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SYNCHRONIZATION OF ECONOMIC SHOCKS IN THE VISEGRAD GROUP: AN EMPIRICAL ASSESSMENT

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ABSTRACT. The main goal of the paper is to assess a degree of coherence of macroeconomic shocks in the Visegrad Group (Czech Republic, Hungary, Poland and Slovak Republic, collectively: V4). We set out to consider the historical decomposition of unobservable supply and demand disturbances among V4 economies from 1995 to 2013. In order to extract the underlying supply and demand shocks in V4 economies we employ a bivariate vector autoregressive model with a long-term structural decomposition (SVAR). The identification scheme is based on the theoretical aggregate supply-aggregate demand model. Thus we assume that supply shocks have a permanent impact on both output and prices, while demand shocks only temporarily influence output. The model parameters are estimated numerically using maximum likelihood method. Once the disturbances are obtained, we build 9-period moving window of correlation coefficients and compute their range as a statistical measure of magnitude. Eventually, based on SVAR decomposition, we construct impulse response functions to structural shocks. Concerning the supply shocks, we find that the correlation among the V4 Group is lower than in any other chosen sub-sample. The V4 countries are characterized by low correlation coefficient both with each other and with other EU economies. Furthermore, the supply shocks in the V4 Group are significantly stronger than in the 'old' member states. When compared to the peripheral EMU countries, the V4 economies show fast adjustment to this type of shocks. The demand shocks among the four economies are described by the highest correlation among all chosen sub-samples. The dynamic approach revealed that the

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synchronization of the demand shocks in the V4 Group was stronger even when compared to the EMU core. The adjustments to the demand shocks in the V4 countries are relatively elastic and these economies tend to converge to long-run equilibria in a fast pace.

Key words: optimum currency area, economic shocks, EMU enlargement, structural VAR, Visegrad Group.

JEL classification: E32, F15, F44, C32.

1. Introduction

The accession of the Visegrad Group countries (the Czech Republic, Hungary, Poland and the Slovak Republic, collectively: V4) to the European Union (EU) in 2004 proved to be a crucial step towards their closer economic integration. As member states of the EU, V4 countries also committed to join the Economic and Monetary Union (EMU) and adopt the single currency. However, nearly ten years after the accession, Slovak Republic is the only one that entered the eurozone (2009), and decisions regarding the adoption of EUR (e.g. appropriate timing and a rate of conversion) in the remaining three countries are subject to fierce debates. The question that is surprisingly rarely asked and notably absent in recent discussions is whether monetary unification would be advisable for the V4 Group as a whole.

The starting point to examine the effectiveness of the further economic integration for a group of countries is often based on the Optimum Currency Area (OCA) theory. The theory states that, among other criteria, overall balance of benefits and costs of integration is dependent on the synchronization of shocks that strikes economies. If disturbances of any source are distributed symmetrically across countries, their business-cycles are prone to be inter-correlated. It is then possible to conduct a single monetary policy which responses are sufficient to counter negative shocks across the entire currency area (one-size-fits-all). What is more, enterprises in these countries operate in the same macroeconomic environment and are subject to shocks of similar characteristics.

The main goal of the paper is to assess a degree of coherence of macroeconomic supply and demand shocks in the V4 economies from 1995 to 2013. We set out to extract approximations of unobservable shocks and to identify, in a comparative manner, their correlations, magnitudes, and adjustment processes afterwards. We specifically test the hypothesis that the similarity of macroeconomic shocks within the V4 Group has increased since its accession to the EU. The analysis is based on the structural vector auto-regression (SVAR) model with the long-run, theory-based restrictions (Bayoumi and Eichengreen, 1992; Blanchard and Quah, 1989), which we estimate using quarterly times-series of real GDP and price levels for the set of 23 EU economies.

The reminder of this paper is structured as follows. Section 2 reviews the theoretical literature on the subject of macroeconomic shocks in the light of the OCA theory and the process of European integration. Section 3 outlines the framework used to identify the disturbances, as well as describes data and its properties. Section 4 reports on the empirical results and discusses our basic findings. Section 5 concludes and points out several areas for the future research.

2. Literature review

Most of the shock similarity analyses have their theoretical bases in the OCA theory built upon seminal works of Mundell (1961), McKinnon (1963) and Kenen (1969). The theory states that in case of asymmetrical demand shocks monetary policy and flexible exchange rate cannot be used to stabilize an economy of a common currency area. As a consequence, only countries with symmetrical distribution of shocks or/and ones having properly working alternative adjustment mechanisms (i.e. elastic wages/prices, mobile labour force or federal fiscalism) can form effectively performing monetary unions. Initially, the authors attributed more symmetrical distribution to a degree of economic openness and diversification of a product-mix in an economy. Although nowadays diversification criterion has been replaced with more adequate similarity of a production structure (Theodoropoulos, 2005).

The original OCA theory was static in its nature, but further research provided more dynamic analysis that produced two contradicting views. The first one, called the 'European Commission View' (Commission of the European Communities, 1990), states that integrating economies should be characterized with more symmetrical distribution of shocks, due to an increase in intra-industry trade. Along with this view came the hypothesis of the endogeneity of optimum currency area criteria. This notion states that economic integration, through trade creation, leads to a tighter business cycles synchronization (Frankel and Rose, 1996). Opposite argument came to be known as the 'Krugman's View'. The author suggested that ongoing integration leads to a higher specialization in regions with a comparative advantage, making their aggregate demand less stable, and distribution of shocks more idiosyncratic (Krugman, 1993). Even up till now neither of the hypotheses has been fully proved or rejected by empirical research (de Grauwe and Mongelli, 2005).

