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A Panel of Impulse Responses From a Time-Varying Parameter Model

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Explaining the Strength and Efficiency of Monetary Policy Transmission: A Panel of Impulse Responses from a Time-Varying Parameter Model

Jakub Matějů *

Abstract

This paper analyzes both the cross-sectional and time variation in aggregate monetary policy transmission from nominal short-term interest rates to the price level. Using Bayesian TVP-VAR models where structural monetary policy shocks are identified by a mixture of short-term and sign restrictions, I show that monetary policy transmission has become stronger over the last few decades. This finding is robust across both developed and emerging economies. Monetary policy sacrifice ratios (the output costs of disinflation induced by monetary policy tightening) have decreased over the last four decades. Exploring the cross-country and time variation in monetary policy responses using panel regressions, I show that after a country adopted inflation targeting, monetary transmission became stronger and sacrifice ratios decreased. In periods of banking crises, the transmission from monetary policy interest rate shocks to prices is weaker and the related output costs are higher. Furthermore, countries with higher domestic private credit to GDP feature stronger transmission of interest rate shocks.

Abstrakt

Tento článek analyzuje prostorovou i časovou variaci v transmisi měnové politiky od nominálních krátkodobých úrokových sazeb do úrovně cenové hladiny. S použitím bayesovských TVP-VAR modelů, kde jsou strukturální měnověpolitické šoky identifikovány kombinací krátkodobých a znaménkových restrikcí, ukazuji, že transmise měnové politiky v posledních dekádách zesilovala. Tento závěr je robustní napříč vyspělými a rozvíjejícími se ekonomikami. Náklady měnověpolitické restrikce (ztráta výstupu v důsledku dezinflace vyvolané zpřísněním měnové politiky) se během posledních čtyř dekád také snížily. Analýza prostorové a časové variace v transmisi měnové politiky za pomoci panelových regresí ukazuje, že zavedení režimu cílování inflace bylo provázeno zesílením měnové transmise a snížením nákladů restriktivní měnové politiky. V obdobích bankovních krizí byl přenos šokových změn měnověpolitických sazeb do cenové hladiny naopak slabší a náklady restriktivní politiky vyšší. Ekonomiky s vyšším poměrem domácího soukromého zadlužení k HDP vykazují silnější transmisi úrokových šoků.

JEL Codes: C54, E52.
Keywords: Monetary policy transmission, sign-restrictions, TVP-VAR.

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Nontechnical Summary

This paper explores how the transmission of monetary policy shocks to inflation has evolved in a wide set of developed and transition countries. The analysis also aims to establish which factors were associated with stronger, faster, and more efficient transmission, where the efficiency of transmission is defined as the output cost of disinflation (the monetary policy sacrifice ratio).

Simple cross-country studies of the strength of monetary policy transmission suffer from country-specific unobserved factors (omitted variables), which can bias the results. Simple time series analyses, on the other hand, are spoiled by spurious relationships, as possibly many characteristics of economies change simultaneously over time, and deciphering the effects of variables on the characteristics of monetary transmission is close to impossible. Because of that, this paper estimates and analyzes a panel of impulse responses to monetary policy shocks, which allows for exploring both the time and cross-country dimensions.

First, a model with time-varying parameters is estimated on a set of 33 countries, with the data series for some countries reaching back to the 1970s. This leads to estimates of monetary policy impulse response functions which evolve over time, illustrating how monetary policy changed over time in a given economy. The time variation in the parameters allows us to illustrate that monetary policy transmission has strengthened over time and the monetary policy sacrifice ratios have decreased.

Furthermore, I examine the factors which are associated with stronger monetary policy transmission and lower sacrifice ratios. The results suggest that when a country adopted inflation targeting, the response of the price level to a one percentage point monetary policy rate shock strengthened by about 0.1–0.2 p.p. On the other hand, in periods of elevated stress in the banking sector (for the definition of banking crises, the database of Babecký et al. (2012) is used), the transmission is weaker by about 0.05–0.1 p.p. of the price level response to a 1 p.p. shock to the policy rate. The results also suggest that an increase in the ratio of domestic private credit to GDP (higher leverage) is associated with stronger transmission of policy interest rates to the price level, illustrating the importance of the credit channel. Euro area countries and more open economies generally have stronger transmission, in the latter case due to the exchange rate channel. The monetary policy sacrifice ratios decreased with the adoption of inflation targeting and with entry into the euro area, while the costs of monetary restriction in terms of output are higher in banking crises. This finding has a plus side: in banking crises, monetary policy makers can pursue a countercyclical policy and not worry too much about increasing inflation.

However, one has to be cautious when interpreting the results, as they still represent correlations rather than causalities.

