Monetary policy effects: comparing macroeconomic impulse responses for the Visegrad Group countries

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Abstract. Our paper focuses on the analysis and comparison of monetary policy impacts on industrial production and inflation in different EU countries. The Visegrad Group (VG) countries (Czech Republic, Slovak Republic, Poland and Hungary) and their specific impulse response dynamic behaviours are compared against each other and with selected euro zone countries. This comparison is based on a standardized VAR model specification (using monthly data from 2000 to 2011 for the underlying estimation). We use Blanchard-Quah [1] decomposition scheme to isolate macroeconomic shocks for further analysis. Alternative VAR model specifications may be used to generate impulse response functions with varied degrees of stratification and interpretation possibilities. We evaluate the homogeneity of expected costs of disinflationary monetary policy among VG countries by studying the impulse response dynamics of the output cost of disinflation. Our results indicate that VG countries do not exhibit a statistically significant symmetric behaviour in response to incurred monetary shocks. The nature of heterogeneous behaviour found is discussed and results are compared to previous studies with similar focus.

Keywords: VAR, impulse-response, monetary policy.

JEL Classification: C32, E31, E52
AMS Classification: 91B64

1 Introduction

Regardless of the general operational framework or individual monetary policy measures applied by the European Central Bank (ECB), individual euro area economies should exhibit reasonably homogenous responses to monetary shocks. Otherwise, conducting common monetary policy would be politically unsustainable in the long term. For example, as the timing and extent of a disinflationary policy action is decided by the ECB upon weighting the expected benefits and costs of such action, countries prone to unfavourable asymmetric macroeconomic shock/response behaviour might soon perceive such restrictive measures as being carried out at their expense. Hence, possible heterogeneities in different aspects of macroeconomic dynamics among prospective euro area member states were widely addressed even prior to establishing the Economic and Monetary Union (EMU). Demertzis et. al. [4] provide relevant overview in their study. Also, ever since the euro currency was actually introduced, there has been an increased interest in studying the potential cross-country differences in monetary policy transmission mechanisms (see e.g. Jarociński [9] for a review of recent literature).

We compare the impulse-response (IR) dynamics (see Hušek [6] for description) relevant for sacrifice ratio (SR) estimates among different EU economies, with main focus on Visegrad Group (VG) countries. Our data panel consists of 2000 – 2011 monthly variable observations for Czech Republic, Slovakia, Hungary, Poland, Austria, Germany, France and EMU total. This article is structured as follows: Next section describes the theory behind IR dynamics used for our calculation and provides a brief literature overview. Third section contains the specification of our econometric model and data used for estimation, along with results and their detailed interpretation. Last section and the list of references conclude our article.

2 The IR dynamics of output cost of disinflation

Evaluation of the expected costs of restrictive (disinflationary) monetary policy is usually based on the SR coefficient, which measures the output cost of disinflation. As in Cecchetti and Rich [2], SR is defined as the cumulative loss in relative GDP growth associated with a one percentage point of permanent reduction in the inflation rate. SR also closely relates to inflation targeting, as we may use it as a proxy for nominal inertia of the economy. Higher SR values indicate a less favourable trade-off between price stability and GDP growth.

Unfortunately, individual SR estimations based on real (observed) macroeconomic data are notorious for contradicting conclusions reached by different authors (see e.g. Cecchetti and Rich [2] or Jarociński [9] for ex-

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tensive literature review). Therefore, due to limitations in available space, we focus mainly on evaluation of the **homogeneity of expected reactions** to disinflationary monetary policy actions. By assessing the homogeneity of impulse response dynamics of the output cost of disinflation for different economies, we effectively approach this topic from the **optimum currency area** (OCA) perspective, as described in detail by Demertzis et. al. [4].

For industrialized countries, it is common to use the loss of industrial production growth instead of the GDP growth for SR analysis, e.g. as shown in Corbo et. al. [3] or Jarociński [9] and we adopt a similar approach in this contribution. As in Hušek and Formánek [7], it should be mentioned that our model is built on the implicit assumption that effects of monetary restrictions and expansions on industrial production, inflation and real interest rate are not systematically different, except for their sign (direction of the effect).

