] Exploring the co-movements between real exchange rates and U.S. interest rates in ten Latin American countries in 1988 -1992, Calvo et al (1993) find that around half of the variance in real exchange rates can be explained by variations in U.S. interest rates. Uribe and Yue (2003) estimate that U.S. interest rate shocks explain 20% of movements in aggregate activity in emerging markets in Latin America and Asia. In a study of the Mexican economy, Del Negro and Obiols-Homs (2001) confirm these results by showing that over the period from 1976 to 1994 about 75-85% of shocks to output and prices in Mexico originated in the foreign sector in the form of shocks to the U.S. industrial production, interest rates, and consumer and commodity prices. Mendoza (2002) presents a model-based evaluation of the contribution of terms-of-trade shocks to output variability in developing countries, and concludes that this type of shock accounts for around half of the variance of GDP.

Focusing on the role of exchange rate as an absorber of external shocks, Süppel (2003) finds that during the period of flexible exchange rates in the Czech Republic, Poland, and the Slovak Republic, relative output Granger-caused the movements in real exchange rate. By employing an unrestricted VAR, Süppel (2003) concludes that real exchange rates respond to shocks in relative output and help reduce divergences in the cycle. Dibooglu and Kutan (2001) confirm that in Poland in 1990-1999 nominal shocks contributed significantly to movements in nominal and real exchange rates, while in Hungary the impact of nominal shocks was limited[5]. A key conclusion is that monetary policy has a significant role in influencing the real exchange rate in Poland in contrast to Hungary, where changes in real exchange rate are mostly dominated by real shocks. Creel and Levasseur (2004) extend the Dibooglu and Kutan (2001) framework in several directions and illustrate the following gains and costs of the exchange-rate regime. First, they testify a high degree of flexibility in the CPI. Second, Poland's nominal shocks are found to have a strong effect on the real exchange rate, i.e. the fluctuations in the nominal exchange rate explain a large part of the real exchange rate fluctuations, in contrast to the Czech Republic and Hungary. Third, in Poland, the policy mix seems to be more credible than in the other two countries. Consequently, the authors infer that moving to the European Exchange Rate Mechanism (ERM II) will be of less benefit to Poland compared to Czech Republic and Hungary.

With the similar objective, Borghijs and Kuijs (2004) estimate short-run macroeconomic behavior in response to the shocks identified with a Clarida and Gali (1994)–type structural VAR for five CEE countries - Czech Republic, Poland, Slovakia, Slovenia and Hungary. They show that in 1996-2003 exchange rate responded little to the shocks that affect output, and the

[5] At the short-term forecasting horizons, Dibooglu and Kutan (2001) find that nominal shocks explain 63.1% of real exchange rate forecast error in Poland

(nominal) LM shocks contributed significantly to nominal exchange rate variability, at 58-80% level in the smaller more open CEE countries. Thus, the Borghijs and Kuijs's (2004) cast doubt on the usefulness of the exchange rate in absorbing shocks. Summarizing, the Borghijs and Kuijs (2004) suggest that the cost of losing a flexible exchange rate as a stabilizing tool in the CEE countries is modest, if at all positive. Borowski (2004) also shows that given the degree of economic integration between Poland and the euro area, the potential costs of relinquishing the monetary policy autonomy in Poland are likely to be modest. His tentative assessment suggests that the switch to the euro is expected to raise GDP per capita in Poland by 4–7% in the long run. Borowski (2004) concludes that, on balance, Poland is likely to benefit significantly from the EMU membership. Finally, using a two-country dynamic stochastic general equilibrium model for Poland in 1995-2007, Gradzewicz and Makarski (2013) find that after the euro adoption Polish volatility of domestic output will increase, while the volatility of inflation will decrease. Similar to Borghijs and Kuijs (2004), and Borowski (2004), Gradzewicz and Makarski (2013) expect the welfare cost of this monetary policy change to be small.

Interestingly, but these findings contrast with the Stazka-Gawrysiak (2009) study that employs the structural VAR framework for Poland in 2000-2009. Stazka-Gawrysiak (2009) finds that in the zloty/euro exchange rate has been a shock-absorbing rather than a shock-propagating instrument, and thus, concludes that its irrevocable fixing on the day of euro adoption will, at least in the short term, constitute a sizable cost in terms of output stability. Arratibel and Michaelis (2014) also show that the exchange rate shock has a time-varying effect on Poland's output. Their empirical findings of time-varying VAR approach confirm that from 1996 to 2000, output in Poland declined in response to exchange rate shock, whereas for periods between 2000 and 2008, exchange rate had a positive significant effect.