1. Introduction

Knowledge of the functioning of the transmission mechanism from the short-term policy interest rate to the price level and output is crucial for the conduct of monetary policy. Central bankers need to know how their decisions about policy interest rates affect the economy. How large is the expected impact of an interest rate cut on output and the price level? What is the time profile of the response of the targeted variables? Obviously, these questions have been frequently addressed in the academic literature. For a quantitative summary of studies estimating monetary transmission in various countries, over different time periods, and using different modeling strategies see Havranek and Rusnak (2012). The current consensus is that the response of the price level to a monetary policy shock reaches its peak in 4–8 quarters. Some studies (Canova et al., 2007; Koop et al., 2009) show that monetary policy has changed over time in some countries. Other studies illustrate the cross-country heterogeneity in monetary transmission (Jarocinski, 2010; Elbourne and de Haan, 2006). A natural policymakers' question would be: what are the drivers of the strength and speed of monetary transmission?

This paper aims to explain the cross-country and time variation in the strength of monetary transmission, focusing on the possible role of the monetary regime and the characteristics of the economy and financial sector. I start by estimating time-varying impulse responses to monetary policy shocks on a sample of 33 OECD and EU countries, keeping the model specification fixed across countries. Having obtained the panel of impulse responses to monetary policy shocks (a monetary policy shock is identified by a mixture of short-term and sign restrictions in the framework of Bayesian time-varying parameter vector autoregression (TVP-VAR); see the methodological part for details), I illustrate the time evolution of the impulse responses over the last four decades. Specifically, the results show that the lags of the price level responses to monetary policy shocks have shortened during the observed period. This may reflect changes in monetary policy strategies and better functioning of financial markets. Furthermore, using panel fixed-effects regressions I show the differences in monetary transmission for different monetary policy regimes: when a country adopted the inflation-targeting monetary policy regime, the transmission from monetary policy interest rates to prices became significantly stronger (by 0.1–0.2 p.p. in response to a 1 p.p. shock to the policy interest rate). On the other hand, inflation targeters as a whole have marginally weaker transmission than euro area countries. In addition, part of the time variation in the fixed-effects model is explained by variables linked to the functioning of the financial sector: while higher leverage in the economy (with higher domestic private credit) is associated with stronger transmission, the occurrence of a banking crisis reduces the magnitude of the response of prices to a monetary policy shock. In a banking crisis, the response of prices to a 1 p.p. monetary policy shock is 0.05–0.1 p.p. lower. The between-effects regressions show that euro area member countries and countries more open to international trade have stronger transmission.

Finally, we examine the "sacrifice ratios" of monetary policy in the spirit of Jarocinski (2010), measuring the ratio of output losses to the price level decrease as a result of a non-systematic monetary policy tightening. The results suggest that the sacrifice ratios have decreased over the last few decades from their peak in the 1970s (which coincides with the U.S. disinflation under the Volcker chairmanship of the Federal Reserve). A monetary policy regime switch to inflation targeting was typically followed by lower output costs of disinflation. In periods of stress in the banking sector the sacrifice ratios were higher.

Still, the standard shortcomings of small-size VAR analysis apply. Due to the limited number of variables in the VAR system, the observed responses may be influenced by shocks to omitted or unobserved variables. The analysis relies on an identification strategy based on a mixture of short-term and sign restrictions, matching the established understanding of the nature of monetary policy shocks. Furthermore, one has to be cautious about interpreting the obtained relationships between the transmission strength and the explanatory variables as causalities. The fixed-effects model mitigates the identification problem to some extent by avoiding time-invariant endogeneity, but other types of endogeneity, most notably omitted variable bias or spurious relationships, may still be present.

Following the introduction, Section 2 describes the empirical methodology in more detail, Section 3 presents the estimated time-varying impulse responses illustrating the time evolution and cross-country heterogeneity of monetary transmission, and Section 4 examines the role of the monetary policy regime, financial sector characteristics, and other economic factors in explaining the cross-country and time variation in the strength of monetary transmission. Finally, Section 5 concludes.

2. Relation to Existing Literature

Early attempts to explain cross-country heterogeneity in monetary policy transmission often focused on the differences in transmission among the members of the European Economic and Monetary Union, both before (Mojon and Peersman, 2001; Ehrmann, 2000) and after euro adoption (Angeloni and Ehrmann, 2003; Ciccarelli and Rebucci, 2002), with mixed conclusions regarding the pre-euro adoption heterogeneity of transmission and its homogenization in euro area countries after euro adoption. The weak conclusions are caused largely by wide confidence intervals of the estimates. Recently, the heterogeneity of transmission in euro area countries has been explored by Ciccarelli et al. (2013), who show the importance of the credit channel during the crisis. Another recent cross-country study by Aysun et al. (2013) focused on the impact of the financial structure on transmission, similarly showing that in economies with higher financial frictions, the credit channel is stronger, as the financial accelerator theory (Carlstrom and Fuerst, 1997; Bernanke et al., 1999) would predict. The role of the financial system and banks in transmission was examined by Ehrmann et al. (2001) using bank-level data. The paper by Mishra et al. (2012) focuses on the role of financial sector development in transmission differences among low-income countries, stressing the role of the degree of development of financial markets and exchange rate arrangements. Berben et al. (2004) examined the heterogeneity in transmission through the lens of the forecasting and policy evaluation models of national central banks of the euro area, concluding that the differences stem from heterogeneity of economic conditions rather than from differences in modeling strategies.