Due to the fact that economic shocks are unobservable, most of the empirical research on the OCA theory has been conducted through analysis of cyclical components of real GDP which are connected with demand side of the economy. Imbs (2004) using the systematic approach found that business cycles synchronization is affected by trade, patterns of specialization and capital mobility. More recently, same conclusions were reached by Siedschlag (2010), as well as by Dées and Zorell (2011). Using the extreme bound analysis Baxter and Koutraparitsas (2004) proved that trade and gravitational variables robustly influence business cycles synchronization. The same methodology was used by Böwer and Guillemineau (2006) who reported the robust impact of trade, specialization and fiscal policy differences. Beck (2014) using the extreme bound analysis found significant impact of structural similarities and differences in GDP per capita distance on business cycles synchronization. Employing similar methodology, Sachs and Schleer (2013) demonstrated the significant impact of structural reforms and labour market institutions similarity, although the authors concluded that combinations of different institutions had the crucial role for cycles coherence.

Measuring business cycle synchronization in a VAR model, Bordo and Helbling (2010) found that the on-going tightening of business cycles is a global tendency and not a regional phenomenon, like most of the authors suggested. Lehwald (2012), using Bayesian dynamic factor model, also concluded that a great deal of an increasing business cycles synchronization in Eurozone may be attributed to global rather than regional tendencies. Kalemli-Ozcan, Papaioannou and Peydro (2009) using panel approach found significant impact of capital mobility, while Azali and Lee (2010) concluded that international trade is the main driver of business cycles synchronization. Same conclusions were reached by Silvestre, Mendonca and Passos (2009) who emphasize diminishing marginal impact of trade on cycles correlation.

Even though very popular, business cycles synchronization approach have one significant drawback – it does not correspond directly to the OCA theory. Because economic shocks are unobservable, methods based on their artificial extraction are required. This approach was initiated by Bayoumi and Eichengreen (1992) in their seminal work. The authors found that shock similarity among the core European countries is much stronger than in the peripheral ones.

3. Methods and data

Unlike the main macroeconomic variables, the underlying shocks that affect them are unobservable. For instance, basic statistical time-series analysis of GDP cannot verify whether its dynamics, at a given moment, are influenced by a demand shock, a supply shock or a mixture of both (Lippi and Reichlin, 1993). Consequently, any attempt to investigate similarities of macroeconomic disturbances in V4 countries requires a set of three assumptions that allow for an extraction and measurement of shocks. First of all, one needs to assume how many macroeconomic disturbances there are. Secondly, one has to use an identification scheme (i.e. a theoretical model) to define each shock, as well as to decide what distinguishes a positive and a negative shock. The third assumption describes adjustment processes of the main macroeconomic variables to the particular type of disturbance: direction, magnitude, and their short- and long-run effects.

The theoretical identification in our study is given by the aggregate supply-aggregate demand model (AS-AD). This model allows to reveal basic dependencies between the aggregate production (y) and prices (p), both in static (short-run) and dynamic approach, including adjustments to shocks. Due to the well-known recognition in empirical studies, we employ the New Keynesian version of the AS-AD model (Benigno, 2009). The upward-sloping AS curve consists of the actual and expected price levels, the GDP gap, and allows for the Calvo-style rigidities (Calvo, 1983). The downward-sloping AD depends on the naturals levels of production and prices, and can be shifted by either fiscal or monetary policies. The long-run aggregate supply curve, independent on the current price level, closes the model. A supply shock in this identification scheme permanently influences both output and price levels. A demand shock only temporarily changes output that gradually returns to its initial level (Fig. 1). The responses to shocks depend on the efficiency of adjustment mechanisms and allow for fluctuations around the long-run equilibria.

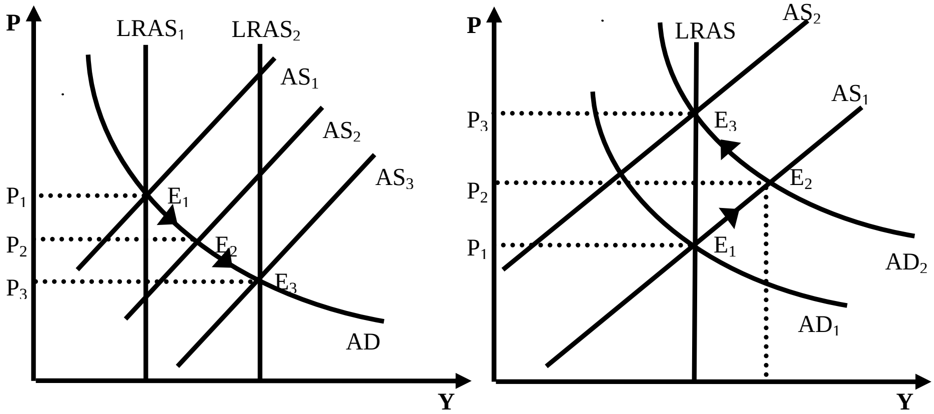

Figure 1. A positive supply shock (left panel) and a positive demand shock (right panel) in the AS-AD framework

Source: adapted from (Bayoumi and Eichengreen, 1992, p. 12).