Addressing these multiple controversies in the literature, we would like to re-visit the empirical study on the aggregate fluctuations, the role of the national currency and exchange rate mechanism, and the costs of euro adoption for Poland. As pointed by Stazka-Gawrysiak (2009), at the first glance, it appears that earlier studies highlight a dominant role of nominal shocks in stochastic exchange rate fluctuations, while more recent studies suggest that in the newly accepted EU members real exchange rate movements to a large extent are driven by real shocks. The latter thus conclude that giving up exchange rate will constitute cost of euro adoption. All the existing studies on Poland draw their conclusions primary from relatively small data sets, with annual or quarterly observations of up to 10-12 years. The data choice and model specifications might partly explain the euro adoption cost controversy in the literature.

Focusing on the cost of joining the Eurozone that arises from asymmetric shocks, and employing a much larger dataset of 1990-2014 quarterly data, we create a theoretical model of the Polish economy and empirically identify the sources of aggregate fluctuations in this country, using the Granger causality rather than Blanchard and Quah (1989) identification. In contrast to Fidrmuc and Korhonen (2002) and Dibooglu and Kutan (2001, 2005), who primary rely on the later identification, we believe our study will produce a more precise estimation of output and real exchange rate volatilities, which are highly relevant for evaluating the cost of euroization.

3. MACRO STABILIZATION POLICIES IN POLAND IN 1990-2014

The stabilization of the Polish economy began under much less favorable conditions than in other CEE countries. In 1989—the year Poland's communist government fell—inflation peaked at nearly 55% per month, while the budget deficit was 8% of GDP. Both loss-making state firms and the government deficit were financed by the rapid expansion of money and credit. Although the government began to deal with the crisis in late 1989, a major stabilization was

introduced only in January 1990 with the implementation of a “shock therapy”, the Balcerowicz Plan. The zloty was devalued from 5,560 to 9,500 per US dollar and pegged at the latter rate. Monetary and fiscal policies tightened, enabling the government to achieve a surplus of 0.4% of GDP by the end of the year. Credit creation at this time was sharply curtailed. The consequences of this first stabilization and liberalization effort in a transition economy were sufficiently virulent, both in the upsurge in prices and in the decline in production. The effects were felt more in an acceleration of inflation rather than in real output growth. Thus, the government soon abandoned the effort.

As the recession deepened in 1991, the fiscal deficit reappeared, while high inflation reduced the competitiveness of Polish exports. The zloty was devalued by 16.8 % again; its peg was changed to a basket of five currencies. With time, Poland’s policy priorities gradually shifted from stabilization to stimulating growth. Although the fiscal deficit was cut from 6.7 % of GDP in 1992 to 3.1 % in 1993, a level Polish government tried to achieve ever since, monetary policy was relatively expansionary. While real interest rates remained positive, money supply and credit growth consistently outpaced targets set by the NBP. The zloty’s peg was abandoned in October 1991, being replaced by a crawl with a pre-announced devaluation of 1.8% per month.

In the early stabilization period, the NBP faced difficulties in conducting monetary policy, when the money market did not exist, and the policy heavily relied on credit ceilings. Open market operations have become the main policy instruments only after 1993. In the post-stabilization period (1991-1994), financing of a fiscal deficit kept the monetary policy relatively lax. The NBP real interest rates were positive, and inflation declined in line with the exchange

rate crawling peg. Over time, the rate of depreciation was reduced, and devaluations and revaluations alternated to accommodate exogenous shocks.

In 1995 an increase in capital inflow to the country driven by growing credibility of economic reforms and an ongoing privatization process became a source of excessive monetary expansion. In order to increase a risk faced by portfolio investors and tame the capital flows, in May 1995 the zloty fluctuation band was widened to ±7%. As anticipated, zloty appreciated after introduction of the new system[6]. Yet, the new regime did not bring any significant changes in volatility, since exchange rate was persistently close to the strong bound of the zone. The capital inflow slowed down only after interest rate cuts and revaluation of the central parity at the end of 1995[7]. In 1996 a fast expansion of credit to non-financial institutions became a main source of money creation. Monetary policy reacted sluggishly to this rapid credit growth. Significant interest rate increases were introduced only in the end of 1996 and in 1997. Policy tightening was facilitated by an increased risk on international financial markets after the Asian crisis in October 1997, giving the NBP more scope for independent monetary policy actions.

In 1998-1999, Poland's output growth has slowed slightly due to a fall in exports to Russia and Ukraine caused by the financial crises in these countries. As inflation slackened and as the nominal anchor of the crawling peg decreased with a further widening of the bands, Poland has adopted inflation targeting as the framework for its monetary policy[8]. In January 1998, the newly established Monetary Policy Council (MPC) set a goal of lowering Polish CPI inflation to 6.8-7.8% in 1999, and to 4% by 2003. The exchange rate band was widened to ±10%

[6] In 1995 Poland's exchange rate policy became sufficiently credible to foreign investors, so that in 1995 short-term capital inflows turned to be a problem for the NBP. Even with some NBP sterilization, capital inflows accounted for 59% of the growth of the money supply.