A study close to the analysis conducted here is that of Georgiadis (2012), who attributes the cross-country differences in transmission, estimated through VAR impulse responses, to differences in the financial sector, labor market and industrial mix. However, his work is restricted to a cross-country analysis only and so it cannot control for country fixed effects. There is an inherent omitted variable bias present in such estimations. For better identification of the effects, this paper also explores the time variation in monetary policy transmission. A Bayesian methodology for multi-country estimation of time-varying parameter VARs was proposed by Canova and Ciccarelli (2009). Due to better control over the estimation process, we stick to a set of single-country TVP-VAR models using the methodology of Primiceri (2005), which allows for time-varying (stochastic) volatility.[1] The sample used in this paper is considerably broader than in any previous work, using data for 33 now developed countries, with a time span from 1970 to 2010 where the data permits. This to some extent restricts the set of possible explanatory variables of the strength of monetary transmission. In particular, many financial and labor market indicators started to be collected in a broad set of

[1] Because we estimate the TVP-VARs separately for each country, international spillovers of monetary policy are not captured.

economies only after 2000. The analysis presented here sticks to variables available in a long time series for most countries.

3. Empirical Methodology

To be able to analyze both the cross-country and time variation in the strength of monetary transmission, I need to estimate the impulse responses of monetary policy shocks in the relevant countries and periods. For this purpose, I make use of the time-varying parameter vector-autoregressive model (TVP-VAR) with stochastic volatility as proposed by Primiceri (2005). I include the standard set of variables: output, the price level, the nominal effective exchange rate, the interest rate (as endogenous variables), and oil prices (as an exogenous variable[2]). The reduced-form TVP-VAR with stochastic volatility is estimated using the Bayesian Monte Carlo Markov chain (MC^2) technique (the Gibbs sampler) based on the procedure developed by Primiceri (2005). Structural monetary policy shocks are then identified using a theory-based mix of short-term and sign restrictions. After obtaining the impulse responses to monetary policy shocks, I examine the determinants of cross-country and time variation using panel regressions.

The process can be summarized as follows:

1. Assemble a dataset of 33 OECD+EU countries (where the data coverage permits), including the endogenous and exogenous variables of the VAR and possible determinants of the strength of monetary transmission
2. Estimate a Bayesian TVP-VAR with stochastic volatility, identify structural shocks using short-term and sign restrictions, and compute the impulse response functions
3. Plot the impulse response functions, exploring both the time and cross-country patterns in monetary transmission, including the “sacrifice ratios”
4. Test whether the monetary policy regime and financial sector characteristics matter for the strength of monetary transmission using panel regressions

3.1 Data

For the estimation of the TVP-VARs, I use a quarterly dataset consisting of a seasonally adjusted log-GDP index in constant prices, log-CPI, the money market interest rate – a market-based proxy for the monetary policy target rate, and the logarithm of the nominal effective exchange rate. I also include the logarithm of the oil price index as an exogenous variable.

For the examination of the possible covariates of the strength of monetary transmission and the sacrifice ratios, I use a set of variables consisting of characteristics of the financial sector, the monetary policy regime, and other economic characteristics such as trade openness. The majority of the data were downloaded through Thomson Datastream and come from national sources. The data on exchange rate arrangements and monetary policy regimes were taken from the updated dataset of Reinhart and Rogoff (2004). The data on the occurrence of banking crises are taken from Babecký et al. (2012), where an aggregation of crises recorded by academic papers is complemented by a survey among central bank experts in the relevant countries.

[2] Although the original contribution by Sims (1980) defines VAR with endogenous variables only, later empirical applications have frequently used the restriction that some variables are exogenous to the system (the VAR system with exogenous variables has been called VARX). See Lütkepohl (2007) for details.

The full dataset, including Datastream variable codes, is available from the online appendix.[3]

3.2 TVP-VAR Estimation and Identification

Reduced-form TVP-VAR: I estimate a reduced-form time-varying parameter vector-autoregressive model with stochastic volatility, similarly to Primiceri (2005) and Koop et al. (2009). In models with stochastic volatility, not only the coefficients, but also the covariance matrix of residuals is allowed to change over time. Therefore, these models are able to distinguish between structural changes in the parameters of monetary policy: the "good/bad policy" story (Boivin and Giannoni, 2006; Cogley and Sargent, 2002; Lubik and Schorfheide, 2004), and changes in the magnitude of shocks: the "good/bad luck" story (Sims and Zha, 2006). We estimate the reduced-form system of equations