Once we decide on the theoretical framework, it becomes necessary to choose an estimation procedure for the empirical study. The unobservable shocks can be extracted in a specific version of the SVAR. This approach was firstly developed by Blanchard and Quah (1989) and then adapted to the AS-AD model by Bayoumi and Eichengreen (1992). It requires the estimated system to be a representation of an infinite moving-average process of economic variables (X_t) and economic shocks ε_t, in the form of:

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + \cdots = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i} \; , \tag{1}$$

where particular elements of matrices A_1 can be interpreted as the reactions of variables X_t to the disturbances. For a bivariate AS-AD system, vector X_t consists of the first differences of the basic variables: Δy and Δp. Using the lag operator L, the equation (1) can be then re-written as:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_y \end{bmatrix} = \sum_{i=0}^{\infty} L^i \begin{bmatrix} a_{11i} & a_{12i} \\ a_{21i} & a_{22i} \end{bmatrix} \begin{bmatrix} \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix}, \tag{2}$$

with the underlying supply and demand shocks denoted respectively as ε_{st} and ε_{dt}.

The model defined in equations (1) and (2) is ready to be estimated using vector-autoregression. Assuming that both Δy_t and Δp_t are weakly stationary (integrated of the order of one), according to the Wold's theorem, X_t can be reduced to a bivariate moving-average process:

$$X_t = e_t + B_1 e_{t-1} + B_2 e_{t-2} + \cdots = \sum_{i=0}^{\infty} B_1 e_{t-1}, \tag{3}$$

in which the matrix $B_0 = I$, and the vector e_t consists of the estimated residuals for each dependent variable, e_{yt} and e_{pt}. In order to transform this system into the desired structural model, we need to display residuals in terms of the structural shocks. This can be achieved by comparing equations (1) and (3) that leads us to the following nexus:

$$\forall_i A_i = B_i A_0 \leftrightarrow e_t = A_0 \varepsilon_t. \tag{4}$$

Since there are two disturbances and two variables, the matrix A_0 consists of four unknown elements. Hence, we need four restrictions to properly identify the SVAR. The first two restrictions come from a regular normalization of variance of both shocks. The third one states that supply and demand shocks are independent. The fourth restriction is theory-based and comes directly from the AS-AD specification. If a demand shock only temporarily influences output, then its cumulative effect on the changes in output must be equal to zero:

$$\sum_{i=0}^{\infty} a_{11i} = 0. \tag{5}$$

The last step of the specification involves additional qualitative (over-identifying) restrictions imposed on the model. It was proved by Taylor (2004) that for a given VAR with long-run identification scheme there are exactly 2^N possible parameterizations that fulfil these restrictions. In the case of our model the quantitative identification alone allows for four results of the estimation. With the aim of extracting the actual shocks we assume that an increase in output may be caused by a positive demand or supply shock. This is a key assumption in the section 4.3. where we discuss impulse response functions to shocks.

The empirical estimation of the model covers quarterly data on real GDP and prices (GDP deflator) for the V4 countries and additional 19 European economies[3]. The data covering period 1995q2 to 2013q1was obtained from the Eurostat Database. The GDP time-series were all transformed from nominal to real values. In order to exclude seasonal components from the data a standard X-12 ARIMA procedure was used. Additionally, we applied the ADF test for a unit root[4] (Said and Dickey, 1984), as well the KPSS test for weak stationarity[5] (Kwiatkowski et al., 1992). Both test were run with a constant and a deterministic trend (Tab. 1)[6].

Based on the ADF and KPSS test statistics for levels and first differences of the time-series, we conclude that both output and prices for every country in the sample are I(1). We then compute logarithmic rates of growth, what eventually gives us 72 entries for each country and allows us to estimate a system as in the equation (3).

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[3] Austria, Belgium, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Lithuania, Luxemburg, Netherland, Portugal, Slovenia, Spain, Sweden, United Kingdom. The reliable time-series for Bulgaria, Croatia, Ireland, Malta and Romania do not cover the entire period of 1995-2013.

[4] The number of lags in the ADF equations was chosen using the Akaike information criterion.

[5] The bandwidth for the KPSS was obtained using the Newey-West method.

[6] Although we only report statistics for the V4 economies, the equivalent characteristics for the remaining 19 countries have also been calculated and are available upon request. The same disclaimer applies to the following sections of the paper, including the reaction function to shocks.

Table 1 - Descriptive statistics and integration tests for the real GDP and GDP deflator in the V4 countries (1995-2013)

Country	Real GDP				GDP deflator			
	Average rate of growth (q/q)	Rate of growth standard deviation	ADF p-value	KPSS result	Average rate of growth (q/q)	Rate of growth standard deviation	ADF p-value	KPSS result
Czech Republic	0.006	0.017	0.752	I(1)*	0.012	0.026	0.152	I(1)*
Hungary	0.005	0.010	0.969	I(1)***	0.010	0.031	0.907	I(1)**
Poland	0.011	0.012	0.820	I(1)***	0.009	0.042	0.068	I(1)*
Slovak Republic	0.010	0.021	0.747	I(1)**	0.013	0.029	0.652	I(1)**

Data in natural logarithms. Significance levels: (***) 0.01, (**) 0.05, (*) 0.1.
Source: own calculations.