[7] The revaluation, however, did not increase the exchange rate volatility because the NBP conducted a policy of keeping average deviations of the exchange rate from parity within ±2.5 % zone.

[8] For detailed discussion on Poland's convergence of monetary policy with ECB see Brada and Kutan (2001)

in February and to ±12.5 % in October 1998. In April 2000, zloty finally started to float. Throughout 1998 the reference rate was reduced from 24% to 15.5%. This sharp reduction was a response to economic slowdown, declining inflation, and a large portfolio of capital inflows. Central bank interest rates remained at a stable level for the first half of 1999. However, a higher inflation rate - overshooting the target in 1999 - prompted monetary authorities to reverse the cuts starting from the second half of 1999. In 2000 interest rates were further increased. The cautious period of interest rate cuts started only at the beginning of 2001, when inflation was declining and economic activity plunged into recession. Despite the relaxation of monetary policy, inflation remained below the target up to 2002.

Since 2004, Poland has aimed for a continuous inflation target of 2.5%, ±1%. The setting of the reference rate by the NBP reflected a consistent approach to facilitating growth rather than manipulating the zloty. Unfortunately, for the majority of 2003-2004 the inflation remained at 5.25%. In the second half of 2004, it quickly climbed to 6.5% before falling to 4% in 2006.

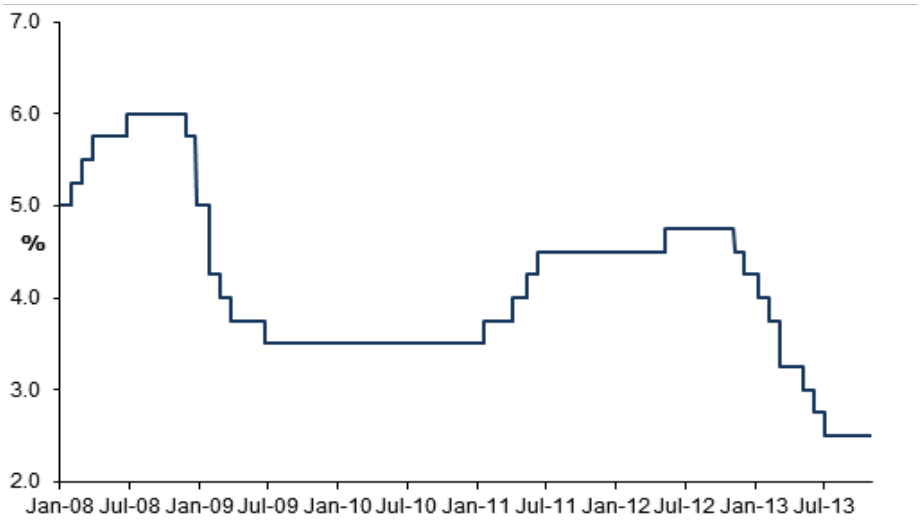
Starting in 2008 with the bankruptcy of Lehman Brothers, the global economy quickly plunged into recession. The EU was hit especially hard, but Poland managed to avoid the worst of it. In 2009-2012, Poland managed to weather the global crisis with some of the highest growth rates in Europe when most of its neighbors in the region faced drastic macroeconomic problems. In 2009, it reported the 1.8% growth; in 2010, it grew by a solid 3.9%, and in 2011 – by outstanding 4.5% despite a substantial decline in public spending. This growth was supported by high domestic demand, and liquid and well-capitalized banking system. Refer to Figure 1 for the dynamics of Poland GDP in 1995-2014.

Figure 1. Poland GDP annual growth rate, 1995-2014.

In addition to growth of real wages, employment, and investment, credit expanded at a healthy pace. While the financial crisis of autumn 2008 and the resulting EU recession were reflected by the initial climb in interest rates to 6%, the subsequent methodical loosening of the NBP monetary policy—the "quantitative easing" portion of Poland's attempt to cushion its economy and stimulate growth—brought the rate to 3.5%. Figure 2 depicts how the NBP manipulated the reference rate to stabilize the economy after the crises. Since July 2009, the NBP had continued to keep the reference rate solidly at 3.5% for 18 months. According to the International Monetary Fund (IMF) Report (2012), Poland's strength and stability at the beginning of the crisis and the rapid implementation of counter-cyclical and automatic stabilizer policies were major factors in its ability to be one of the best performing countries in the EU. The IMF's flexible credit line of $20.6 billion played a large role by keeping Poland's flexibility and capital market access intact. Government policies of fiscal consolidation reduced the budget deficit to 2% of GDP – well below the Maastricht criterion. The debt, even though, at close to 55% of GDP, did not give rise to concerns. The prompt and well-designed NBP policy actions

after the crisis encouraged spending and investment, and assured stable growth of GDP in Poland.[9]

