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Demand and supply shock symmetry across Polish voivodeships[1]

Abstract: The aim of this paper is to evaluate the symmetry of demand and supply shocks affecting Polish voivodeships and to assess the risk of asymmetric shocks in the future. The study employs the SVAR-based Blanchard and Quah (1989) decomposition as modified by Bayoumi and Eichengreen (1992), and uses a new method of estimating quarterly GDP by voivodeships. The results point to a relatively high symmetry of shocks and a rather low risk of their occurrence. Shock asymmetry does not appear to be strongly related to differences in production structures, which is claimed in most theoretical approaches, including the Optimum Currency Areas Theory.

Keywords: demand shocks, supply shocks, voivodeships, monetary policy

Introduction

From a macroeconomic point of view, business fluctuations are driven by shocks, i.e. irregular and unpredictable changes affecting the economy. Referring to the canonical aggregate supply-aggregate demand (AS-AD) theoretical model, these shocks can be classified as supply shocks (when GDP growth and inflation move in the opposite direction) or demand shocks (when both these variables move in the same direction). If a shock hits two or more economies in the same way, it is symmetric, while asymmetry means that different countries or regions are affected differently. In the most extreme case of asymmetry, one country or region can face a positive shock (an increase of GDP), while another one can be affected by a negative shock. One example of a demand shock exerting such an impact on two economies is a preference shock: consumers replace a good supplied by firms operating in one region for a good from another region. More frequently, however, due to various interlinkages and spillovers, shocks are asymmetric in the extent of the impact, while they remain either positive or negative across adjacent countries or regions, especially if they are economically integrated.

The problem of shock symmetry has been investigated mostly in literature related to optimum currency areas (OCA).[2] The occurrence of spatially asymmetric shocks within a monetary union triggers problems with monetary policy adequacy, as it cannot be adjusted to the needs of individual economies. If shocks

[1] This work was supported by the Polish National Science Centre under grant number 2015/19/B/HS4/00370.

[2] See De Grauwe (2012, pp. 3–6) for a clear and comprehensive exposition of this problem.

affecting countries are asymmetric, then at least some of them will have to deal with episodes of inadequate monetary policy, i.e. monetary policy stress.

Ramos et al. (2001) raise the relevance of the regional dimension for this analysis. They claim that, inside every national state, regions are adversely affected by the national single monetary policy in the presence of asymmetric shocks. Suppose that one region encounters a negative demand shock that does not affect the remaining regions. In line with the AS-AD model prediction, lower aggregate demand in the affected region will drive GDP and inflation down. Since other regions remain unaffected (or hardly affected), the national monetary policy cannot sacrifice the aggregate stability and come to the rescue of the affected region by lowering interest rates. The affected region will, therefore, face inadequate monetary policy.

De Nardis et al. (1996) add that European countries show rather homogeneous national industrial structures, but regional industrial structures are more heterogeneous, and this contrast may have important consequences for the national and regional distribution of asymmetric shocks. In the same spirit, De Grauwe and Vanhaverbeke (1991) and Gros and Thygesen (1992) have shown that output and employment variability in Europe is higher at the regional than at the national level, and concluded that one primary source of European shocks comes from the regions. Casella (1993) has even suggested that it is the economic region which should become the relevant economic entity to account for in the evaluation of the effects of a single currency. Finally, some studies have also provided more general evidence that excessive cross-regional disparities may accelerate inflation and decrease the rate of output growth. In this sense, regional asymmetry of shocks is harmful from the point of view of aggregate economy (Estevao, 2002; Bande and Karanassou, 2007; Rogut, 2008).

Understanding regional diversification of exposure to asymmetric shocks can, however, help in taking certain actions to lower the effects of shock asymmetry or to mitigate them once they occur. Another reason to investigate regional shocks is a more general one: to understand the composition of shocks affecting regional economies means to better understand regional growth patterns.

In light of the above reasoning, the aim of this paper is twofold. First, it is to check the extent of demand and supply shock symmetry across Polish regions. Second, it is to investigate the composition of different types of shocks affecting the regional economies. Both empirical exercises are conducted with the help of a well-established methodology, the so-called Blanchard and Quah (1989) decomposition as modified by Bayoumi and Eichengreen (1992). It is expected that shock symmetry is higher across voivodeships than between countries, due to lower barriers of labour mobility and similarity in the structure of demand, but still imperfect, due to pronounced differences in production structures and other factors.

An auxiliary contribution of this paper lies in utilising a method proposed by Pipień and Roszkowska (2015) to calculate quarterly GDP series by voivodeships. To the best of the author's knowledge, this is the first empirical study making use of this method.

The remainder of this paper is organised as follows. The next section contains a brief review of the empirical literature addressing the asymmetry of shocks, followed by some stylised facts regarding regional differences of GDP and CPI dynamics and factors affecting them. Subsequently, the empirical methodology is introduced and statistical data issues are outlined. Finally, the empirical findings from the analyses are presented and discussed. The paper finishes with conclusions and some policy implications.

Literature review

As mentioned earlier, the problem of shock symmetry has been given highest priority in studies assessing fulfilment of the OCA criteria in the Euro Area. This strand of research was initiated by Bayoumi and Eichengreen (1992) who warned that the correlation of shocks affecting Western European countries is substantially lower than the correlation found among U.S. regions. This conclusion was confirmed by Chamie et al. (1994). The renaissance of empirical studies of this type was associated with the eastern enlargement of the EU, which triggered unprecedented interest in possible effects of taking the next step and integrating new EU member states into the common currency area. A few of many studies include Boone and Maurel (1999), Fidrmuc and Korhonen (2003), Horvath and Rátfai (2004) and Frenkel and Nickel (2005). The overwhelming number of these studies was eventually synthetised in a meta-analysis conducted by Fidrmuc and Korhonen (2006), although many more were published after this date. Shock symmetry was also subject to investigations in other parts of the world where monetary integration was discussed as a viable option, such as East Asia (e.g. Ling and Yuen, 2001; Chow and Kim, 2003; Huang and Guo, 2006 or Lee and Azali, 2012), Africa (e.g. Horvath and Grabowski, 1997; Buigut and Valev, 2006) and other regions (Levy and Sturzennegger, 2000; Jayaraman 2007; Braithwaite, 2017).

A related strand of research focuses on outcomes of the shock asymmetry, reinforcing the rationale behind investigating these issues. For example, Sturm and Wollmerhauser (2008), Gajewski (2016) and Quint (2016), among others, provided empirical evidence of substantial and unevenly distributed monetary policy stress in the Euro Area since its inception, which fuelled the process of imbalance accumulation on the run-up to the economic crisis that eventually broke out in 2008.

Compared with this rich empirical evidence gathered on the country level, studies taking a regional perspective are scant. Moreover, most of them are focused on regions within a panel of countries (e.g. Pons-Novell and Tirado-Fabregat, 2006; Marelli, 2007). However, Maza and Villaverde (2007) investigated shock asymmetry across Spanish regions and found limited (although non-negligible) amount of it, but at the same time they point to insufficiently developed mechanisms to deal with such shocks, should they occur in the future. A higher degree of asymmetry was found by Duran (2015) among Turkish regions, although it seems to have been decreasing over the recent decades. More evidence is available directly

on regional asymmetry in monetary policy effects in various countries, for which the effects are usually found pronounced and provide indirect evidence on the existence of regional shock asymmetries (see: Anagnostou and Papadamou, 2016 or Anagnostou and Gajewski, 2018 for a review of these studies).