4. Empirical results and discussion

Based on the procedure presented in section 3., we employ maximum likelihood method to numerically estimated 23 SVAR models for the V4 economies and additional 19 EU countries. Following the recommendation of Bayoumi and Eichengreen (1992) we set exactly the same number of auto-regressive lags in each model. Since most of the commonly used lag-selection criteria (e.g. Schwarz-Bayes, Akaike) indicated four lags for the majority of models, we decided to use this specification all across the sample. Once the models were estimated, we applied diagnostic tests for residuals (e.g. normality, auto-correlation) and found out that there is no clear statistical evidence to reject the models. We thus conclude that models are robust and can be used to infer on the synchronization of structural shocks. For each country in the sample, for instance Poland (Fig. 2), we obtain historical decompositions of supply and demand shocks. Based on these approximations we then calculate correlation coefficients, and build impulse response functions to structural disturbances.

a. Correlations of shocks: static and dynamic approach

Firstly average values of correlation coefficient for demand and supply shocks were calculated for the entire period. Taking into account different geographical areas, correlation coefficients were computed for the whole sample (whole), euro area (ea), core countries[7] (core), peripheral countries[8] (per), core and periphery[9] (core-per), and V4 countries. Descriptive statistics for the groups are presented in Tab. 2.

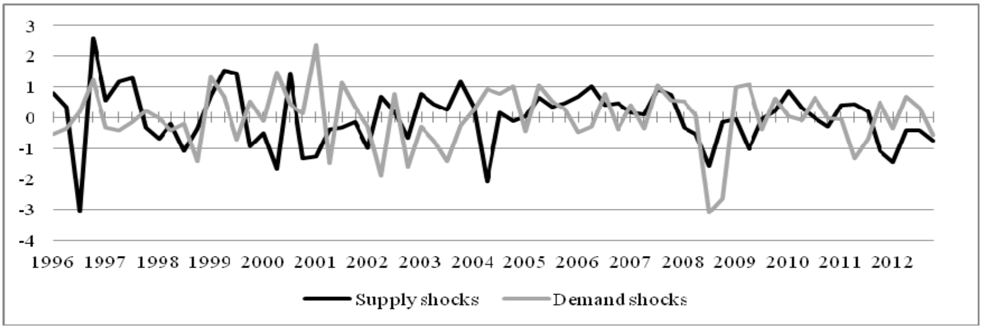

Figure 2. The SVAR approximations of supply and demand shocks in Poland (1996q2-2013q1)

Source: own calculations.

Table 2 - Descriptive statistics of correlation coefficients of supply and demand shocks for of EU countries (1996q2-2013q1)

Supply Shocks						
Sample	**whole**	**ea**	**core**	**per**	**core-per**	**V4**
Mean	0.288	0.321	0.416	0.268	0.312	0.209
Median	0.294	0.338	0.410	0.268	0.325	0.252
Maximum	0.647	0.647	0.627	0.544	0.647	0.331
Minimum	-0.06	-0.028	0.203	-0.028	0.048	-0.060
Standard Deviation	0.146	0.149	0.122	0.132	0.152	0.141
No. of observations	253	105	21	28	56	6
Demand Shocks						
Sample	**whole**	**ea**	**core**	**per**	**core-per**	**V4**
Mean	0.041	0.025	0.137	-0.028	0.01	0.243
Median	0.04	0.022	0.137	-0.043	0.002	0.259
Maximum	0.677	0.451	0.451	0.265	0.436	0.494
Minimum	-0.403	-0.287	-0.135	-0.287	-0.248	0.070
Standard Deviation	0.165	0.15	0.144	0.134	0.141	0.151
No. of observations	253	105	21	28	56	6

Source: own calculations.

[7] Austria, Belgium, France, Germany, Italy, Luxemburg and Holland.
[8] Cyprus, Finland, Greece, Portugal, Slovakia, Slovenia and Spain.
[9] Excluding relations within core and within periphery groups, e.g. Germany and Greece, but not Germany and France nor Greece and Spain.

The correlation of supply shocks is generally higher than of demand shocks with the exception of V4 Group where values are comparable. The correlation of supply shocks in V4 countries is lower than in any other analyzed sample. The corresponding characteristic of supply shocks is particularly strong among core countries of the EMU, which should not be surprising taking into consideration their high GDP per capita levels, structural similarities and a longer time of the on-going economic integration. More unexpected results come from the analysis of demand shocks similarities. In this case, the correlation of shocks among V4 countries is by far the highest (0.243). Even core countries of the euro area are characterized by lower demand shock correlation (0.137). This result implies that among chosen sub-samples V4 countries are best candidates to form a monetary union. Very high correlation of shocks among V4 countries means that a common monetary authority should be able to effectively implement monetary policy that would serve the interest of the entire area.

In the next step, we calculate pairwise correlation of shocks of V4 with the rest of the sample. Pairwise results for the supply shocks are presented in Tab. 3.

Table 3 - Pairwise correlation coefficients of supply shocks of V4 with EU countries (1996q2-2013q1)

Poland		Hungary		The Czech Republic		The Slovak Republic	
Country	**r**	**Country**	**r**	**Country**	**r**	**Country**	**r**
Belgium	0.319	Sweden	0.506	Germany	0.503	Lithuania	0.463
Italy	0.256	Italy	0.488	Slovenia	0.497	Slovenia	0.396
Austria	0.253	Slovenia	0.457	Italy	0.469	UK	0.384
Czech Republic	0.244	Belgium	0.416	Sweden	0.446	Hungary	0.331
Sweden	0.193	Lithuania	0.403	Finland	0.425	Sweden	0.326
Denmark	0.188	UK	0.402	Holland	0.377	Holland	0.308
Hungary	0.186	Latvia	0.388	Lithuania	0.367	Germany	0.294
UK	0.142	Spain	0.385	France	0.364	Czech Republic	0.292
Luxemburg	0.135	Germany	0.361	Austria	0.341	Portugal	0.283
Lithuania	0.122	Slovak Republic	0.331	Estonia	0.335	Estonia	0.283
Germany	0.108	Austria	0.327	Spain	0.305	Cyprus	0.272
Holland	0.107	France	0.321	Slovak Republic	0.292	Spain	0.263
Finland	0.102	Estonia	0.295	Hungary	0.260	Greece	0.240