Figure 2. The NBP Reference Rate (%) After the Global Financial Crisis



Source: National Bank of Poland

In 2011, Poland's growth was driven by capital investments, FDI and primarily exports. However, Poland's extremely consolidated export situation became the cause for concern: with over 60% of exports going to the euro area and over a quarter to Germany alone, further instability in the EU continued to affect Poland. By 2012, the current account deficit and terms of trade shifted to a steady downward path, while the core inflation continued to grow close to 4% (well above the target), leading to the new central bank intervention. The NBP increased the interest rate to 4.5%, and later in early 2012 to 4.75%. In response, the banks tightened their conditions for lending. The real GDP growth moderated to 1.9% in 2012, as both external and domestic demand weakened. In response to lower energy prices, in November 2012 the NBP announced a loosening cycle of its monetary policy, joining the main central banks, who

[9] Velculescu (2009)

maintained interest rates at the historically low levels[10]. In 2013, the monetary policy was conducted against the backdrop of low, but gradually accelerating global economic growth. The NBP pursued its monetary policy amidst liquidity surplus prevailing in the Polish banking sector. The main open market operations were executed on a regular basis once a week, with the POLONIA (Polish overnight) rate running at 0.9 of the NBP reference rate. As seen on Figure 2, the NBP reference rate was slowly reduced from 4.75% to 2.5% in the end of 2013, while in October 2014 it ended up at the historically low level of 2%.

After such a profound use of monetary and exchange rate policies as stabilization tools in Poland in 1991-2014, how costly would it be for Poland to give them up for the sake of euro adoption?

4. THE MODEL

Our theoretical framework is a modified version of Schmitt-Grohe and Uribe (2001) model, which in turn is an extension of an earlier work of Calvo (1983). In particular, we assume a small open economy with endogenous labor supply and capital accumulation. The economy is allowed to produce exportable and non-tradable goods, and to absorb exportables, importables, and non-tradables. We initiate the following two modifications to the Schmitt-Grohe and Uribe's (2001) framework: 1) we include interest rates and money holdings into the model; 2) we assume perfect capital mobility. In addition to domestic rigidities, business cycles in our economy are driven by exogenous, stochastic changes in the terms of trade, the world interest rate, and foreign inflation (import-price inflation).

Similar to Schmitt-Grohe and Uribe (2001) framework, room for cyclical monetary policy in our model arises from two sources. Firstly, product prices in the non-traded sector are assumed to be sticky. Secondly, demand for money originates from the assumption that real

[10] NBP (2012)

balances facilitate transactions in final goods. In our framework, these sources of nominal rigidities create a tension for stabilization policy. On one hand, the presence of sticky prices in the non-traded sector calls for policies that stabilize the non-traded component of the CPI. On the other hand, the fact that via transaction costs money acts as a tax on aggregate spending creates an incentive for the central bank to stabilize the opportunity cost of holding money, that is, the domestic nominal interest rate. A floating exchange rate regime, contrary to euroization, gives the central bank considerable autonomy in setting its interest rates focusing on domestic economic conditions. The policy of the central bank can be oriented towards smoothing business cycle fluctuations, particularly when the economy is hit by external shocks. That is why, when assessing the cost of Poland's adopting euro, it is important to analyze the vulnerability of the economy not only to internal shocks affecting the real sector but also to external shocks.

In this paper we quantify how much of the macroeconomic variation in Poland - a small open economy - originates abroad. So far, there has been mixing evidence on this issue for the CEE economies, primary sensitive to model specifications and data selection[11]. In this paper we take a step towards filling the gap by decomposing the variation in real aggregate output and real exchange rate caused by external and domestic shocks in Poland looking at a large set of quarterly data of 1990-2014. Our goal is to quantify the percentage of variation in real aggregate output and real exchange rate in Poland that originates abroad. To measure external shocks, we use the terms of trade and the world interest rate (proxied by a 3-month U.S. Treasury bill). The empirical model is a recursive VAR.