The use of Blanchard-Quah [1] **BQ decomposition** in this contribution may be justified using the following reasoning: as we analyze actual (observed) macroeconomic time series for different countries, we cannot attribute all fluctuations in industrial production, inflation and real interest rate to monetary policy actions. As a first step, we need to identify and isolate monetary policy shocks from other types of shocks. BQ decomposition is a method for identifying the unobservable (e.g. monetary policy) orthogonalized (mutually independent) shocks from residuals obtained by estimating certain types of VAR models. BQ decomposition is based on additional long term economic restrictions in mathematical form. For a simplistic example of BQ decomposition usage, let's assume a VAR model containing only 2 variables: real GDP growth and inflation. We may use IR dynamics to simulate neoclassical supply and demand shocks by implementing an additional assumption that demand shocks in the long term affect only inflation, not real GDP (that is the BQ zero-value identifying restriction). Cecchetti and Rich [2] provide references to literature covering BQ decomposition theory and applications.

3 Econometric modelling and empirical results

Our baseline model estimations for subsequent IR-dynamics comparison is based on a reduced second order VAR specification, VAR(2). For each country *c*, the model may be written as

$$\boldsymbol{y}_{ct} = \boldsymbol{A}_{c1}\boldsymbol{y}_{ct-1} + \boldsymbol{A}_{c2}\boldsymbol{y}_{ct-2} + \boldsymbol{B}_c\boldsymbol{x}_{ct} + \boldsymbol{u}_{ct} \quad , \tag{1}$$

where $\boldsymbol{y}_{ct}$ is a 3x1 vector of endogenous variables (industrial production index, CPI inflation, real interest rate) for country *c*, matrices $\boldsymbol{A}_{c1}$ and $\boldsymbol{A}_{c2}$ contain 3x3 coefficients for the first and second lags of vector $\boldsymbol{y}_{ct}$. $\boldsymbol{x}_{ct}$ is a 5x1 vector of exogenous elements (first and second lag of country-specific nominal effective exchange rate, country specific constant term, common oil price inflation, common dummy variable reflecting the 2008 crisis onset), $\boldsymbol{B}_c$ is a 3x5 matrix of coefficients for $\boldsymbol{x}_{ct}$ and the 3x1 vector $\boldsymbol{u}_{ct}$ contains *random innovations with a potential for contemporaneous correlations*, as shown e.g. in Hušek [6].

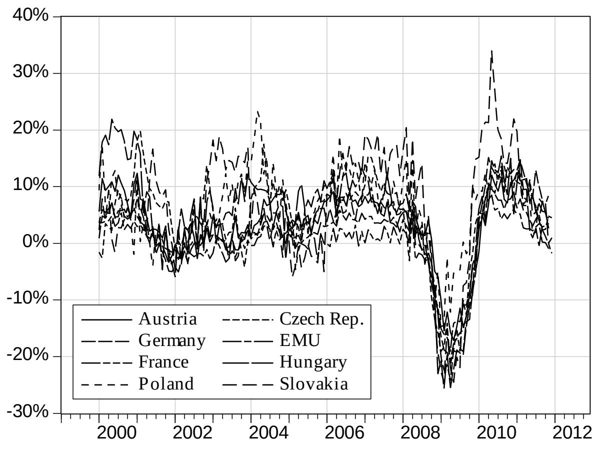

Figure 1 Industrial production: y-o-y index

Model (1) for all countries is estimated using monthly data (2000M03 to 2011M12) from the International Monetary Fund's IFS database (available from http://elibrary-data.imf.org/). Industrial production index (real values, 2005 prices) and CPI inflation are calculated as y-o-y relative changes and real interest rate is the ex-post real p.a. yield from short term assets (nominal interest rate adjusted by CPI index). We follow Jarociński [9] to some extent by introducing the nominal effective exchange rate (NEER) y-o-y relative change, in order to eliminate *price puzzle* IR behaviour, i.e. price level increases in response to a simulated restrictive monetary shock.