$$y_t = Z_t \beta_t + u_t$$

where y_t is a vector of endogenous variables (consisting of the logs of output and the price level, the interest rate, and the log of the nominal effective exchange rate), Z_t is a vector of explanatory variables consisting of the lags of the endogenous variables, an exogenous variable (the log of the commodity price index), and the intercept. I use one lag of the endogenous variables in the TVP-VAR system to reduce the number of coefficients to be estimated.[4] The coefficients are time-varying, and I assume they follow a random walk process

$$\beta_t = \beta_{t-1} + \nu_t$$

where ν_t is i.i.d. $\mathcal{N}(0,Q)$. The error term u_t has a potentially time-varying distribution $\mathcal{N}(0,\Omega_t)$. Similarly to Primiceri (2005) I use a triangular reduction of Ω_t such that

$$A_t \Omega_t A_t' = \Sigma_t \Sigma_t'$$

where A_t is a lower triangular matrix consisting of elements $\alpha_{ij,t}$ for $i > j$, ones on the diagonal $(i = j)$, and zeros elsewhere $(i < j)$. Σ_t is a diagonal matrix with $\sigma_{ii,t}$ elements. It follows that

$$\Omega_t = A_t^{-1} \Sigma_t \Sigma_t' (A_t^{-1})'$$

and consequently

$$y_t = Z_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t$$

where ε_t is i.i.d $\mathcal{N}(0,1)$. The elements of matrices A_t and Σ_t follow

$$\alpha_{ij,t} = \alpha_{ij,t-1} + \xi_t$$

$$\log \sigma_{ii,t} = \log \sigma_{ii,t-1} + \eta_t$$

[3] The online appendix is accessible through `http://home.cerge-ei.cz/jakubm/transmission`

[4] Although Bayesian estimation principally avoids the dimensionality problem, the set of parameters to be estimated consists of 4×6 time-varying coefficients in the VAR equations (including the coefficient on the exogenous variables and the intercept), plus the $4 \times 4 + 4$ elements of the time-varying variance-covariance matrices and a number of time-invariant parameters. To maintain a reasonable degree of estimation efficiency I use one lag of the endogenous variables in the VAR system, which is sufficient for capturing the impulse response dynamics.

where ξ_t is i.i.d. $\mathcal{N}(0,S)$ and η_t is i.i.d. $\mathcal{N}(0,W)$. The matrix describing the whole covariance structure of the model,

$$V = \begin{pmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{pmatrix}$$

is block-diagonal, i.e., the shocks in each random walk equation governing the time variation of each model parameter are assumed to be independent across the model parameters.

For the technical details of Bayesian MC^2 estimation (the Gibbs sampler) see Koop and Korobilis (2009) or Primiceri (2005). The priors on the parameters of the model, as well as the hyperparameters (see Appendix A for details), are held constant across the cross-section of countries for which the TVP-VARs are estimated, and I take them from Primiceri (2005).

Sign-restrictions: After estimating the reduced-form TVP-VAR, I identify structural shocks using a mixture of short-term and sign restrictions (Fry and Pagan, 2011). Sign restrictions identification has frequently been used for the analysis of monetary policy (Canova and Nicolo, 2002; Uhlig, 2005; Rafiq and Mallick, 2008; Scholl and Uhlig, 2008; Jarocinski, 2010). For computing time reasons, this paper focuses only on the identification of the monetary policy shock. I restrict the monetary policy shock to have the following pattern:

response to MP shock	log-GDP	log-CPI	IR	ER
on impact	0	0	+	+
in short run (1–4q)	?	?	+	+
at MP horizon (4–6q)	–	–	?	?

i.e., I search for such structural transformation of (transitory) reduced-form shocks where output and the price level react to a monetary policy shock only with a lag and where the response of prices and output is negative at the monetary policy horizon (four to six quarters ahead). The interest rate and exchange rate can react on impact, while the direction of their responses is positive in the short run (up to four quarters) and unrestricted further on. The set of restrictions may appear exhaustive, but as Matthias (2007) shows on data simulated from a structural model, a large number of sign restrictions are needed to correctly identify shocks.[5] The sign pattern used here is consistent with the theoretical consensus of New Keynesian general equilibrium models (Smets and Wouters, 2003; Christiano et al., 2005; Gali and Gertler, 2007).[6] The structural shocks are identified according to Fry and Pagan (2011). First, the candidate structural shocks are obtained from orthogonal (Givens) rotations of a set of uncorrelated shocks which come from the recursive (Choleski) identification. Specifically, in this case the candidate structural shocks are created by multiplying the set of uncorrelated shocks by a Givens matrix $Q(\theta)$, which takes the following form:

$$Q(\theta) = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \cos\theta & -\sin\theta \\ 0 & 0 & \sin\theta & \cos\theta \end{pmatrix}$$

[5] Canova and Paustian (2011) even show that a large number of restrictions can make up for modest model misspecifiations. Another reason for using the mixture of sign and short-run restrictions is that using sign restrictions alone leads to bias in the estimates of the impulse responses, as the posterior distribution of the estimated IRFs is effectively truncated by the sign restriction. The size of the truncation bias was estimated by Liu and Theodoridis (2012), who show that it increases with IRF horizons and VAR lags and amounts to as much as 0.5 p.p.