Poland		Hungary		The Czech Republic		The Slovak Republic	
Country	**r**	**Country**	**r**	**Country**	**r**	**Country**	**r**
Slovenia	0.098	Czech Republic	0.260	Belgium	0.257	Denmark	0.236
France	0.096	Luxemburg	0.228	Poland	0.244	Latvia	0.221
Estonia	0.084	Finland	0.221	Denmark	0.239	Luxemburg	0.185
Portugal	0.050	Portugal	0.207	Portugal	0.234	France	0.176
Spain	0.038	Holland	0.193	UK	0.213	Austria	0.174
Latvia	0.016	Poland	0.186	Luxemburg	0.191	Finland	0.151
Greece	0.008	Denmark	0.186	Latvia	0.096	Italy	0.148
Cyprus	-0.043	Greece	0.172	Cyprus	0.051	Belgium	0.134
Slovak Republic	-0.060	Cyprus	0.114	Greece	0.048	Poland	-0.060

Source: own calculations.

There seems to be no general tendency in the supply shocks correlation among V4 countries. The highest values of the correlation coefficient were reported for Hungary and Slovakia (0.331) as well as for the Czech Republic and Slovakia (0.292). The lowest and negative synchronization of supply shocks were reported in case of Poland and Slovakia (-0.060). This result might be explained by high differences in their production structures. Pairwise results for demand shocks are presented in Tab. 4.

The analysis of demand shocks similarity brings about more clear-cut conclusions. Firstly, Poland and the Czech Republic are characterized by extremely high correlation coefficient of demand shocks (0.494), which implies that they are very good candidates for a monetary union formation. Secondly, in case of Czech Republic, the two best candidates for a common currency introduction are respectively Poland and Hungary (0.269), and in case of Hungary, Poland (0.264) and the Czech Republic. Taking into consideration the fact that regarding Poland, Hungary is the third country with the highest correlation coefficient, one might consider that these three countries are eligible candidates to form a monetary union. The situation, however, is different in for the Slovak Republic. Slovakia is characterized by a relatively high correlation coefficient of demand shocks only with Poland (0.255), and by rather low ones with Czech Republic (0.070) and Hungary (0.105). This differences could be attributed to the fact that Slovakia has already entered the EMU, but the country reveals even lower correlation coefficients with most of the core countries (with exception of Belgium).

Table 4 - Pairwise correlation coefficients of demand shocks of V4 with EU countries (1996q2-2013q1)

Poland		Hungary		The Czech Republic		The Slovak Republic	
Country	**r**	**Country**	**r**	**Country**	**r**	**Country**	**r**
Czech Republic	0.494	Czech Republic	0.269	Poland	0.494	Belgium	0.436
Denmark	0.330	Poland	0.264	Hungary	0.269	Cyprus	0.265
Hungary	0.264	Finland	0.231	Finland	0.191	Poland	0.255
Latvia	0.258	Greece	0.176	Denmark	0.183	Lithuania	0.185
Slovak Republic	0.255	Cyprus	0.157	Belgium	0.154	Latvia	0.153
Sweden	0.251	Sweden	0.150	Slovenia	0.148	Hungary	0.105
Finland	0.249	Latvia	0.142	Austria	0.102	Greece	0.096
Belgium	0.238	Germany	0.139	Lithuania	0.102	Denmark	0.081
Cyprus	0.237	Lithuania	0.108	Holland	0.086	Spain	0.081
Lithuania	0.194	Slovak Republic	0.105	Portugal	0.072	Finland	0.075
Greece	0.149	Denmark	0.077	Slovak Republic	0.070	Czech Republic	0.070
Germany	0.134	Portugal	0.069	Germany	0.062	France	0.062
France	0.127	UK	0.066	Greece	0.022	Sweden	0.023
Holland	0.061	Estonia	0.029	Sweden	0.004	Holland	-0.010
Austria	0.040	Slovenia	-0.004	France	-0.036	Portugal	-0.019
UK	0.001	Belgium	-0.008	UK	-0.048	UK	-0.048
Spain	-0.007	Italy	-0.012	Italy	-0.064	Italy	-0.050
Luxemburg	-0.029	Holland	-0.078	Spain	-0.108	Germany	-0.052
Italy	-0.070	France	-0.094	Cyprus	-0.114	Austria	-0.063
Portugal	-0.088	Luxemburg	-0.119	Estonia	-0.124	Estonia	-0.082
Estonia	-0.100	Spain	-0.157	Latvia	-0.141	Slovenia	-0.132
Slovenia	-0.113	Austria	-0.193	Luxemburg	-0.151	Luxemburg	-0.179

Source: own calculations.

Insofar analysis had a static nature. The degree of demand and supply shocks correlation was examined with respect to a given period of time. The results of a dynamic approach are presented as a 9-element rolling window of correlation coefficient[10]. The calculations for V4 pairs of countries and average value for the whole V4 Group, as well as for the core countries of the EMU are presented in Fig. 3 and Fig. 4.

[10] The computations obtained using 11- and 13-elements rolling window led to the same conclusions and are available upon request.