The risk of asymmetric shocks depends on many features. It will be lower if regions are highly diversified in terms of economic structures, openness, business sector structures and various other structural features (Marelli, 2007). Regions that are most dissimilar from the national economy may be, generally, most exposed to the risk of asymmetric shocks. Obviously, geographical location also matters significantly, so the problem of shock asymmetry tends to be more pronounced within larger areas subjected to a single monetary policy.

The OCA theory stresses that mechanisms and insurance schemes exist and can be implemented to prevent and mitigate the effects of asymmetric shocks on regional economies (de Grauwe, 2012). The most important of these mechanisms and schemes are wage flexibility, labour mobility and fiscal transfers. When wages are flexible, their downward adjustment in a region affected by a negative shock lowers production costs and pushes the AS curve to the right, compensating the fall in demand. When labour is mobile, it flows towards unaffected regions, thereby alleviating the pressure on the domestic labour market. Finally, when the system of fiscal transfers can be used, funds are directed towards the troubled region to support incomes in that region.

Admittedly, most of these mechanisms are more developed at a cross-regional level within countries than across countries in the Euro Area, which somewhat alleviates the problem of possible monetary policy stress within particular countries. Indeed, higher labour mobility at a regional level stems from their higher proximity and lower cultural barriers, including lack of language differences. National budgets are relatively well suited to deal with asymmetric shocks due to the built-in systems of automatic stabilisers, their large size (usually between 30 and 60% of GDP) and the short planning period of one year. By contrast, the Euro Area budget is non-existent, and the EU budget is not designed to cope with ad-hoc asymmetric shocks. Be that as it may, due to substantial differences in economic structures, trade openness, infrastructure (affecting labour mobility, especially commuting), and business sector dynamics across regions in Poland, the question of the extent of shock asymmetry remains important and open.

Stylised facts

Regional variations of GDP growth rate and inflation

The greatest information content regarding spatial shock asymmetry is embedded in regional variations of GDP growth and inflation. Figures 1 and 2 present descriptive statistics of these variations in the form of boxplots based on the available data, i.e. annual and quarterly, respectively.

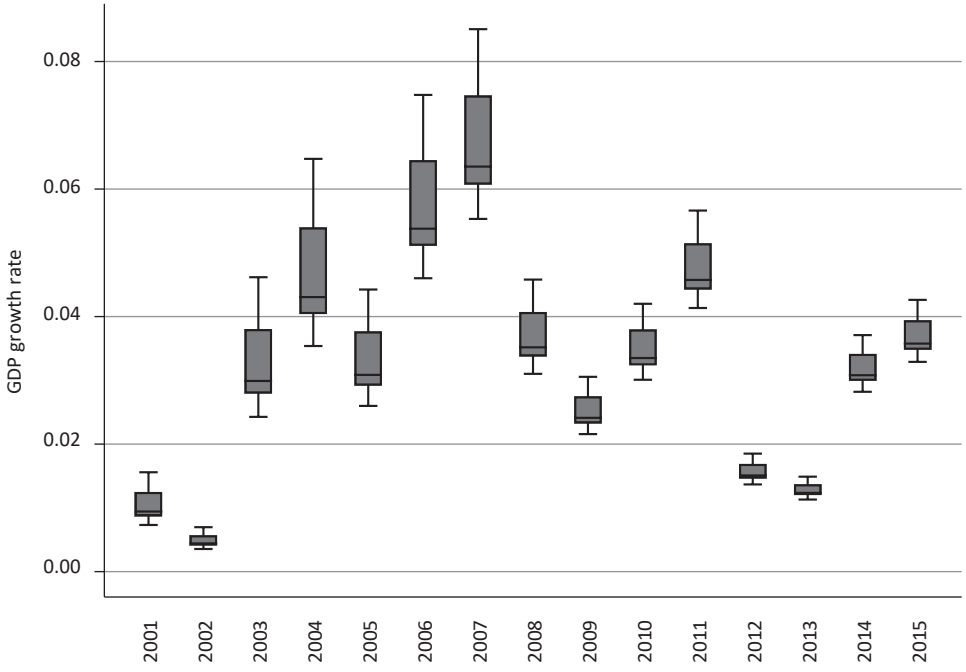

Fig. 1. Boxplots of GDP growth rates in voivodeships

Source of data: GUS.

Interestingly, regional differentials in GDP growth rate appear the highest during the so-called "great moderation", an economically buoyant period preceding the global financial economic crisis. We can observe that years marked by high GDP growth at a country-level have generally seen the highest regional differentiation of this variable. Such patterns may suggest some degree of persistently different exposures to asymmetric shocks of the regions. Some of them grow fast due to their exposure to positive external shocks, while adverse shocks may push their GDP growth down towards the rates observed in regions less connected to the external environment. The latter group of regions may have fewer capacities to benefit from "global" positive shocks, but this also means lower growth potential. This pattern, if confirmed, could be one of the explanations behind regional income divergence observed in Poland (e.g. Gajewski and Kutan, 2018).

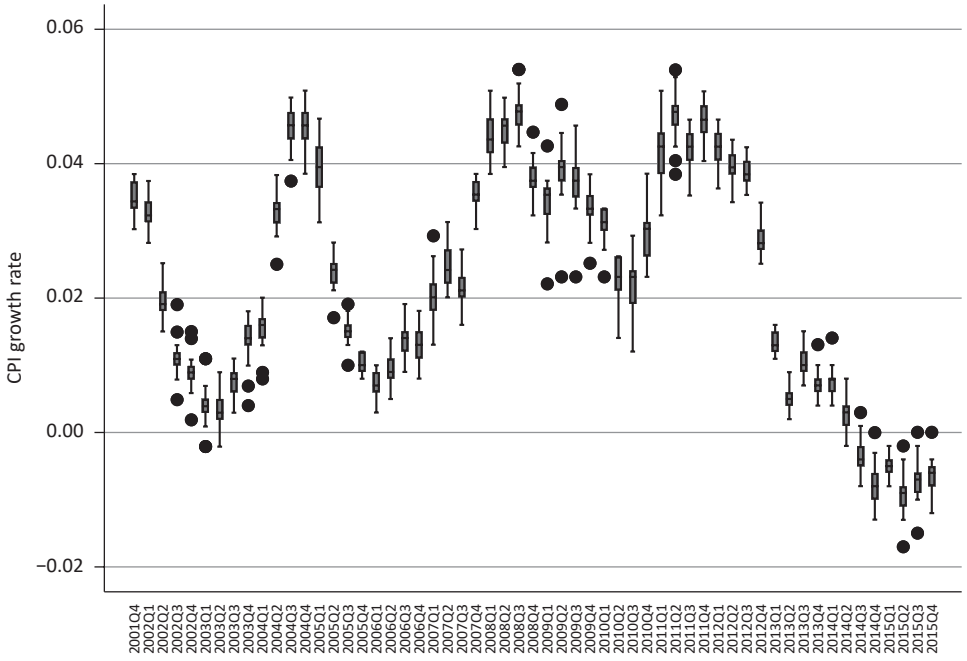

Fig. 2. Boxplots of CPI growth rates in voivodeships

Source of data: GUS.