Consider a macroeconomic variable *y(t)* in a small open economy. Our objective is to decompose the sources of the variation in *y(t)* into domestic and external. A structural model in a linear, stochastic, dynamic form is:

[11] For a detailed description and controversies, refer to the literature review

$$\sum_{s=0}^{p} A(s)y(t-s) = \varepsilon(t),\ \text{t = 1, .., T,} \qquad (1)$$

where *y(t)* and *ε(t)* are *(M × 1)* each, *A(s)* matrices are (M × M), A (0) is non-singular, and ε(t) is Gaussian with zero mean and $\mathrm{E}[\varepsilon(\mathrm{t})\varepsilon(\mathrm{t})' \,|\, \mathrm{y(t-s)}, \mathrm{s} > 0] = I_M$. ε(t) is the vector of structural disturbances, and represents changes in technology, consumer preferences, and/or policy. Multiplying (1) by the inverse of A(0) yields a reduced-form VAR model:

$$y(t) = \sum_{s=1}^{p} B(s)y(t-s) + v(t), \qquad (2)$$

with $B(s)$ of size (M × M), and $v(t)$ an (M × 1) Gaussian vector with zero mean and $E[v(t)v(t)' \,|\, y(t\text{-}s), s > 0] = \Omega = A^{-1}(0)[A^{-1}(0)]'$. We follow Mackowiak (2006) and partition the model (1) into a domestic and an external block, with m_1 "external" variables ($y_1(t)$ vector) and m_2 "domestic" variables ($y_2(t)$ vector), and $m_1 + m_2 = M$:

$$y(t) = \begin{bmatrix} y_1(t) \\ y_2(t) \end{bmatrix}, \qquad \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix}, \qquad A(s) = \begin{bmatrix} A_{11}(s) & A_{12}(s) \\ A_{21}(s) & A_{22}(s) \end{bmatrix}$$

for all s = 0, 1, ..., p, with $y_i(t)$ and $\varepsilon_i(t)$ each of dimension $(m_1 \times 1)$, $(m_2 \times 1)$, and $A_{ij}(s)$ of dimension $(m_i \times m_j)$, i = 1, 2 and j = 1, 2. The small open economy restriction A_{12}(s) = 0, for all s = 0, 1, ..., p makes the $y_1(t)$ vector block exogenous. External variables are generated by a linear combination of external disturbances only, while domestic variables are subject to both domestic and external shocks. The partitioned into a domestic and an external block reduced – form VAR (2) is:

$$\begin{aligned} y_1(t) &= \sum_{s=1}^{p} B_1(s)y(t-s) + v_1(t), \\ y_2(t) &= \sum_{s=1}^{p} B_2(s)y(t-s) + v_2(t), \end{aligned} \qquad (3)$$

with $B_1(s) = [B_{11}(s) \quad B_{12}(s)]$, $B_2(s) = [B_{21}(s) \quad B_{22}(s)]$, $B_{ij}(s)$ of size $(m_i \times m_j)$, i=1,2, and j =1,2. Ω is also partitioned into four Ω_{ij}'s. The block-exogeneity restriction $B_{12}(s)$ = 0 for s=1,..., p implies that the external vector $y_1(t)$ is Granger causal prior (GCP) with respect to the domestic vector $y_2(t)$, and the local fluctuations in the small economy do not predict fluctuations in external variables[12].

The vector of external variables $y_1(t)$ in our model contains two variables – the terms of trade p_t^x and the world interest rate r_t. The vector of domestic variables $y_2(t)$ includes a measure of real aggregate output y_t and a real exchange rate e_t. These identification assumptions give rise to the following block recursive structure of the empirical model:

$$\begin{bmatrix} \alpha_{11} & 0_{2x2} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} p_t^x \\ r_t \\ y_t \\ e_t \end{bmatrix} = \begin{bmatrix} b_{11}(L) & 0_{2x2} \\ b_{21}(L) & b_{22}(L) \end{bmatrix} \begin{bmatrix} p_{t-1}^x \\ r_{t-1} \\ y_{t-1} \\ e_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^{p^x} \\ \varepsilon_t^r \\ \varepsilon_t^y \\ \varepsilon_t^e \end{bmatrix} \qquad (4)$$

where α_{11} and α_{22} are lower triangular matrices whose diagonal elements are equal to 1. The disturbance vector ($\varepsilon_t^{p^x}$, ε_t^r, ε_t^y, ε_t^e) has a mean of zero and a variance/covariance matrix Σ. The external block of the VAR system is formed by the first two equations in (4) and it serves as the driving force of aggregate fluctuations in the theoretical model. After estimating (4), we decompose the sources of variation in $y_2(t)$ in Poland. The above matrix $\begin{bmatrix} \alpha_{11} & 0_{2x2} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}$ implies the following contemporaneous causal ordering of the variables. For the external variables, causality runs from terms of trade to the world interest rate, reflected in the lower triangular

[12] Mackowiak (2006) accepted the GCP hypothesis for economy of Poland in 1992-2004.

matrix a_{11}. We put the terms of trade before the world interest rate (proxied by the U.S. T-bill rate) to allow for the world largest trading nation's – the US - monetary policy to adjust to terms of trade changes. Putting the world interest rates second in the causal ordering of the external variables also implies that terms of trade do not react to the U.S. monetary policy contemporaneously. With respect to domestic variables, we reflect fundamentals of a small open economy and assume that the external variables are casually prior to them, which was confirmed by Mackowiak (2006). The source of this is the null matrix a_{12} in our model. In addition, within the domestic variables, we assume that the contemporaneous direction of causation goes from the domestic output to real exchange rate which translates into a lower triangular matrix a_{22} [13]. Furthermore, our exchange rate position is consistent with the uncovered interest rate parity, stating that interest rate differentials account for expected changes in the exchange rate.