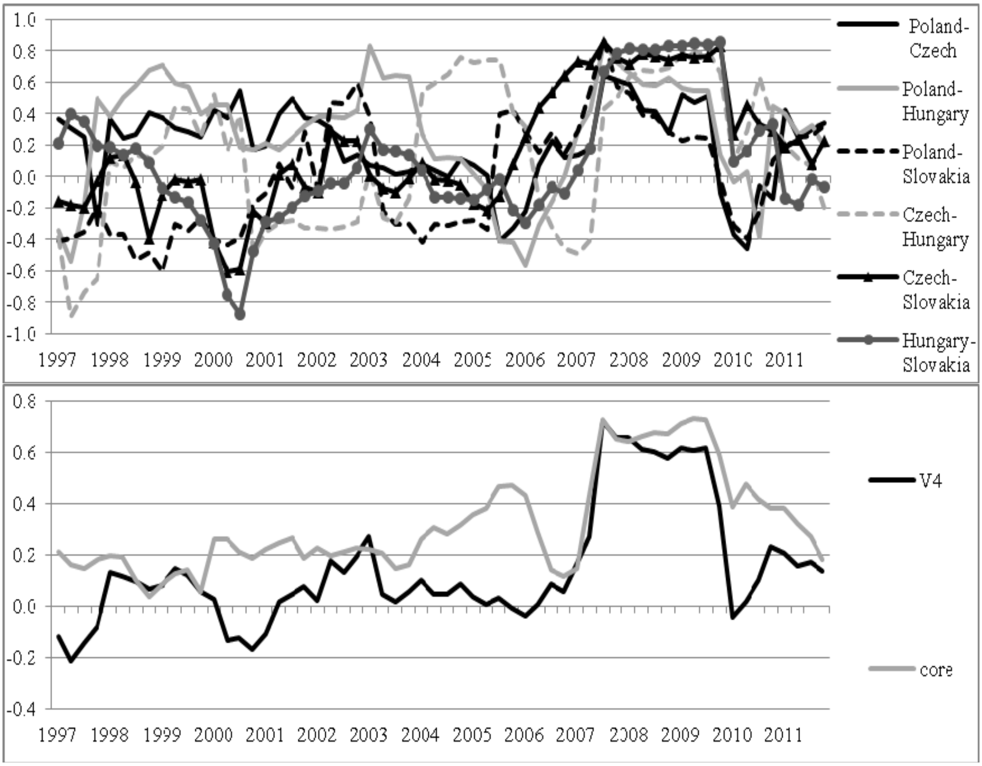

Figure 3. Supply shocks: pairwise correlations of V4 countries and average correlations of the EMU core and V4 in nine-element rolling window (1996q2-2013q1)

Source: own elaboration.

The analysis of pairwise correlation coefficients reveals no tendencies over time with respect to both demand and supply shocks with two considerable exceptions. In case of demand shocks, one can observe a sharp increase in values of correlation for early stages of the crisis and the downturn right afterwards (ca. 2007-2009). This might indicate that the economies of V4 countries reacted similarly at the beginning of the crisis, but due to differences in economic fundamentals and implemented policies they subsequently diverged. Similar conclusion can be derived from the observation of supply shocks correlation. The only difference being that the higher synchronization of supply shocks prevailed longer, which can be attributed to more profound consequences of crisis on the supply side of the V4 economies.

The investigation of the average values of correlation coefficients for V4 and the EMU core countries leads to two main conclusions. Firstly, over almost the entire period demand shocks of V4 were more closely correlated than these of core countries, although the variability in case of V4 was higher. Once more this suggests that V4 countries are better prepared to form a monetary union than countries of the Eurozone core. Secondly, similarity of supply shocks was higher during the whole period regarding the core countries, but both groups experienced a sharp increase in the correlation of supply shocks at the beginning of the crisis, that was sustained for almost until 2010.

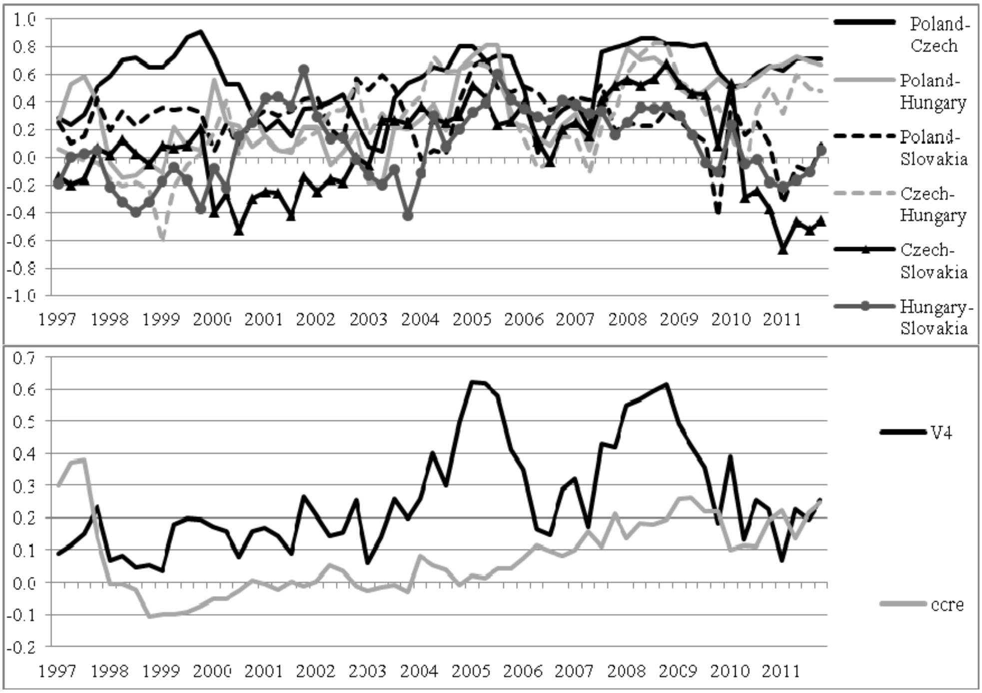

Figure 4. Demand shocks: pairwise correlations of V4 countries and average correlations of the EMU core and V4 in nine-element rolling window (1996q2-2013q1)