The CPI inflation differential range amounted to 0.5-1 percentage points between 2001 and 2015, with an exception of the period spanning the second half of 2010 and first half of 2011, when it would reach 2 or 3 percentage points. Also, outliers were recorded much more frequently than in the case of GDP, both on the upper and lower end. The overall pattern of regional inflation disparities is less clear, in the sense that there does not seem to be an immediate relationship with the aggregate level of inflation. However, Gajewski (2017) found a positive impact of the EU-Poland inflation differential on cross-regional inflation divergence. Again, this may be due to the differences in exposure to external shocks. As long as inflation in Poland and its external environment remains similar, regional differences are low. When inflation deviates from the external one (e.g. in the EU), regional disparities rise.

Similarity of regional economic structures

The OCA theory provides some guidance as to which regional features are to be observed to determine whether there is a case for shock asymmetry across the regions. One of such features is linked to deficiencies in the similarity of production structures. Mundell (1961) showed that a region with a highly diversified

production structure and one that is similar to the one of monetary union is less prone to asymmetric shocks (Kenen, 1969).

Even at the voivodeship level of disaggregation, regional economic structures are visibly diversified. The differences are especially striking when regional economic structures are assessed through the prism of employment shares. To illustrate these differences, the well-known and simple Krugman specialisation index is computed:

$$K = \sum_{i=1}^{n} | b_i - b_i^{pl} |$$

where is the employment share in the i-th industry (68 branches of industry and services are considered). The Krugman index takes values between 0 (perfect similarity of regional and Polish employment structure) and $\frac{2(n-1)}{n}$. The indices calculated for individual voivodeships are illustrated in Fig. 3.

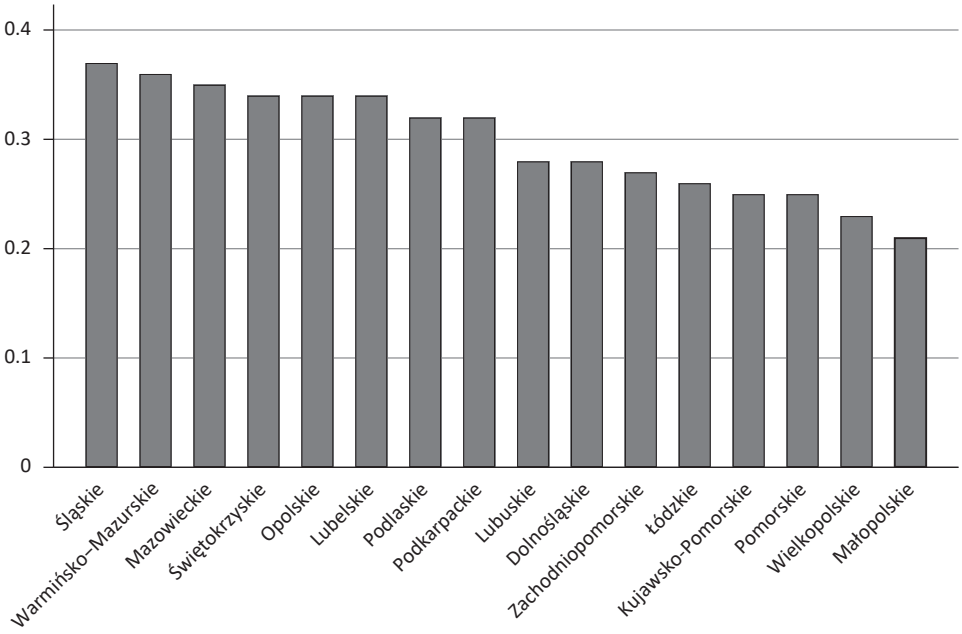

Fig. 3. Krugman employment specialisation index for voivodeships

Note: Data as of 2013, 68 branches of industry and services, benchmark: Poland.

Source of data: GUS.

This preliminary analysis confirms a widely known fact, that Śląskie exhibits the most distinctive structure. It is followed by Mazowieckie with its highly developed market and financial services and Warmińsko-Mazurskie due to the high importance of wood and furniture industries (Gajewski and Tchorek, 2017). On

the other side, employment structures in Małopolskie and Wielkopolskie most closely resemble this structure in Poland.

Trade openness

Originally, one of the OCA criteria was high openness and intensity of trade between regions forming a currency area (McKinnon, 1963). Due to lack of data, it is not possible to analyse trade between voivodeships, but the problem can be approached from the perspective of reliance on international trade. Regions highly integrated with foreign countries are potentially more prone to external shocks. Admittedly, regions that do not trade with other countries, but also other regions within a country, are more capable to produce "own" idiosyncratic shocks, but the role of the latter appears very limited in light of earlier results. For example, Gajewski (2017) investigated sources of inflation shocks across voivodeships and found very low contributions of idiosyncratic shocks, but regional inflation rates were found to be mostly driven by diverse relative contributions of national and external shocks.

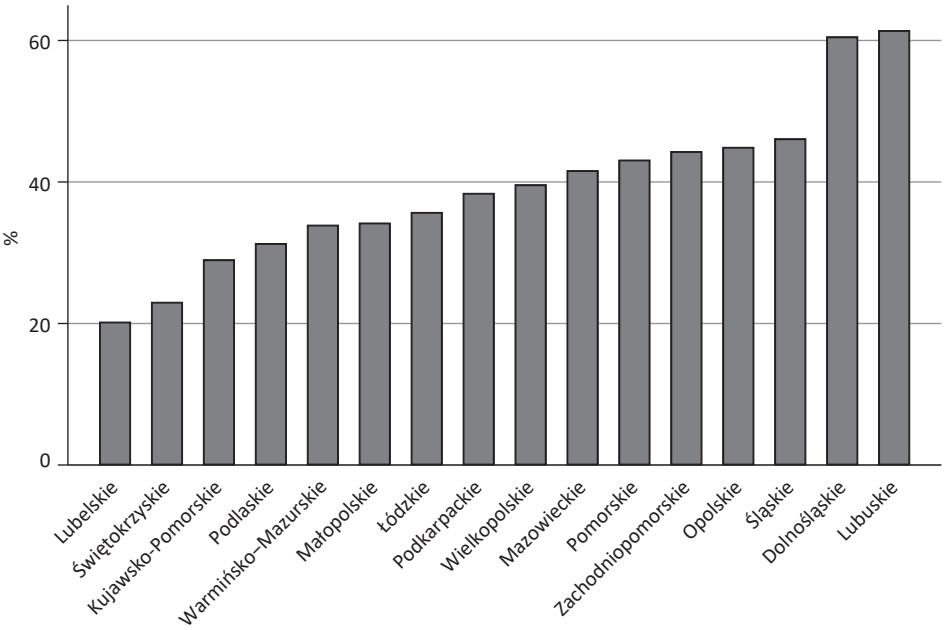

Fig. 4. The percentage share of overall revenue from sales in Polish voivodeships accounted for by the sum of exports and imports, as of 2012

Note: Source of data: Umiński (2016).

Fig. 4 confirms the conventional wisdom that voivodeships are polarised in terms of their openness to international trade, and this polarisation is closely related to geographical location. In regions sharing borders with Germany (Lubuskie,

Dolnośląskie, Zachodniopomorskie), enterprises record the highest shares of exports in terms of total revenues. By contrast, the rural, eastern regions (Lubelskie, Świętokrzyskie, Podlaskie) are relatively closed. Theoretically, judging by this criterion, both these "extreme" groups of regions are likely to face the lowest correlation of shocks with the shocks affecting Poland.