5. EMPIRICAL ESTIMATIONS

Our sample consists of quarterly observations from 1990:Q1 to 2014:Q4. We define the terms of trade as the ratio of export price index to import price index in Poland. The world interest rate in our study is a maturity yield on a 3-month U.S. Treasury bill. The output of Poland is measured by the real GDP, in prices of 2000. The real exchange rate is measured as the nominal exchange rate adjusted by the ratio of a Eurozone CPI index to a corresponding Polish price index. Detailed information on original data series and their sources is reported in Table 1.

Table 1. Description of Data

Data Series	Description	Data Source
Export Price Index	Price index of exports of goods and services in Poland, base year 2000, euro based	Quarterly National Accounts, Eurostat's New Cronos

[13] In general, it is difficult to determine the direction of causality between real exchange rate and output. Certainly, changes in the exchange rate policy affect output. Yet, the international financial theory would insist that for a small open economy, changes in domestic productivity relative to foreign productivity would affect the real exchange rate as well. Since the latter effect is more of a long-run phenomenon in most open economies, it is reasonable to place the output prior to real exchange rate in the contemporaneous causality ordering.

Import Price Index	Price index of imports of goods and services in Poland, base year 2000, euro based	Database Quarterly National Accounts, Eurostat's New Cronos Database
Yield on 3-month U.S. Treasury bills	Discount rate on 3-month Treasury bills, bond equivalent yield	Federal Reserve Bank and authors' calculations
GDP	Gross domestic product of Poland, in market prices of 2000, thousands PLN	OECD Economic Outlook
Consumer Price Index (CPI)-Eurozone	Economic and Monetary Union (Eurozone) consumer price index, chain-weighted, base year 2000	Global Insight Inc.
Consumer Price Index - Poland	Poland's Consumer Price Index, base year 2000	Central Statistical Office of Poland
Nominal exchange rate	Poland - Euro Exchange Rate, period average, PLN per euro (synthetic euro prior to 1999)	National Bank of Poland

After checking the data for seasonality, we found that export/import price indices were not seasonally adjusted. We adjusted the series using a Census X-11 additive technique[14]. We also performed variance-stabilization in the form of logarithmic transformations to all the series in the model. In our further analysis we refer to these transformed data as the original series.

To implement VAR estimation, the reduced form VAR process (4) must be covariance stationary. In order to pretest log-transformed variables for stationarity and determine the order of their integration, we perform the Augmented Dickey-Fuller (ADF) test. We let the data generating process to be:

$$\Delta y_t = \gamma y_{t-1} + v_t , \qquad (5)$$

where y_t is the variable we are testing for stationarity, $\Delta y_t = y_t - y_{t-1}$, and v_t is the error term. The hypothesis to be tested is: $H_0 : \gamma = 0$ (variable has a unit root) against the alternative $H_0 : \gamma < 0$ (variable is stationary). To test this hypothesis, we estimate (5) by least squares and

[14] The X11 procedure is based on the U.S. Bureau of the Census X-11 seasonal adjustment program. The procedure seasonally adjusts monthly or quarterly time series, makes additive adjustments, and creates an output data set containing the adjusted time series and intermediate calculations.

examine the τ-statistics, the 5% critical values for which are taken form MacKinnon (2010). In addition, we test for the unit root in presence of a drift and a time trend. To control for autocorrelation in the error term, we modify (5) to:

$$\Delta y_t = \alpha_0 + \alpha_{1t} + \gamma y_{t-1} + \sum_{i=1}^{m} a_i \Delta y_{t-1} + v_t \qquad (6)$$

The procedure is performed for each variable under three specifications of (6) – (a) with no constant term and no time trend; (b) with constant term and no time trend; (c) with constant term and time trend. We select the optimum lag for the ADF test by Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC)[15]. If the null hypothesis of a unit root is not rejected at the optimum lag length at the 5% significance level, the ADF test is performed again for the series in first differences. The results of the ADF test are summarized in Table 2.