[6] However, a number of assumptions, such as habit formation, capital installment costs, and persistent autoregressive shocks, need to be made to generate hump-shaped responses in those models.

where the parameters θ are drawn from $U[0,\pi]$. That way, I obtain candidate structural (uncorrelated) shocks. Among the candidate shocks, only those which satisfy the sign restrictions are picked. This identification strategy does not deliver an exact model identification, because I generally find multiple candidate sets of structural shocks which satisfy the restrictions. We follow the consensus (Fry and Pagan, 2011) by reporting the median impulse response of the ones which satisfy the sign restrictions. As I identify only one structural shock, the choice of median model is straightforward.

3.3 Panel of Impulse Responses

As a result, I obtain a panel of impulse responses of the price level to (transitory) monetary policy shocks. I examine the cross-country and time variation first graphically (showing, for example, that the lag of monetary transmission has gradually decreased over recent decades) and then test for the possible correlates of stronger monetary transmission using panel regressions. As a measure of the transmission strength (the explained variable), I use the value of the impulse response function (IRF) at the conventional monetary policy horizons ($h = 4,6,8$ quarters). The different horizons generally yield similar conclusions, so I show only the results for the cumulative response from the impact up to $h = 6$ quarters after the initial shock. Using panel regressions, I proceed by testing the relationships between the strength of the impulse responses and various characteristics of the economy and the financial sector, such as monetary policy regime, stock market capitalization, trade openness, and occurrence of banking crises. The standard errors are clustered at country level.

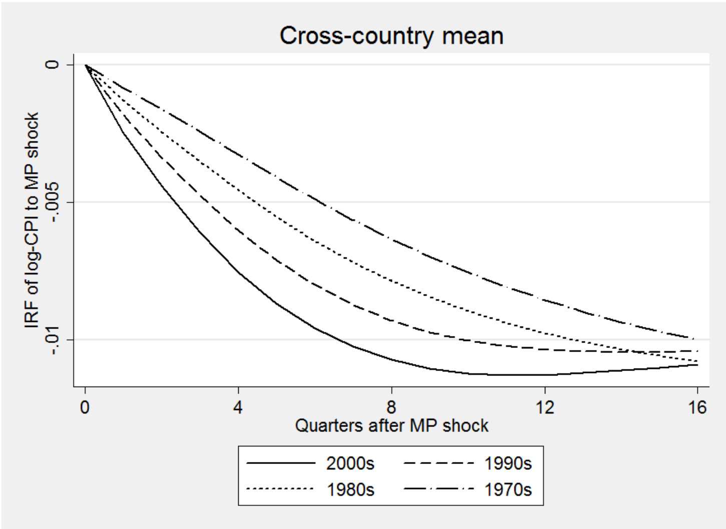
Using panel fixed effects and between estimators I am able to distinguish which of the factors capture the cross-country variation and which are better at capturing the time variation in the strength of monetary transmission. For example, the results suggest that although euro area countries generally feature stronger monetary transmission of monetary policy shocks than inflation targeters, the fixed-effects estimator (explaining the time variation) shows that when a country adopted inflation targeting, its transmission strengthened on average. Moreover, the results suggest that in periods of elevated financial stress (captured by the occurrence of banking crises), monetary policy transmission is weaker. On the other hand, part of the cross-country variation can be explained by the degree of openness: more open economies have stronger transmission on average, probably because of the exchange rate channel. Finally, with increasing leverage the transmission is stronger.

Finally, I compute and analyze the behavior of the monetary policy sacrifice ratios in the spirit of Jarocinski (2010). The sacrifice ratios measure the output cost of disinflation, i.e., how much output needs to be sacrificed to deliver lower inflation after a monetary tightening, and are defined as $\frac{IRF^{GDP}(h)}{IRF^{P}(h)}$ at horizon h. According to the results, the sacrifice ratios have decreased over time after having peaked during the 1980s. The figures below also show that the inflation-targeting monetary policy regime is associated with lower output costs of disinflation. Moreover, the sacrifice ratios increase in periods of financial stress in the banking sector.

4. Results: Cross-country Characteristics and Time Evolution of Monetary Transmission

In this section, the impulse responses from the TVP-VAR on the sample of 33 countries are presented, illustrating both the cross-country and time variation in the impulse responses to a monetary policy shock of a magnitude of one percentage point.