Labour mobility

Mundell (1961) pointed to labour mobility as a critical adjustment mechanism, capable of absorbing asymmetric shocks. The theoretical hypothesis pointing to an important role of labour flows between countries or regions for smoothing economic activity encounters major problems in empirical verification. First, measuring actual flows and different types (i.e. daily commuting, temporal migration, permanent migration) is difficult. Second, historical data (even if reliable) might not necessarily be informative for future situations. Third, there is always the question of a threshold rate or benchmark against which labour mobility figures should be compared.

Nevertheless, the importance of labour mobility for overall economic performance has contributed to many empirical studies that compare flows of labour across countries and regions. According to Arpaia et al. (2014), for example, annual rates both of sub-national and international inward mobility in Poland were amongst the lowest in the EU as of 2013.[3] While low international labour mobility is comprehensible, as the Polish labour market has not been very attractive for other EU citizens, low cross-regional mobility might be somewhat surprising. Yet, several explanations seem plausible. First, after the EU accession, a substantial number of the mobile working-age population moved to other EU countries. This could mean that the country has been drained from its most mobile labour force already. Moreover, for those who live in Poland and face employment problems, moving abroad is still an attractive substitute to taking a still lower paid job in another part of the country. Finally, the measurability issue remains.

Perhaps an empirical problem that could be most easily resolved is the one of establishing a convenient benchmark. Usually, a benchmark is provided by the U.S., i.e. a smoothly functioning monetary union. If we rely on the data provided by Arpaia et al. (2014), the ratio of cross-regional migration in Poland (below 0.25% of total population) turns out to be strikingly low compared to inter-state mobility in the U.S. There, despite incomparably larger distances, this rate ranges between 1.5% and 3% depending on the methodology (Molloy et al., 2011).

Methodology

The basic methodological framework of our analysis is the Blanchard and Quah (1989) decomposition, as modified by Bayoumi and Eichengreen (1992), who applied a bi-variate vector autoregressive procedure and considered two

[3] It was found the lowest among 12 EU countries for which data were available and reliable.

types of orthogonal shocks that are the sources of variation in two endogenous variables, output y_t and the price level p_t, and identify them as supply and demand shocks. In line with the textbook AS-AD model, a theoretical underpinning of this framework, supply shocks, which are associated with a shift in the aggregate supply curve, have both short-term and long-term impacts on output and prices, while demand shocks only exert a short-run impact on both endogenous variables. In the long run, however, they do not have a long-term impact on output and become fully absorbed by price-level adjustments. Blanchard and Quah (1989) showed that it is possible to identify these two types of shocks and their dynamic effects on output and prices with the help of a structural vector auto-regression (SVAR) model with long-run restrictions. The structural moving average representation of the model is:

$$X_t = D_0 e_t + D_1 e_{t-1} + D_2 e_{t-2} + \ldots = \sum_{i=0}^{\infty} D_i e_{t-i} \tag{1}$$

where $X_t = \begin{bmatrix} \Delta y_k \\ \Delta p_k \end{bmatrix}$, $e_t = \begin{bmatrix} e^k_{d,t} \\ e^k_{s,t} \end{bmatrix}$ and $D_i = \begin{bmatrix} \delta_{11i} & \delta_{12i} \\ \delta_{21i} & \delta_{22i} \end{bmatrix}$,

y_k denotes the log of regional GDP, p_k denotes the log of regional CPI level, while $e^k_{d,t}$ and $e^k_{s,t}$ denote demand and supply shocks, respectively, observed within a region. The long-run restriction of no impact from a demand shock on real output ($\phi_{11} = \sum_{i=1}^{\infty} \delta_{11i} = 0$) is imposed.

Two alternative benchmark sets of shocks are then produced to calculate pairwise correlation coefficients with the regional shocks. First, model (1) is run on Polish national data so that national demand and supply shocks are restored in the same way as is done for every voivodeship. Second, as a robustness check, the principal component (PC) analysis is performed on regional shocks, and first principal components are extracted from the set of regional demand and supply shocks. Regional demand and supply shocks can then be compared with these common components. This latter method corresponds to the original study of Bayoumi and Eichengreen (1992) and their numerous followers.

In order to perform the variance decomposition and gain insights into the composition of shocks affecting GDP growth across voivodeships, the above method is augmented with two additional variables: the growth rate of Poland's GDP (Δy_{pl}) and the national CPI inflation (Δp_{pl}). Consequently, in addition to idiosyncratic demand (ε^k_d) and supply shocks (ε^k_s), common (national) demand and supply shocks (ε^{pl}_d and ε^{pl}_s, respectively) are introduced, external to the *k*-th voivodeship of interest. It is noteworthy that common shocks associated with economic activity in Poland also capture global shocks (i.e. all global shocks are embedded in economic activity at a national level, as no "more exogenous" shocks are introduced). This modification is very similar to the one introduced by Huang and Guo (2006), although the real exchange rate is replaced by the external price level as regions within the same country are investigated and the nominal exchange rate is fixed, by definition.

To summarise, the original bi-variate SVAR is now modified into a four-variable system of the form:

$$\begin{bmatrix} \Delta y_{pl} \\ \Delta p_{pl} \\ \Delta y_{k} \\ \Delta p_{k} \end{bmatrix} = \sum_{i=1}^{\infty} \begin{bmatrix} d_{11i} & d_{12i} & d_{13i} & d_{14i} \\ d_{21i} & d_{22i} & d_{23i} & d_{24i} \\ d_{31i} & d_{32i} & d_{33i} & d_{34i} \\ d_{41i} & d_{42i} & d_{43i} & d_{44i} \end{bmatrix} \begin{bmatrix} \varepsilon^{pl}_{d,t-1} \\ \varepsilon^{pl}_{s,t-1} \\ \varepsilon^{k}_{d,t-1} \\ \varepsilon^{k}_{s,t-1} \end{bmatrix} \tag{2}$$

The following assumptions are imposed to identify all the shocks:

i. Demand and supply shocks are serially uncorrelated and orthonormal, with a variance-covariance matrix normalised to the identity matrix:

$$Var(\varepsilon_d) = Var(\varepsilon_s) = 1$$

$$Cov(\varepsilon_d, \varepsilon_s) = 0$$

ii. Output and price dynamics in an individual voivodeship does not affect aggregate output and price dynamics in Poland, so in the long-run:[4]

$$\sum_{i=1}^{\infty} d_{13i} = \sum_{i=1}^{\infty} d_{14i} = \sum_{i=1}^{\infty} d_{23i} = \sum_{i=1}^{\infty} d_{24i} = 0$$

iii. Demand shocks have no long-run impact on the real output (i.e. a fundamental assumption of Bayoumi and Eichengreen, 1992, originating from the AS-AD model):

$$\sum_{i=1}^{\infty} d_{11i} = \sum_{i=1}^{\infty} d_{31i} = 0$$

The remaining coefficients are estimated.

Statistical data

As data on real GDP and inflation necessary for the empirical analyses are only available at the NUTS 2 level, this level of disaggregation must be retained even though internal heterogeneity of the voivodeships is acknowledged and widely known. This being said, the data issue is not completely resolved even at this level. The methodology of empirical exercises in this paper is data-consuming; hence quarterly rather than annual data must be used to enable the analysis. While regional CPI data are available at this frequency from the Polish Central Statistical Office (GUS), real GDP data are only available at an annual frequency. The lack of quarterly regional accounts has been an important obstacle for empirical analyses in Poland and many other countries. In an attempt to overcome this barrier, Pipień and Roszkowska (2015) proposed a method to bridge annual regional data

[4] While this assumption might seem restrictive, at least for some voivodeships, it is necessary to identify the shocks.

with quarterly national data in order to estimate quarterly regional GDP and other related variables. The two-stage procedure proposed in their paper boils down to:

- estimating parameters of the 16-equation system, linking annual national GDP with regional GDP, and
- calculating quarterly GDP using the estimated parameters and quarterly national GDP data.