World factors are represented by oil price inflation (y-o-y index). From Figure 1, we may observe the onset of the 2008 crisis on industrial production. In order to control for this important shock, we introduce a dummy variable covering twelve consecutive months starting from 2008M09. For the sake of consistency, common dummy variable specification is used for all economies considered, although statistically significant country-specific dummies can be introduced and justified by data mining methods. Similarly, unified VAR(2) specification was also chosen with respect to consistency of estimates throughout different economies. The use of y-o-y relative indexes allows for direct comparison among different countries, eliminating the need for further data transformation into a common currency denomination. EViews 6 software was used for all estimations.

Due to limited space available, we only show results for Czech Republic and Slovakia in Table 1. The remaining estimates, econometric verification outputs and IR-dynamics data are available from the authors upon request. Along with other econometric verification tests, the R^2 coefficients and F-tests provide sufficient assurance for the next step: computation of IR dynamics for evaluation of macroeconomic dynamics homogeneity. Unlike Jarociński [9], we do not compare the individual regression coefficients of the estimated model (1) among different economies, as observed (real) variables are more susceptible to multicolinearity issues than carefully curated artificial sampling. Instead, we exercise the OCA approach by pair wise comparison of the responses of industrial production index and inflation to ε_{ct}^{LM} (monetary shock) among the different economies.

Once stationarity is tested both for data up to 2008M09 (pre-crisis) and for residuals of the model (1) estimated after controlling for the crisis-related fluctuations using the dummy variable previously described, we may re-write our VAR(2) model by switching to a vector moving average (VMA) representation:

$$\begin{bmatrix} ip_{ct} \\ \pi_{ct} \\ (i_{ct} - \pi_{ct}) \end{bmatrix} = \boldsymbol{A}(L) \begin{bmatrix} \varepsilon_{ct}^{ip} \\ \varepsilon_{ct}^{LM} \\ \varepsilon_{ct}^{IS} \end{bmatrix} . \tag{2}$$

In the VMA specification (2) as pioneered by Shapiro and Watson [11], ip_{ct}, π_{ct} and (i_{ct} - π_{ct}) are endogenous variables of the model (1) and $\boldsymbol{A}(L)$ is a 3x3 matrix of polynomial lag operators, as described e.g. in Cecchetti and Rich [2]. As shown by Shapiro and Watson [11], random elements may be interpreted as follows: ε_{ct}^{ip} is an aggregate supply shock, ε_{ct}^{LM} and ε_{ct}^{IS} are aggregate demand shocks (stratified into IS and LM shocks). Hence, for our calculation we associate the non-systematic changes in monetary policy with LM shock, i.e. with ε_{ct}^{LM}. Further theoretical background for such association is provided e.g. by Hušek and Formánek [7]. Estimates of the VAR(2) model from equation (1) were consistently performed for each country in our panel.

BQ decomposition is used to identify the *unobservable orthogonalized shocks* ε_{ct}^{ip}, ε_{ct}^{LM} and ε_{ct}^{IS} from equation (2). Using theoretical reasoning provided by Cecchetti and Rich [2], the additional BQ long-term zero value identifying conditions hold for coefficients c_{12}, c_{13} and c_{23} of the 3x3 long-term BQ identification matrix $\boldsymbol{C}_c$ containing long run cumulative responses of endogenous variables (in rows) to structural shocks (in columns) for each country c. Therefore, demand shocks ε_{ct}^{LM} and ε_{ct}^{IS} have no long-term cumulative effect on industrial production ip_{ct} and IS shock ε_{ct}^{IS} has zero long term cumulative effect on inflation π_{ct}.