Source: own elaboration.

b. Magnitudes of shocks

In addition to the correlation structure of supply and demand disturbances, the SVAR framework allows for estimation of the magnitude of shocks. If the relative size of shocks in particular countries strongly differ, it will be more costly for each of them to join a monetary union, and submit to a common monetary policy. Consequently, the basic criteria of the OCA may not be satisfied. As a statistical measure of the magnitude of shocks we use their range, defined as a difference between the strongest positive (maximum) and strongest negative (minimum) disturbance for each economy in the sample[11]. We compute these values for the V4 countries, as well as for the geographical areas set in the section 4.1. (Tab 5.).

Regarding the supply disturbances, the V4 economies are in general subject to relatively strong shocks. The range for the core of EMU is 13.38% lower than for the V4 Group, and the corresponding value describing peripheral countries is 2.12% smaller. Interestingly enough, when compared to the average value of supply disturbance in the V4 countries is close to the mean value of the whole sample. Within the V4 Group, the Czech Republic is characterized by the least persistent supply shocks, 8.27% weaker than for the whole group. This result may be attributed to the highest GDP per capita level in this country.

Table 5 - Range of supply and demand shocks in the EU countries (1996q2-2013q1)

Supply disturbances			Demand disturbances		
Country/Group of countries	Range	Difference from V4 (in %)	Country/Group of countries	Range	Difference from V4 (in %)
core	4.732	-13.38	core	4.196	-21.53
Czech Republic	5.011	-8.27	Czech Republic	4.755	-11.09
per	5.347	-2.12	ea	5.302	-0.86
ea	5.401	-1.13	V4	5.348	-
whole	5.447	-0.29	whole	5.421	1.37
V4	5.463	-	Poland	5.456	2.02
Hungary	5.521	1.06	Hungary	5.538	3.55
Poland	5.655	3.51	Slovak Republic	5.643	5.52
Slovak Republic	5.666	3.71	per	5.850	9.40

Source: own calculations.

11 Alternatively, we calculated several more robust measures of the size of shocks, e.g. the inter-quantile range for 0.9 and 0.1 quantile. This exercises, however, produced results congruent with the basic analysis.

The magnitude of the demand disturbances reveals a higher variability across the sample than for the supply ones. The core of the EMU is again characterized by the lowest magnitude, 21.53% smaller then the V4 Group. On the contrary to the supply shocks, the demand disturbances for the peripheral countries of the EMU are 9.40% stronger than for the V4 group. The evidence supports the notion that the V4 economies demand shocks could be mitigated by a common monetary policy. Among the four countries, Czech Republic reveals the lowest, and Slovak Republic the highest size of the demand disturbances.

c. Adjustments to shocks

The estimated bivariate SVAR system may be also used to bring evidence on the adjustment processes to economic shocks across countries. The identified shocks follow the theoretical AS-AD framework. We define them as reaction functions to structural disturbances, as presented in the section 3. The expected reaction function to supply shocks is based on the assumption that the shocks have permanent effect on output[12] (Fig. 5). Demand shocks, on the other hand, only temporarily influence output (Fig. 6). The pace of adjustment to shocks in particular economies depends largely on their structural characteristics, such as the degree of economic openness, elasticity of production factors or their foreign-exchange regime. These differences are captured by heterogeneous shapes of the estimated functions, which we report for all the V4 countries and compare them to the selected EU economies.

The shapes of the supply disturbance for the V4 economies strictly follow the theoretical pattern. The initial effect of supply shocks on output is significant and stabilizes in each country after maximum ten quarters (Fig. 5). There is a clear evidence the largest economy in the V4 (Poland) possesses the highest ability to absorb shocks, while in Hungary supply disturbances reveal an increasing effect on GDP up to eight quarters after their detection. The adjustment to supply shocks was fastest in the core EMU countries (France, Germany), where the ratio of the value of response function to their long-run level is around 0.99. The functions for Poland and the Czech Republic can be consider similar to some of the smaller EMU economies, for instance the

[12] In order to keep the discussion of results concise, we focus solely on the responses of output to structural shocks and omit corresponding functions for prices, which are of lesser interest to this paper.

Netherland. The entirely different adjustments can be identified for the peripheral EMU countries (Greece, Spain). Their functions absorb only c.a. 75% of shocks in the first eight quarters, and are still non-stationary after four years of adjustments. Confronted with the reaction functions of the peripheral countries, the response patterns of the V4 countries to supply shocks seem to be relatively smooth and homogenous.