Here, quarterly regional CPI and GDP data, estimated by the procedure of Pipień and Roszkowska (2015), are used. The period covered spans from the 4th quarter of 2001 to the 4th quarter of 2015.

Before taking the data to estimations, they are tested for the presence of a unit root using the ADF test. The results are presented in Tab. 1. It can be concluded that the null hypothesis (of a unit root) can be rejected at least at the 5% level of significance for both variables in all voivodeships.

Tab. 1. ADF unit root test results of regional GDP and CPI growth rates

	CPI growth	GDP growth
Dolnośląskie	–2.071**	–2.523***
Kujawsko-Pomorskie	–2.537***	–2.545***
Lubelskie	–2.986***	–2.545***
Łódzkie	–2.284**	–2.546***
Lubuskie	–2.307**	–2.539***
Mazowieckie	–2.442***	–2.533***
Małopolskie	–2.188**	–2.513***
Opolskie	–2.395**	–2.541***
Podkarpackie	–2.287**	–2.545***
Podlaskie	–2.361**	–2.545***
Pomorskie	–2.760***	–2.535***
Śląskie	–2.045**	–2.545***
Świętokrzyskie	–2.462***	–2.546***
Wielkopolskie	–2.392**	–2.546***
Warmińsko-Mazurskie	–2.331**	–2.527***
Zachodniopomorskie	–2.367**	–2.540***

Notes: H_0: a series follows a random walk with drift. Number of lags selected by the Schwartz criterion.

Empirical results

In line with the empirical strategy outlined earlier, demand and supply shocks are first estimated for all the voivodeships and Poland separately.

Fig. 5 presents correlation coefficients between regional demand and supply shocks and the respective shocks affecting Poland. Based on these results, several conclusions can be made. First, the correlation of supply shocks is very high, ranging from 0.970 to 0.997 for all the regions. The explanation could be that

most supply shocks affecting Poland either result from changes in energy prices or import prices due to shifts in the exchange rate. As such, they affect all regions in a similar way. Additionally, individual regions have a very limited capability to generate idiosyncratic supply shocks. The correlation of demand shocks is lower, but still high, ranging between 0.87 and 0.96. To put these numbers into perspective, the highest correlation of supply shocks between a CEE country and the EU in the study by Babetskii et al. (2004) was found for Estonia (0.72), while the highest correlation of demand shocks was found for Romania (0.89). In a recent study by Bąk and Maciejewski (2017), which deals with the EMU countries, German shocks were found to be the most correlated with EMU-12 shocks, ranging between 0.7 and 0.9 in all periods, except for the most recent years when the correlation of demand shocks is found somewhat lower. Shock symmetry across Polish voivodeships, hence, appears to be robustly higher than between European countries.

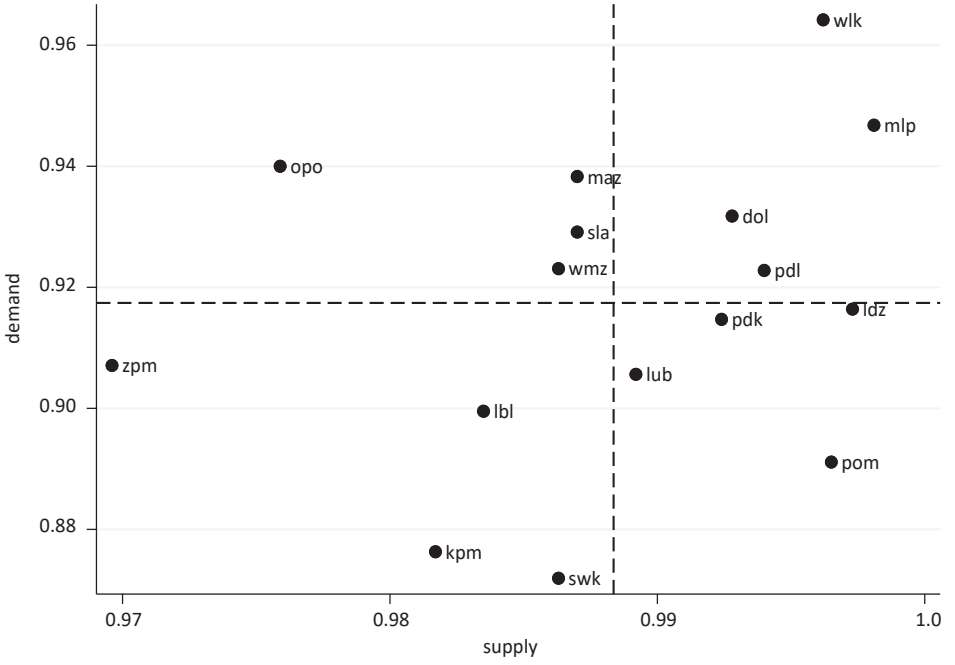

Fig. 5. Correlation of demand and supply shocks with shocks affecting Poland

Note: dashed lines indicate mean correlation coefficients.

While a formal analysis to establish a causal link between economic structures and shock symmetry is beyond the scope of this paper (and would be difficult due to the insufficient number of regions to perform cross-sectional estimations), it is noteworthy that the two voivodeships with the lowest values of the Krugman index (Wielkopolskie and Małopolskie) exhibit the highest correlation of both

types of shocks. The general relationship, however, does not appear strong as the spectrum of factors affecting shock symmetry is wide, as was discussed earlier.

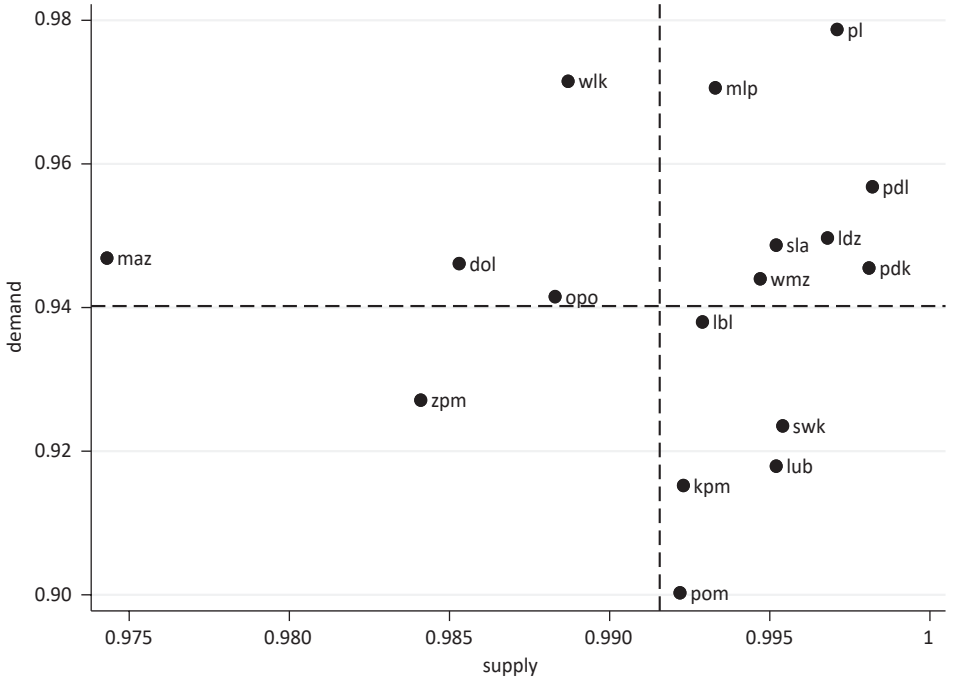

Fig. 6. Correlation of demand and supply shocks with common shocks extracted via the PC analysis

Note: dashed lines indicate mean correlation coefficients.