Table 2. ADF Test Results with the SBC Optimal Lag

Series	**Alternative Hypothesis**		
	Case (a) No constant term, no time trend	**Case (b) Constant term, no time trend**	**Case (c) Constant term, time trend**
Terms of trade	Optimal lag=6 H_0 rejected	Optimal lag=6 H_0 rejected	Optimal lag=5 H_0 rejected
World interest rate	Optimal lag=1 H_0 not rejected H_0 in first differences rejected	Optimal lag=1 H_0 not rejected H_0 in first differences rejected at 10% level	Optimal lag=2 H_0 not rejected H_0 in first differences not rejected
Real exchange rate	Optimal lag=1 H_0 rejected	Optimal lag=1 H_0 rejected	Optimal lag=1 H_0 rejected
GDP	Optimal lag=4 H_0 not rejected H_0 in first differences rejected	Optimal lag=1 H_0 not rejected H_0 in first differences rejected	Optimal lag=1 H_0 not rejected H_0 in first differences rejected

[15] The optimal lag lengths selected by AIC and SBC generally match, with ±1. Further in a paper for the space constraints, we report the ADF test outcomes based on the SBC optimal lag selection.

For *terms of trade*, the optimal lag length is 6 for cases (a) and (b). We reject the unit root in both cases at the 5% significance level. When the model (6) includes an intercept and a linear trend, the optimal lag is 5. We reject the null hypothesis as well. For the *world interest rate*, lag of 1 is optimal according to the SBC in cases (a) and (b). Lag of 2 is optimal, when the specification includes the intercept and a trend. In all three specifications, we cannot reject the null hypothesis at the 5% significance level, i.e. the world interest rate series is non-stationary in level. However, in the first differences the null hypothesis is rejected at the 5% significance level in case (a), and at the 10% level of significance in case (b). We reject the unit root for *real exchange rate* at the 5% significance level for all three specifications of the ADF test with the optimal lag of 1. Finally, we cannot reject H_0 of a unit root for the *GDP* series in levels. The unit root null hypothesis is rejected at the 5% significance level for the GDP series in the first differences, in all three specifications, suggesting that the series is I(1).

Next, in order to properly specify the VAR, we investigate the cointegration properties of the data. Engle and Granger (1987) state that if the contemporaneous elements of a vector Y_t were cointegrated, then it is not correct to fit a VAR to the differenced data. We test the null hypothesis that there is no cointegration among the elements of Y_t by employing a two-step procedure. The first step involves regressing one variable on the selected variables in the system and testing the residual for a unit root using the ADF test. That is,

$$y_{1t} = \beta_1 + \beta' Y_{2t} + \varepsilon_t \qquad (7)$$

where Y_{2t}=(y_{2t}, …, y_{nt}), and β'=(β_2,… β_n). The second regression is estimated to perform the unit root test:

$$\Delta\hat{\varepsilon}_t = \delta\hat{\varepsilon}_{t-1} + u_t \qquad (8)$$

Since the critical values are sensitive to the lag length in the ADF test, we perform an AIC test to determine the optimum lag length for each regression. The estimated test statistics for the null hypothesis of a unit root (non-cointegration) are in Table 3.

Table 3. Results of the Engle-Granger Test for Cointegration

Residuals from the OLS Estimation	**Optimum lag length, AIC**	**τ - ratio**
Terms of trade on world interest rate	4	-1.94
Real exchange rate on real output	1	-2.25
Real exchange rate on world interest rate	1	-1.27
Real exchange rate on terms of trade	3	-1.68
Real output on real exchange rate	5	-0.59
Real output on terms of trade	8	-0.57
Real output on world interest rate	3	-1.74
Real output on terms of trade, world interest rate, real exchange rate	4	-2.14
Real exchange rate on terms of trade, world interest rate, real output	4	-2.82

According to the Engle and Yoo (1987) tables, all test statistics are smaller in the absolute value than the corresponding critical values at the 5% significance level. Hence, we conclude that the evidence supports non-cointegration, and the VAR in the first differences is appropriate.

After specifying the recursive structure of our empirical model, we estimate the VAR model for Poland based on the differenced variables. Starting with the maximum lag length of 5, both the AIC and the SBC were calculated. Based on the test results at the 5% level of significance, we choose the optimal lag length of 4 for the Polish VAR model in 1990-2014.

In order to show how much of the forecast error variance for endogenous variables can be explained by each disturbance, after estimating the model, we perform the variance decomposition. The econometric results for selected periods are in Table 4.