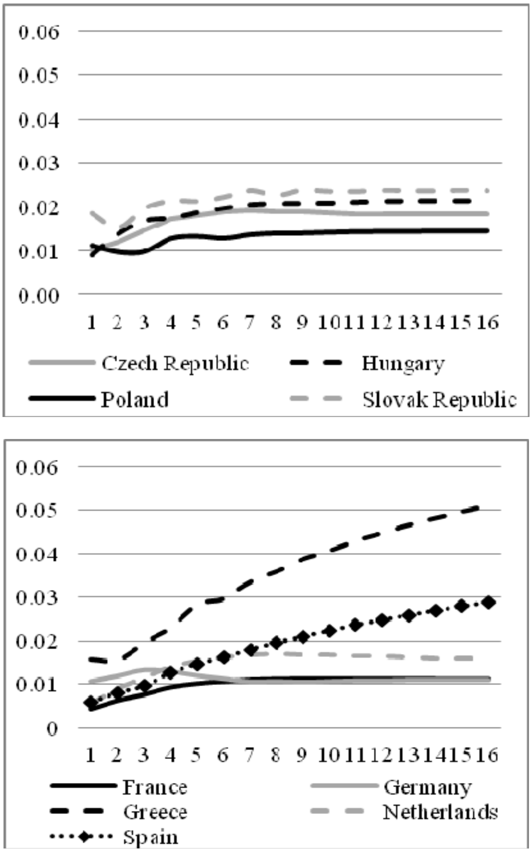

Figure 5. Supply shocks: impulse response functions of output in the V4 and selected EU economies

Source: own elaboration.

The response functions built for demand disturbances in the V4 countries also fit the AS-AD framework (Fig. 6). Except for the Slovak Republic, which oscillates around the equilibrium substantially longer, the shocks in the V4 Group gradually extinguish and return to the baseline after c.a. six quarters. The demand disturbances in other EU economies are considerably more idiosyncratic. There are examples of high sensitivity to shocks (Greece), their long-lasting persistence (France), and strong overshooting in the adjustment (Germany). The reaction of these economies to demand shocks, as measured in the sixth quarter, are either above or below the level to which V4 economies converge. Overall, when compared to other EU economies, the V4 countries are characterized by relatively elastic adjustment to demand shocks and absence of any significant volatility.

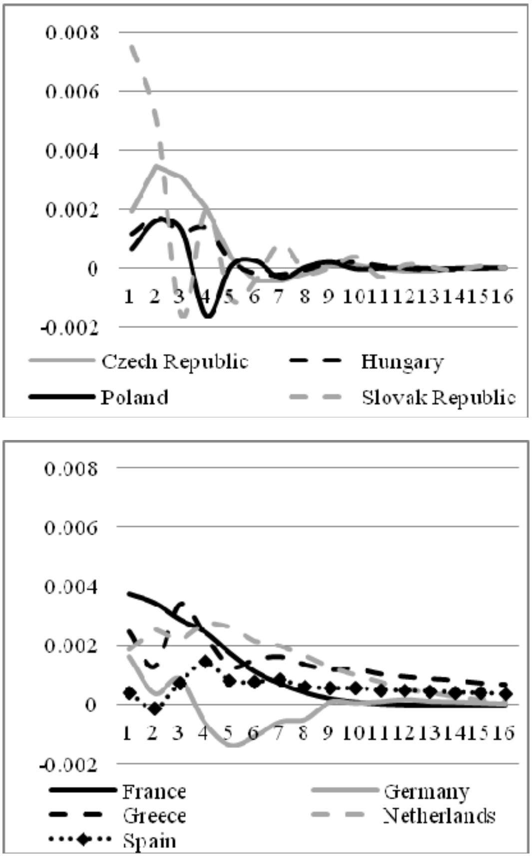

Figure 6. Demand shocks: impulse response functions of output in the V4 and selected EU economies

Source: own elaboration.

5. Conclusions

The main goal of the paper was to assess a degree of coherence of macroeconomic supply and demand shocks in the V4 economies from 1995 to 2013. The investigation was based on the SVAR model with the long-run, theory-based restrictions. This framework allowed us to identify the underlying disturbances in the V4 countries and additional 19 EU economies. The comparative analysis and assessment of the shocks characteristics led us to numerous conclusions, the most important of which we present below.

Concerning the supply shocks, we find that the average correlation among the V4 Group is lower than in any other chosen sub-sample of countries, particularly the core EMU economies. This result was confirmed successively using the static and dynamic approaches. The pairwise analysis also revealed that the V4 countries are characterized by low values of correlation coefficients both with each other and with the remaining EU economies. Furthermore, the magnitude of supply shocks in the V4 Group is significantly stronger than in the 'old' member states. When compared to the peripheral EMU countries, the V4 economies show fast adjustment to this type of shocks.

In spite of the differences identified with respect to the supply shocks, the demand ones give a better justification for the readiness to form a monetary union by the V4 countries. The demand shocks within the four economies are described by the highest correlation among all the chosen sub-samples. The dynamic approach showed that over the entire period of 1996-2013 the synchronization of the demand shocks in the V4 Group was getting tighter, even when compared to the EMU core, often exemplified as an optimum currency area. The pairwise correlations exposed that the Czech Republic and Poland are eligible to unify their currencies, and they also constitute, among all the analysed countries, the best two partners for Hungary to join a currency union. The magnitude of the demand shocks in the V4 economies is higher than in the EMU core, but significantly lower than the corresponding values for the peripheries of the Eurozone. It should be noted, that the adjustments to the demand shocks in the V4 countries are relatively elastic and these economies tend to converge to long-run equilibria in a fast pace. Our findings generally imply that, regarding cohesion of economic shocks, V4 countries as a whole fulfil substantial criteria of an optimum currency area and could benefit from the adoption of a single currency.

The authors are, however, aware of the limitations of the undertaken methodology which allows for extraction of only two main economic shocks. The analysis could be enriched if we considered separately more types of shocks, specifically real and nominal ones. The future research could be also enhanced by employing Bayesian inference techniques and the European regional-level data.

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