In Fig. 6, an alternative picture of shock symmetry is presented. The reference shocks, against which all regional shocks are correlated, are computed as first principal components extracted from all series regional demand and regional supply shocks. This method thus allows us to include Poland as yet another region. Fig. 6 shows that Poland (as expected) is a "region" most correlated with the common demand shocks and also highly correlated with the common supply shock. Generally, correlation coefficients are even higher than those illustrated in Fig. 5. Some differences between the two approaches are visible, but some other conclusions are reinforced. Most notably, the pool of voivodeships with the lowest degree of demand shock symmetry against Poland includes Pomorskie, Świętokrzyskie, Kujawsko-Pomorskie, Lubelskie, Lubuskie and Zachodniopomorskie. The latter region also stands out in terms of low supply shock symmetry. In turn, demand shocks affecting Wielkopolskie and Małopolskie appear to be the most symmetric with aggregate shocks, regardless of the method employed.

The second part of the analysis employs a system of four-variable models (2). Fig. 7 presents impulse responses of regional output dynamics and inflation to all four types of shocks, in four representative voivodeships: Lubelskie (a relatively

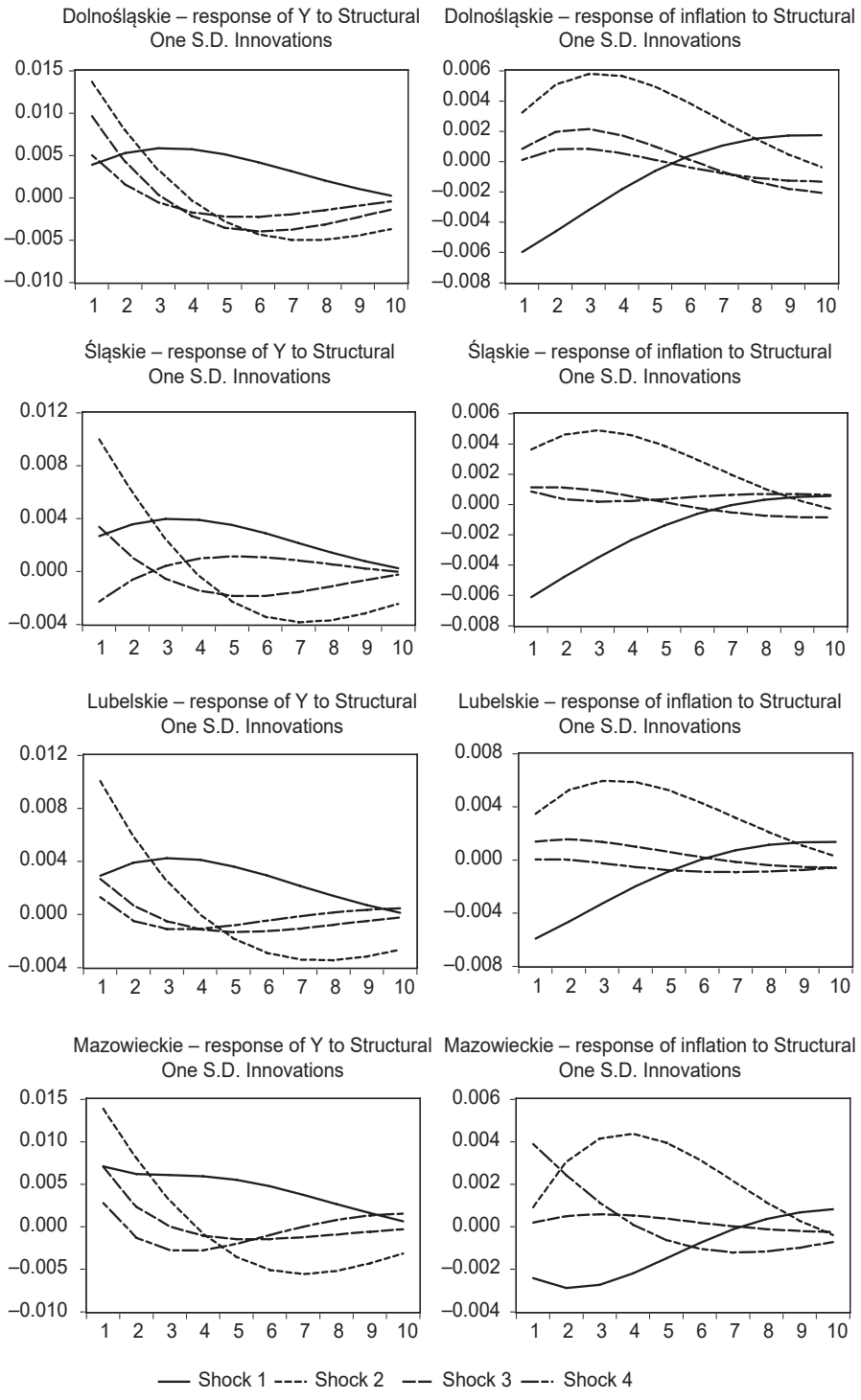

Fig. 7. Impulse responses of output dynamics and inflation to shocks in four selected voivodeships

Notes: Shock1 – common supply shock; Shock2 – common demand shock; Shock3 – idiosyncratic supply shock; Shock4 – idiosyncratic demand shock.

closed region in Eastern Poland), Dolnośląskie (one of the most open regions, with a relatively modern industrial structure, located in the western part of the country) and two voivodeships exhibiting most distinctive industrial structures, i.e. Mazowieckie and Śląskie.

Common supply and demand shocks affect all voivodeships in a similar way. In Dolnośląskie, Lubelskie and Śląskie, output growth peaks after three to four quarters and then slowly adjusts, to fade away completely after around 10 quarters. Inflation initially goes down as expected and the return to the initial level takes about seven to eight quarters. In Mazowieckie, the responses are slightly different, but do not contradict the theory or the usual findings. Also the responses to common demand shocks are plausible and similar across the voivodeships. By contrast, idiosyncratic shocks appear to exert a weaker impact on regional variables and their effect for regional inflation is often negligible. In addition to this, idiosyncratic supply shocks seem to be short-lasting. Indeed, voivodeships have a very limited potential to generate own supply shocks, apart from those weather-related, which can in reality be rather short-lasting.

Generally, the pattern observed in impulse responses supports the evidence of high correlation of shocks and suggests a relatively low importance of idiosyncratic shocks for driving regional economic activity.