Figure 1: Evolution of the IRFs of CPI to an MP Shock over Decades



First, I present the time evolution of the response of log-CPI to a monetary policy shock. Figure 1 shows the mean impulse responses averaged across countries (data permitting) as they have evolved over the last four decades. Note that the panel of impulse responses is unbalanced because of data restrictions during the first two decades of the sample in particular.[7] The figure shows that monetary transmission has strengthened considerably over the last 40 years. At the same time, the hump-shape of the IRF of log-CPI to a monetary policy restriction has become more pronounced, with the peak response now occurring earlier after the initial shock. This illustrates that the lags of the response of prices to monetary policy shocks have become shorter.[8]

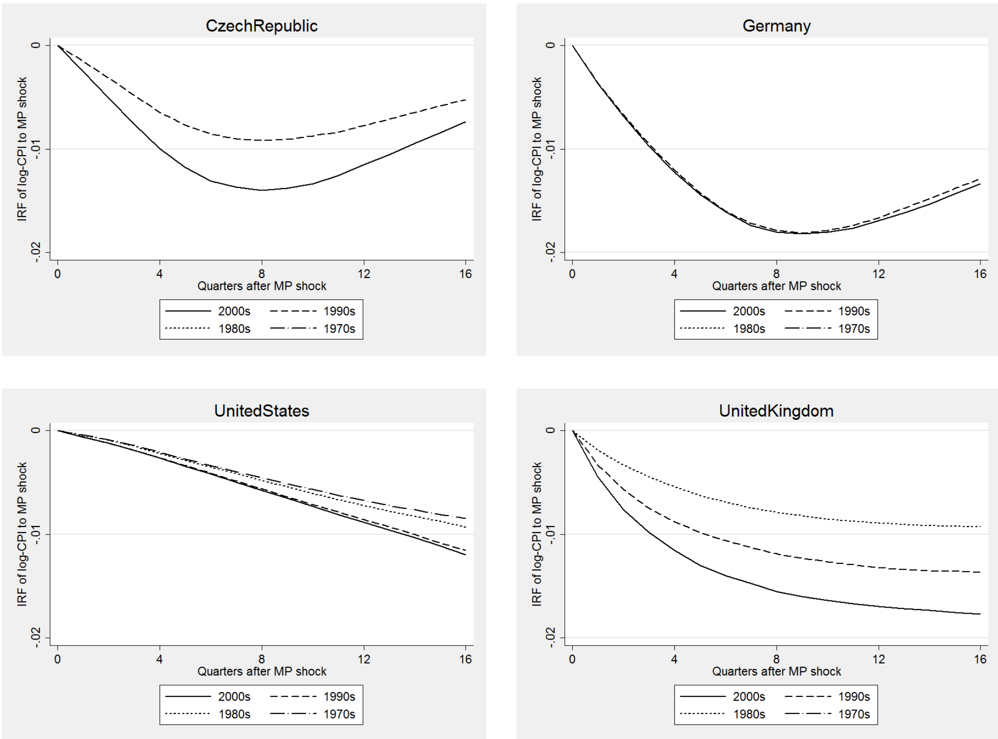
Figure 2 shows the evolution of the impulse responses in several selected countries. The Czech Republic is chosen to represent (historically) developing inflation-targeting countries, the UK to represent a developed inflation-targeting economy, Germany to represent a major euro area economy, and the U.S. as the world's leading economy. The development of monetary transmission in these four countries represents the overall trends in recent decades. The transmission from short-term interest rates to prices has become stronger, and the duration between the initial shock and the peak response in CPI (where there is one) has become shorter.

Figure 3 (left panel) illustrates the different strength and speed of monetary transmission under different monetary policy regimes. The figure presents the typical (mean) impulse responses of

[7] Confidence intervals for the estimates are not explicitly presented, as the uncertainty consists of both model uncertainty (generally more impulse responses satisfy the restrictions) and parameter uncertainty. However, the parameter uncertainty around the mean impulse responses is fairly stable across countries, periods, and horizons and amounts to about 0.5–0.8 p.p.

[8] Note that all the shocks represent deviations from a systematic monetary policy rule rather than actual monetary policy actions. In other words, the presented IRFs illustrate the responses to non-systematic shocks. These could represent either a situation where the policy rule would imply no reaction, but monetary policy reacted, or the opposite situation where monetary policy should have reacted according to the rule, but did not, or the reaction was weaker than that implied by the policy rule (or stronger, or even went in the opposite direction). The (time-varying) monetary policy rule is estimated as part of the TVP-VAR model, constituting one of the equations of the VAR system. The model allows for an immediate reaction of the monetary policy rate to developments in all endogenous variables and the exogenous variable, and as such it can be considered a generalization of the simple empirical Taylor (1993) rule.

Figure 2: Evolution of the IRFs of CPI to an MP Shock in Different Countries



the price level to a 100 b.p. monetary policy restriction for countries operating under inflation targeting, members of the euro area, non-euro pegged exchange rate regimes, and non-inflation-targeting floaters. As monetary policy transmission has changed over time (as illustrated in Figure 1) and, at the same time, countries have been adopting inflation targeting and entering the euro area, spurious relationships are likely to arise. We control for the time trends here by subtracting time effects (the cross-country mean for each time period) from the values of the IRFs in the relevant periods. Still, the differences stem from both the cross-country and time variation, as there have been changes of monetary policy regime during the sample period.