Table 4. Variance Decomposition of Forecast Errors

Period, quarter	**Standard Error**	**External Shocks**		**Domestic Shocks**	
		Terms of Trade	World Interest Rate	Output	Real Exchange Rate
		Variance Decomposition of Output			
1	0.01	0.37	0.96	98.67	0.00
4	0.01	1.63	0.82	95.56	1.99
8	0.01	2.91	0.82	93.73	2.54

12	0.01	3.49	0.80	93.15	2.57
16	0.02	3.80	0.79	92.85	2.57
20	0.02	3.98	0.78	92.67	2.57
		Variance Decomposition of Real Exchange Rate			
1	0.03	0.22	2.00	1.14	96.64
4	0.03	2.37	10.63	1.62	85.39
8	0.03	2.20	10.22	10.88	76.70
12	0.034	2.32	9.92	13.36	74.41
16	0.035	2.44	9.73	14.85	72.99
20	0.035	2.52	9.61	15.80	72.07

Table 4 shows the fraction of a k-quarter forecasting error variance of Poland's output and the real exchange rate explained by two external shocks (terms of trade and world interest rate) and two domestic shocks (output fluctuations and real exchange rate). In the long run (20 quarters), a relatively low share of forecasting error variance of output, 4.76%, is explained by external shocks[16]. External shocks explain a higher share of the variance in the real exchange rate forecasting errors - about 12% for a horizon of 20 quarters. Of the two external shocks, the world interest rate seems to be more important for Polish economy, explaining up to 11% of the real exchange rate fluctuations for the 4-quarter horizon and up to 10% for the 20-quarter horizon. Interestingly that in the variance decomposition of the Polish output, the impact of external shocks, and terms of trade in particular, rises with time, while the strength of the combined domestic shocks diminishes.

These findings suggest that, since the real exchange rate responds to the external shocks which explain over the 12% of its variation in the long run, the exchange rate serves as an absorber of external and domestic shocks in Poland. As a consequence of elimination of such an absorber, adoption of the euro can be costly for Poland. The policy makers arguing for the elimination of exchange rate should not ignore this perceptible variation. On the other hand, given the fact that a relatively small share (under 5% for a horizon of 20 quarters) of the output

[16] The 4.76% variance is obtained by the summation of 3.98% and 0.78% external shock components in quarter 20.

series variance is explained by external shocks, the loss of the stabilization policy towards smoothing a business cycle when the economy is hit by external shock should not be very sizable.

Additionally, we find that our analysis of variance decomposition reports a slightly lower volatility of Poland's output due to external shocks in 1990-2014 when compared to earlier studies on Polish economy, for example Korhonen (2003) and Mackowiak (2006). The study echoes Arratibel and Michaelis (2014) to confirm time-varying effects across time, with the higher output volatility documented in Poland in 1990s versus in the recent years. Overall, our results suggest that over the past decade the Polish economy has become more resilient to external shocks, and thus it reasonable to expect the cost of euro adoption to decline with further EU integration.

6. CONCLUSIONS

Following its accession to the European Union in 2004, Poland is eventually expected to meet the Maastricht criteria and to adopt euro. The membership in the Eurozone involves potential costs and benefits. On one hand, Poland will abandon the zloty/euro exchange rate and, as a result, exchange rate risk and transaction costs within a single currency area will be eliminated. There will also be other long-term benefits, such as expansion of foreign trade, an increase in domestic and foreign investment, integration to euro financial markets, and improved productivity. On the other hand, abolishing a national currency involves costs. A single currency area implies losing autonomous monetary policy, which allows for setting independent interest rates as stabilization mechanism against macroeconomic disturbances. Since business cycles may be divergent in countries of the currency union, uniform interest rates set by the European Central Bank (ECB) may not be fully appropriate for economic conditions in all countries of the

EMU. Joining the Eurozone also entails losing the stabilization function that a zloty floating exchange rate may have for the national economy.

Our analysis of the cost of euro adoption in Poland is based on a model of a small open economy with domestic nominal rigidities and exogenous shocks. After employing the VAR procedure to identify the relationships between terms-of-trade, world interest rates, domestic output and Poland's real exchange rate, we performed a variance decomposition analysis to quantify the portion of the forecasting error of Poland's output and real exchange rate explained by two external shocks – terms-of trade and world interest rates. We find the zloty exchange rate to serve a shock absorbing function in Poland. Our empirical analysis shows that external shocks explain on average about 12% of the variation in the real exchange rate forecasting error and up to 5% in the variation of Poland's output in 1990-2014. We also show that the impact of the external shocks has a tendency to increase error variance over time, while the impact of domestic rigidness decreases in the long run. The elimination of the exchange rate function as an absorber of exogenous shocks would lead to higher volatility, and thus constitutes costs of euro adoption. For the 1990-2014 period, we report a slightly lower volatility of Poland's output due to external shocks when compared to outcomes of studies focusing on Poland prior to 2004 – the year of Poland joining the EU. Overall, our results suggest that over the past two decades the Polish economy has become more resilient to external shocks, and thus we expect the cost of euro adoption to decline with time. For the future work, provided data availability, we would like to apply the VAR framework for estimations of the impact of external shocks on short- and long-term variances in domestic output and exchange rates in other CEE countries scheduled to join the Eurozone.

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