Results from performing real output variance decomposition (in 4- and 10-quarter horizons) obtained from the four-variable models confirm the predominant role of common shocks in driving regional economic activity. As Figs. 8 and 9 show, these are common supply shocks, which turn out to be the most important. In the 4-quarter horizon, they account for 79–99% of the GDP growth variance and in the 10-quarter horizon – for 63–99% of the variance. Despite the large contribution of a common supply shock, the differences between voivodeships are still surprisingly strong. In Małopolskie and Podkarpackie, for example, almost no role is played by shocks other than common supply ones. In turn, Dolnośląskie stands out as a voivodeship with the strongest reliance on demand shocks, both common and idiosyncratic ones, which jointly account for 12–17% of the GDP growth variance. Pomorskie reveals the strongest capacity to generate idiosyncratic supply shocks, which is visible especially in the 10-quarter horizon. The relatively low contribution of idiosyncratic shocks in Śląskie can be seen as another surprise, given the distinct economic structure of this region.

From the perspective of the monetary policy adequacy, such a composition of shocks across voivodeships is rather good news. The role of idiosyncratic shocks is much lower than in the Euro Area member states, for example (see: Bąk and Maciejewski, 2017). While Dolnośląskie seems to be most exposed to the risk of asymmetric shocks, this risk has not materialised so far, at least during the period under analysis.

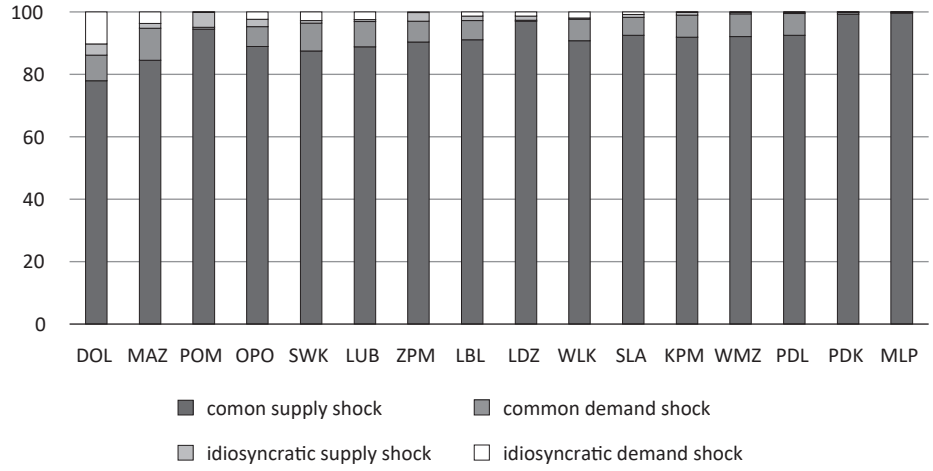

Fig. 8. Variance decomposition of regional GDP growth – 4-quarter horizon

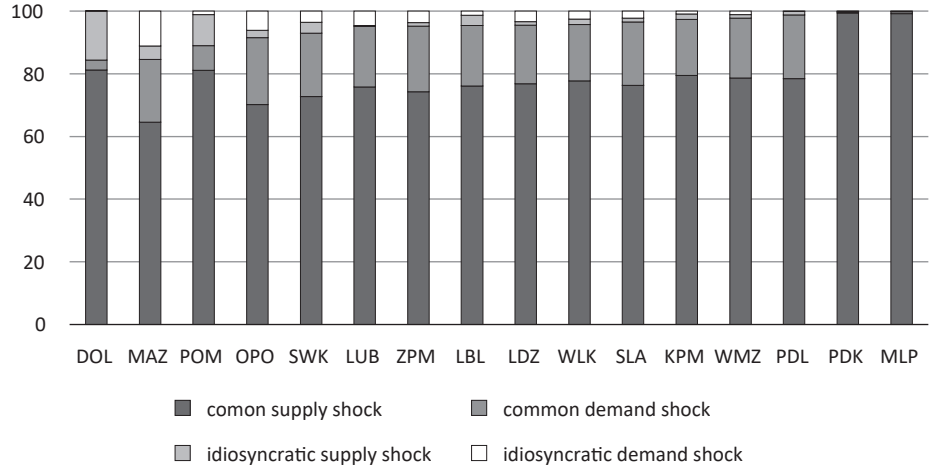

Fig. 9. Variance decomposition of regional GDP growth – 10-quarter horizon

Summary

This paper aimed to assess the existence and exposure to asymmetric shocks in the Polish voivodeships. The theoretical underpinning of this research has been the OCA theory, preoccupied with economic criteria conditioning monetary policy adequacy. The results indicate that shocks affecting voivodeships are very symmetric, and the importance of idiosyncratic shocks is low. The correlation of shocks is high not only compared to the correlation observed between the EMU member states, but also within some other countries, including the U.S. or Germany. An important finding is that the link between industrial structures and openness on the one hand and shock symmetry on the other is not as strong

as advocated by the OCA theory or in earlier studies. Moreover, contrary to the common perception, it is the highly open Dolnośląskie rather than Śląskie voivodeship (with its distinct economic structure) that seems to be most exposed to the risk of asymmetric shocks, even though this risk has not materialised so far. Overall, however, the extent of materialised and potential monetary policy stress is rather limited. The results may suggest that mechanisms exist between regions that prevent a large scale asymmetry of shocks. If the conclusion of low cross-regional labour mobility is to be accepted, these could be cross-regional trade linkages, unregistered commuting or other spillovers which create effective asymmetric shock absorption mechanisms.

One important caveat needs to be made related to the regional GDP dataset used in this study obtained through the method proposed by Pipień nad Roszkowska (2015). As this method is sensitive to differences between national and regional intra-annual deviations of GDP dynamics, some region-specific dynamics might be lost. Consequently, the correlation coefficients of shocks obtained here should be treated as an upper bound, and the same caveat applies to the contribution of common shocks to regional GDP growth variance. Further studies would be required to validate our results. In the absence of regional quarterly national accounts, a possible research avenue lies with employing micro-level data on enterprises in different regions. Such an approach would also enable a more disaggregated composition of the regions themselves.

References

Anagnostou, A., and S. Papadamou, 2016, "Regional asymmetries in monetary policy transmission: The case of the Greek regions," *Environment and Planning C: Government and Policy*, Vol. 34, No. 5, pp. 795–815.

Anagnostou, A., and P. Gajewski, 2018, "Heterogeneous impact of monetary policy on regional economic activity: Empirical evidence for Poland," *Emerging Markets Finance and Trade* (forthcoming).

Arpaia, A., Kiss, A., Palvolgyi, and A. Turrini, 2014, "Labour mobility and labour market adjustment in the EU," European Commission, *Economic Papers* 539.

Babetskii, I., Boone, L. and Maurel, M. (2004). "Exchange rate regimes and supply shocks asymmetry: The case of the accession countries," *Journal of Comparative Economics*, Vol. 32, No. 2, pp. 212–229.

Bande R., and M Karanassou, 2007, "Labour market flexibility and regional unemployment rate dynamics: Spain 1980–1995," *IZA Discussion Papers*, 2593.

Bayoumi T., and B. Eichengreen, 1992, "Shocking aspects of monetary unification," *NBER Working Paper*, 3949.

Bąk, H., and S. Maciejewski, 2017, "The symmetry of demand and supply shocks in the European Monetary Union," *Bank i Kredyt*, No. 48(1), pp. 1–44.

Blanchard, O., and D. Quah, 1989, "The dynamic effects of aggregate demand and supply disturbances," *American Economic Review*, Vol. 79, No. 4, pp. 655–673.