Interpretation of empirical results

In this paper, we explore the IR dynamics directly related to SR calculation, i.e. the responses of ip_{ct} and π_{ct} to simulated LM shocks. At the same time, a few related findings should be briefly mentioned: Given Germany's leading economic role in the region, we have experimented with adding lagged German industrial production index as an exogenous variable to VAR(2) models for the remaining individual economies, aiming for better distinction between domestic dynamics and external developments. This approach provides statistically sound and theoretically relevant results for individual economies, yet due to inconsistent statistical significance of lags of German ip_{ct} used as exogenous variable throughout other economies and for the sake of available space we decided to drop such specification from this contribution. Also, from Figure 1 we may see that Slovakia has experienced the most severe relative y-o-y ip_{ct} fluctuations in the observed time series of all the VG countries: -24.5 % in 2009M02, 2009M05 and +34.0 % in 2010M05. Because Slovakia's real exports and other publicly available data for the 2008-2010 period also exhibit fluctuations exceeding other VG countries, we plan to further econometrically approach this topic in order to asses weights of possible causes for this behaviour: absence of monetary policy tools due to euro accession, higher fiscal deficits, decline in foreign direct investment (FDI) dynamics, etc.

Vector Autoregression Estimates. Sample: 2000M03 2011M12. Included observations: 142 (after adj.) Standard errors in ( ).						
	Czech Republic			**Slovakia**		
	ip_{ct}	π_{ct}	$(i_{ct} - \pi_{ct})$	ip_{ct}	π_{ct}	$(i_{ct} - \pi_{ct})$
$ip_{c\ t-1}$	0.598	-0.010	0.016	0.489	0.011	-0.011
	(0.087)	(0.013)	(0.013)	(0.087)	(0.014)	(0.014)
$ip_{c\ t-2}$	0.142	0.017	-0.017	0.277	0.006	-0.005
	(0.082)	(0.012)	(0.012)	(0.079)	(0.013)	(0.013)
$\pi_{c\ t-1}$	2.619	1.194	-0.035	0.608	1.472	-0.157
	(1.977)	(0.290)	(0.288)	(2.121)	(0.340)	(0.335)
$\pi_{c\ t-2}$	-2.682	-0.227	0.062	-0.655	-0.549	0.212
	(1.984)	(0.291)	(0.289)	(2.086)	(0.334)	(0.330)
$(i_{c\ t-1} - \pi_{c\ t-1})$	3.803	0.134	0.892	0.345	0.434	0.886
	(1.991)	(0.292)	(0.290)	(2.177)	(0.349)	(0.344)
$(i_{c\ t-2} - \pi_{c\ t-2})$	-3.558	-0.124	0.070	0.060	-0.433	0.082
	(1.928)	(0.283)	(0.281)	(2.120)	(0.340)	(0.335)
Constant	2.048	0.081	-0.099	1.874	0.173	-0.084
	(0.771)	(0.113)	(0.112)	(2.091)	(0.335)	(0.330)
Dummy variable (*t*)	-6.235	-0.240	0.277	-7.784	0.145	-0.086
	(1.749)	(0.257)	(0.255)	(2.233)	(0.358)	(0.353)
Oil price inflation (*t*)	0.014	0.003	-0.003	0.008	0.002	-0.002
	(0.009)	(0.001)	(0.001)	(0.015)	(0.002)	(0.002)
NEER_index (*t*-1)	-0.214	-0.013	0.010	0.260	-0.006	-0.004
	(0.138)	(0.020)	(0.020)	(0.246)	(0.039)	(0.039)
NEER_index (*t*-2)	0.129	-0.008	0.007	-0.191	-0.005	0.015
	(0.131)	(0.019)	(0.019)	(0.247)	(0.040)	(0.039)
R-squared	0.849	0.945	0.903	0.807	0.951	0.928
Adj. R-squared	0.837	0.941	0.896	0.792	0.947	0.923
S.E. equation	3.132	0.459	0.456	4.778	0.766	0.755
F-statistic	73.504	226.997	121.865	54.760	252.905	169.715
Akaike AIC	5.195	1.356	1.342	6.040	2.378	2.351

Table 1 VAR(2) model estimates for Czech Republic and Slovakia

Based on the estimated model (1) and using BQ decomposition, we may now generate a set of 72 IR functions (responses of 3 endogenous variables to each of the 3 orthogonalized innovations, for all 8 economies) with each IR series spanning 5 years (60 months). For this contribution, we only follow up on the responses of ip_{ct} and π_{ct} to a simulated restrictive monetary shock ε_{ct}^{LM}. While the introduction of lagged $NEER_c$ explanatory variables to our model has improved the overall IR dynamics attributes, it was not completely successful in eliminating the price puzzle. Poland still exhibits sustained price puzzle behaviour and for Slovakia and Germany we experience brief π_{ct} increases (oscillations) after the simulated negative monetary shock ε_{ct}^{LM}.