Interestingly, the transmission of (non-systematic) monetary policy is strongest in countries using the euro, even after controlling for the time effects of the generally stronger transmission in more recent time periods. This finding may not be that surprising given that euro area members face a common monetary policy, which may not be fully suited to the needs of individual economies. Therefore, the deviations from the country-specific, idiosyncratic monetary rules (represented by the VAR equation with the interest rate as the explained variable) are generally larger and more frequent. As Castelnuovo (2012) and Matthias (2007) show, when the variance of shocks is large, their identification using sign restrictions is better. Another explanation may be that the euro area countries are among the nations with the most developed financial sectors in the sample, which may be associated with better functioning transmission.

Figure 3 (right panel) illustrates the mean IRFs for countries going through a banking crisis. Again controlling for time effects, the figure shows that during banking crises the transmission is marginally weaker. It is important to note that the presented typical responses for the different regimes mix two sources of variation arising from different dimensions: cross-country variation and time variation. For example, transmission can become weaker when a country enters a banking

Figure 3: IRFs of CPI to an MP Shock under Different MP Regimes and in Banking Crises

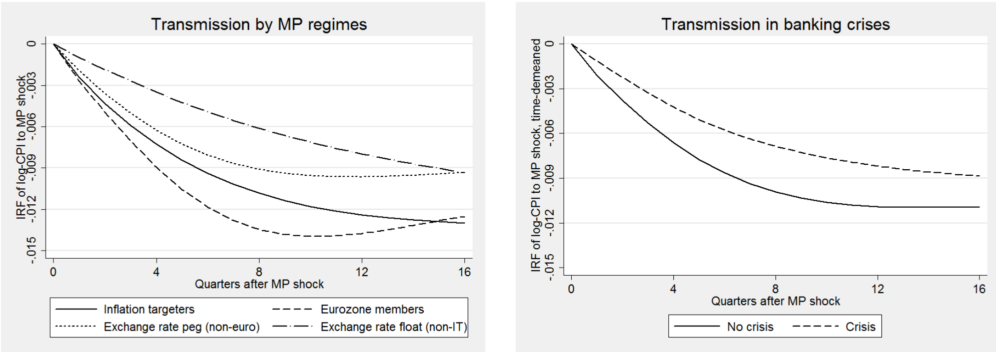
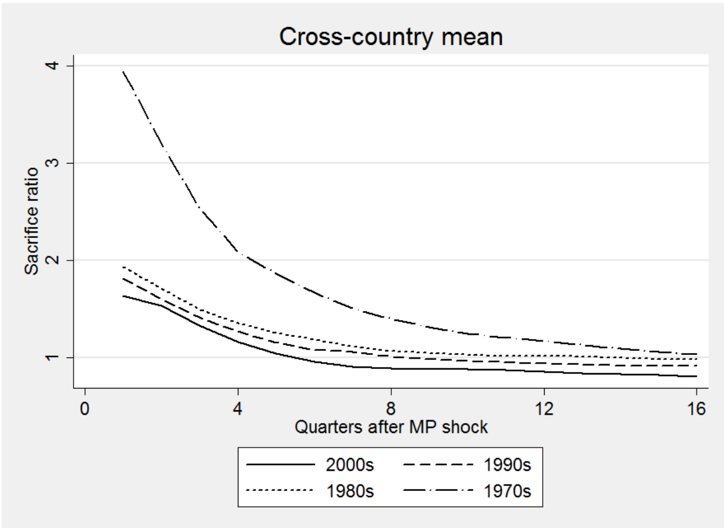


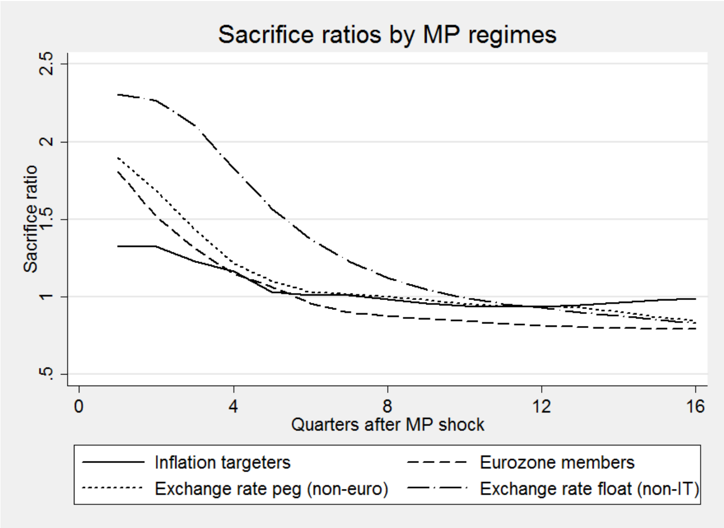
Figure 4: Evolution of the Monetary Policy Sacrifice Ratios over Decades



crisis, but may be stronger in countries which generally experience crises more frequently. The presented figures pool the two dimensions. As the identification of pure cross-country effects is a rather difficult task because of possibly many omitted variables (unobserved country-specific endogeneity), more reliable relationships can be obtained from the time variation in each. To distinguish between the two dimensions of variation, we later run both between-effects and fixed-effects panel estimators.