Boone, L., and M. Maurel, 1999, "An optimal currency area perspective of the EU enlargement to the CEECs," *CEPR Discussion Paper*, 2119.

Braithwaite, S., 2017, "What do demand and supply shocks say about Caribbean monetary integration?," *The World Economy*, Vol. 40, No. 5, pp. 949–962.

Buigut, S.K., and N.T. Valev, 2006, "Eastern and Southern Africa monetary integration: A structural vector autoregression analysis," *Review of Development Economics*, Vol. 10, No. 4, pp. 586–603.

Casella, A., 1993, "Discussion on 'Lessons of Massachusets for EMU' by P. Krugman," in: F. Torres and F. Giavazzi (eds.), *Adjustment and Growth in the European Monetary Union*, Cambridge: Cambridge University Press.

Chamie, N., DeSerres, A., and R. Lalonde, 1994, *Optimum Currency Areas and Shock Asymmetry. A Comparison of Europe and the United States*, Bank of Canada Working Paper, 94-1.

Chow, H. K., and Y. Kim, 2003, "A common currency peg in East Asia? Perspectives from Western Europe," *Journal of Macroeconomics*, Vol. 25, No. 3, pp. 331–350.

De Grauwe, P., 2012, *The Economics of Monetary Union*, 9th rev, Oxford University Press, Oxford, UK.

De Grauwe, P., and W. Vanhaverbeke, 1991, *Is Europe an Optimum Currency Area? Evidence from Regional Data*, CEPR Discussion Papers, No. 555.

De Nardis, S., Goglio A., and M. Malgarini, 1996, "Regional specialization and shocks in Europe: Some evidence from regional data," *Weltwirtschaftliches Archiv*, Vol. 132, No. 2, pp. 197–214.

Duran, E.H., 2015, "Dynamics of business cycle synchronization in Turkey," *Panoeconomicus*, Vol. 62, No. 5, pp. 581–606.

Estevao M., 2002, *Regional Labour Market Disparities in Belgium*, IMF Working Paper 02/134.

Fidrmuc, J., and I. Korhonen, 2003, "Similarity of supply and demand shocks between the euro area and the CEECs," *Economic Systems*, Vol. 27, No. 3, pp. 313 –334.

Fidrmuc, J., and I. Korhonen, 2006, "Meta-analysis of the business cycle correlation between the euro area and the CEECs," *Journal of Comparative Economics*, Vol. 34, No. 3, pp. 518–537.

Frenkel, M., and K. Nickel, 2005, "How symmetric are the shocks and the shock adjustment dynamics between the Euro Area and Central and Eastern European countries?," *Journal of Common Market Studies*, Vol. 43, No. 1, pp. 53–74.

Gajewski, P., 2016, "Monetary policy stress in EMU: What role for fundamentals and missed forecasts?," *Emerging Markets Finance and Trade*, Vol. 52, No. 5, pp. 1226–1240.

Gajewski, P., 2017, "Sources of regional inflation in Poland," *Eastern European Economics*, Vol. 55, No. 3, pp. 261–276.

Gajewski, P., and G. Tchorek, 2017, "What drives export performance of firms in eastern and western Poland," *European Planning Studies*, Vol. 25, No. 12, pp. 2250–2271.

Gajewski, P., and A. Kutan, 2018, "Determinants and economic effects of new firm creation: Evidence from Polish regions," *Eastern European Economics*, 56(3), pp. 201–222.

Gros, D., and N. Thygesen, 1992, *European Monetary Integration: From the European Monetary System to European Monetary Union*. London: Longman.

Horvath, J., and R. Grabowski, 1997, "Prospects of African integration in light of the theory of optimum currency areas," *Journal of Economic Integration*, Vol. 12, No. 1, pp. 1–25.

Horvath, J., and A. Rátfai, 2004, "Supply and demand shocks in accession countries to the Economic and Monetary Union," *Journal of Comparative Economics*, Vol. 32, No. 2, pp. 202–211.

Huang, Y., and F. Guo, 2006, "Is currency union a feasible option in East Asia?: A multivariate structural VAR approach," *Research in International Business and Finance*, Vol. 20, No. 1, pp. 77–94.

Jayaraman, T.K., 2007, "Towards a single regional currency in the Caribbean and Pacific Regions," *Social and Economic Studies*, Vol. 56, No. 1–2, pp. 135–181.

Kenen, P. J., 1969, "The theory of optimum currency areas: An eclectic view," in: R.A. Mundell, and A.K. Swoboda (eds.), *Monetary Problems of the International Economy* (pp. 41–60), Chicago: University of Chicago Press.

Lee, G.H.Y., and M. Azali, 2012, "Is East Asia an optimum currency area?", *Economic Modelling*, Vol. 29, No. 2, pp. 87–95.

Levy Y.E., and F. Sturzennegger, 2000, "The Euro and Latin America: Is EMU a blueprint for Mercosur?," *American Journal of Economics*, Vol. 110, pp. 63–99.

Ling, P., and H. Yuen, 2001, "Optimum currency areas in East Asia: A structural VAR approach," *ASEAN Economic Bulletin*, Vol. 18, No. 2, pp. 206–217.

Marelli, E., 2007, "Specialisation and convergence of European regions," *The European Journal of Comparative Economics*, Vol. 4, No 2, pp. 149–178.

Maza, A., and J. Villaverde, 2007, "A state space approach to the analysis of economic shocks in Spain," *Journal of Policy Modeling*, Vol. 29, No. 1, pp. 55–63.

McKinnon, R., 1963, "Optimum currency areas", *American Economic Review*, Vol. 53, No. 4, pp. 717–725.

Molloy, R., C.L. Smith, and A. Wozniak, 2011, "Internal migration in the United States," *Journal of Economic Perspectives*, Vol. 25, No. 3, pp. 173–196.

Mundell, R.A., 1961, "A theory of optimum currency areas," *American Economic Review*, Vol. 51, No. 4, pp. 657–665.

Pipień, M., and S. Roszkowska, 2015, "Szacunki kwartalnego PKB w polskich województwach," *Gospodarka Narodowa*, No. 5, pp. 145–169.

Pons-Novell, J., and D.A. Tirado-Fabregrat, 2006, "Specialization and asymmetries in macroeconomic fluctuations: Evidence for the European regions," *Regional Studies*, Vol. 40, No. 7, pp. 695–706.

Quint D., 2016, "Is it really more dispersed?," *International Economics and Economic Policy*, Vol. 13, No. 4, pp. 593–621.

Ramos, R. Ollero J.L., and J. Surinach, 2001, *Macroeconomic Implications of EMU at Regional Level*, ERSA, Congress, Zagreb, http://www.ersa.org/ersaconfs/ersa01/papers/full/146.pdf.

Rogut, A., 2008,, *The Efficiency of Regional Labour Market Mechanisms in Absorbing Regional Shocks in Poland in the Context of Accession to Euro Area*, NBP.

Sturm, J.E., and T. Wollmershäuser, 2008, "The stress of having a single monetary policy in Europe," *KOF Working Papers*, 08–190, KOF Swiss Economic Institute, ETH Zurich.

Umiński, S., 2016, "The regionalisation of commercial policy and of export-related analyses," in: K. Gawlikowska-Hueckel, and T. Umiński (eds.), *An Analysis of Poland's Foreign Trade in the Light of the Latest Theoretical Concepts* (pp. 212–231), Warsaw: Scholar Publishing House.