	Austria	CZ	Germany	Slovakia	EMU	France	Hungary	Poland
Austria	1.0000	0.8079	0.4615	-0.0846	0.9051*	0.6091	0.9797*	-0.2304
CZ	0.8116	1.0000	0.8220	0.3965	0.6938	0.3902	0.7910	-0.5991
Germany	0.9228*	0.7970	1.0000	0.7699	0.1983	-0.1773	0.3736	-0.9347
Slovakia	0.9628*	0.9255*	0.9393*	1.0000	-0.2869	-0.4688	-0.1601	-0.8966
EMU	-0.0434	-0.1092	-0.4175	-0.1625	1.0000	0.8791*	0.9692*	0.0665
France	-0.8556	-0.7525	-0.9788	-0.8935	0.5375	1.0000	0.7473	0.4237
Hungary	-0.7634	-0.9745	-0.6782	-0.8633	-0.1005	0.6044	1.0000	-0.1176
Poland	-0.8696	-0.9725	-0.7866	-0.9405	-0.0303	0.7358	0.9644*	1.0000

Table 2 Correlations of IR dynamics of ip_{ct} (lower triangle) and π_{ct} (upper triangle) after ε_{ct}^{LM} shock

The responses of ip_{ct} and π_{ct} to simulated restrictive monetary shocks may be efficiently compared using correlation coefficients. Table 2 shows both ip_{ct} and π_{ct} IR dynamics correlation coefficients. ip_{ct} coefficients are in the lower triangle (under the diagonal) and homogeneity of π_{ct} IR dynamics is evaluated in the upper triangle. So, for Austria and Czech Republic, the coefficient 0.8116 in Table 2 describes the correlation of ip_{ct} reactions to the ε_{ct}^{LM} shock and the coefficient 0.8079 refers to π_{ct} IR dynamics correlation. Due to data limitations, we were unable to eliminate duplicity in correlation coefficients calculated for EMU total. The bias incurred for Austria and Slovakia is negligible, but EMU's IR dynamics correlations with Germany and France should be interpreted with caution. Fisher's *z*-transformation is used for the evaluation of homogeneity of internal macroeconomic dynamics as measured by the IR functions in Table 2: correlation values significantly exceeding an arbitrarily set homogeneity threshold of +0.8 at the 5 % significance level are marked by *. Interestingly, all ip_{ct} IR functions regarded as homogenous at this significance level also hold their homogeneity even at the 1 % level. For illustration purposes, IR dynamics of ip_{ct} for a group of four most tightly positively correlated economies (as per Table 2) are provided in Figure 2.

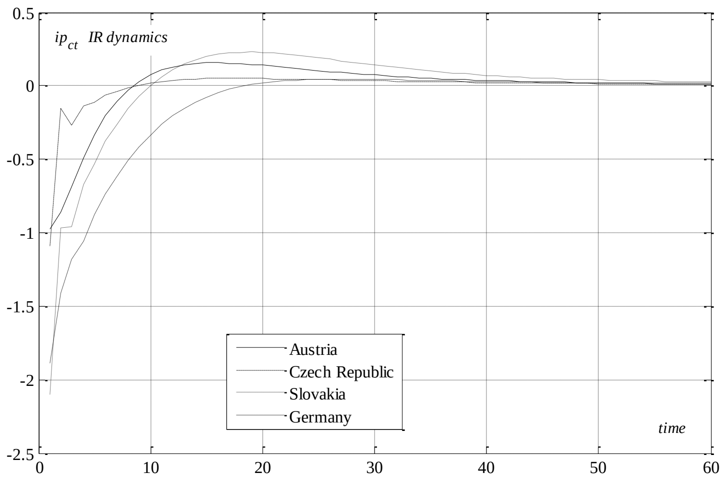

Figure 2 IR dynamics of ip_{ct} resulting from standardized restrictive monetary shock ε_{ct}^{LM}

Correlation coefficients are rather self-explanatory and the level of heterogeneity observed may seem alarming (this interpretation does not change even if the homogeneity threshold is lowered to, say, +0.5). However, the values from Table 2 need to be interpreted considering the theoretical context provided by Mundell [10] and the actual (and arguably successful) existence of common European currency. Also, we should keep in mind that the current euro currency problems are mostly due to prolonged fiscal irresponsibility in certain EMU member states and not induced by asymmetric reactions to monetary shocks.

Hence, in context with previous estimates, as for example in Demertzis et. al. [4] or Hušek and Formánek [8], it is possible to state the following: We do not find a homogenous (common) macroeconomic IR dynamics behaviour pattern among VG countries. Instead, π_{ct} IR functions in Table 2 are rather heterogeneous and for the IR dynamics of ip_{ct} we may discern two main patterns: Industrial production in Czech Republic and Slovakia reacts very similarly to monetary shocks, yet we must bear in mind that only Czech Republic may exercise autonomous monetary policy. Hungary and Poland are also strongly correlated, but they differ from Czech Republic and Slovakia. Although strong historical ties provide a simple explanation for the correlation among ip_{ct} IR dynamics of Czech Republic and Slovakia, it is more difficult to find convincing evidence to support the observed similarity between Hungary and Poland (relatively similar FDI dynamics during the EU accession period era and – generally speaking – ongoing structural changes induced by EU membership should be mentioned as possible significant factors).

Although strong overall heterogeneity of IR dynamics for the economies analyzed was identified, we find evidence for various subgroups of relatively similar economies (i.e. homogeneous IR dynamics). In addition to the two groups mentioned in previous paragraph, Austria-Germany is the most prominent, historically and economically justifiable subgroup. Austria's IR behaviour is also very similar to Czech Republic and Slovakia. On the other hand, Germany and France exhibit strongly dissimilar reactions to monetary shocks, with negatively correlated IR dynamics. The overall heterogeneous IR dynamics among the economies compared should not come as a surprise, they match the findings in other previously published studies on IR dynamics (where GDP growth was used instead of ip_{ct}): For the period 1961Q3 to 1995Q1, Demertzis et. al. [4] have also identified strong asymmetry between Germany and France, as well as among many other 'old' EU economies (EMU candidates at the time of publication of their paper). Hušek and Formánek [8] reach similar conclusions for a different set of EU members, using data from 1997Q2 to 2004Q2. Therefore, robust evidence exists in the analyzed economies for prevalent heterogeneity in internal macroeconomics dynamics induced by monetary restrictive shocks, as measured using the methodology described here.

4 Conclusions

Our results indicate that Visegrad Group countries do not exhibit a unique symmetric behaviour in response to incurred monetary shocks. The reactions of CPI inflation to a simulated monetary restrictive shock are rather heterogeneous. We find two distinctive patterns of IR dynamics in industrial production: after a monetary shock, the response of industrial production in Czech Republic closely resembles Slovakia and Hungary's IR dynamics is similar to Poland – yet the two subgroups are different from each other.

All economies analyzed in this contribution considered, our findings indicate strong heterogeneity in internal macroeconomic dynamics related to monetary policy actions as modelled by IR functions. Also, we find evidence for possible existence of similarly behaving (homogenous) subgroups among the economies analyzed. The magnitude and persistent nature of the heterogeneous behaviour found is supported by comparison to previous studies with similar focus (although actual methodology and data used differ), such as Demertzis et. al. [4] or Hušek and Formánek [8].

Our results should not be interpreted as evidence against common European currency from the point of view of OCA theory, as Mundell [10] and many subsequent theoretical studies (such as Desmet [5]) show that international coordination of monetary policies may help minimizing costs as measured by fluctuations in real macroeconomic variables, even in the presence of prominent asymmetric shocks which are closely related to the heterogeneous IR dynamics behaviour identified here. Also, the current euro zone crisis is generally attributed to long term fiscal irresponsibility in some countries, not to monetary policy issues.

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