Figure 4 illustrates the evolution of the monetary policy sacrifice ratios over recent decades. As defined earlier, the sacrifice ratios show how much output (in %) has to be sacrificed on average to induce a 1% decrease in the price level at a desired horizon, given the estimated impulse response functions of (real) log-GDP and log-CPI to a monetary policy shock. In other words, the sacrifice ratios measure the output costs of disinflation. We illustrate that the monetary policy sacrifice ratios have decreased substantially since the 1970s. Finally, Figure 5 shows that the sacrifice ratios are marginally lower for inflation targeters at short horizons. Possible determinants of the lower sacrifice ratios are analyzed in the next section.

Figure 5: Sacrifice Ratios under Different MP Regimes



5. Results: Factors Associated with the Characteristics of Monetary Transmission

Finally, I examine the cross-country and within-country variation using panel regressions. While the IRF plots presented above mix these two dimensions of variation together, in this section I show that when one controls for country fixed-effects, the results can be different.

In the fixed-effects regressions the following equation is estimated:

$$IRF^P(h)_{i,t} = \alpha_i^{FE} + \beta^{FE} X_{i,t} + \varepsilon_{i,t}^{FE} \tag{5.1}$$

where $X_{i,t}$ captures possible explanatory variables for the strength of monetary policy transmission. The fixed-effects regression measures the correlation of the within-country variation in the explanatory variables with the cumulative response of the price level to a monetary policy shock. We present results for $h = 6$. We use clustered standard errors at the country level, as the standard errors are probably correlated within country.

The between-effects regression explains the cross-country variation, which is filtered out in the above fixed-effects regression. The between-effects equation is the following:

$$IRF^P(h)_i = \alpha^{BE} + \beta^{BE} X_i + \varepsilon_i^{BE} \tag{5.2}$$

where both the left- and right-hand side variables are within-country averages. The between-effects regression may be largely influenced by the problem of omitted variables, as there are possibly many country-specific factors not explicitly included in the regression. I believe that there is more information value in the fixed-effects model, which filters out this time-invariant endogeneity, while the coefficients of the between-effects model can be interpreted only as correlations.

The results, presented in Table 1, suggest that when a country adopted the inflation-targeting monetary policy regime, the transmission of monetary policy to the price level became 0.1–0.2 p.p. stronger in response to a 1 p.p. shock to the monetary policy rate. For comparison and evaluation

Table 1: Correlates of the Cumulative Response of Price Level to a MP Shock after 6 Quarters

	FE	BE	FE full	BE full
InflTargeters	-0.00176***		-0.00137***	-0.000172
	(-4.52)		(-3.81)	(-0.06)
DomPrivCredit	-0.0000151***		-0.0000132***	-0.00000994
	(-4.12)		(-2.84)	(-0.41)
BankCrisis	0.000725***		0.000759***	0.00862
	(3.69)		(3.58)	(0.99)
Eurozone		-0.00844***	-0.000152	-0.00568
		(-3.25)	(-0.47)	(-1.41)
Openness		-0.0000353*	-0.0000139	-0.0000208
		(-1.75)	(-1.27)	(-0.83)
MktCapitalization			6.07e-18	1.18e-16
			(0.07)	(0.21)
GovtDebt			0.00000507	0.0000248
			(0.69)	(0.71)
Constant	-0.00579***	-0.00364*	-0.00564***	-0.00666*
	(-17.05)	(-2.02)	(-6.34)	(-1.78)
Observations	3256	3284	2631	2631
Adjusted R^2	0.274	0.262	0.194	0.055

Note: t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Correlates of the MP Sacrifice Ratios at the Horizon of 6 Quarters

	FE	FE full	BE full
InflTargeters	-0.108***	-0.0862***	-0.863
	(-4.95)	(-4.57)	(-0.96)
Eurozone	-0.0507***	-0.0301	-1.307
	(-3.75)	(-1.62)	(-1.11)
BankCrisis	0.0865	0.0521**	0.221
	(1.46)	(2.31)	(0.09)
MktCapitalization		-2.41e-16	-8.17e-14
		(-0.08)	(-0.49)
DomPrivCredit		0.0000692	0.0000552
		(0.27)	(0.01)
GovtDebt		0.00217	0.00314
		(1.32)	(0.31)
Openness		-0.000140	-0.00817
		(-0.33)	(-1.11)
Constant	1.452***	1.319***	2.469**
	(147.19)	(11.98)	(2.26)
Observations	3311	2631	2631
Adjusted R^2	0.085	0.152	-0.117

Note: *t* statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

of the economic significance of this effect, as Figure 1 shows, the mean cumulative response at the monetary policy horizon is 1 p.p. The relationship between inflation targeting and stronger transmission can be attributed to increased transparency, more careful communication, and increased monetary policy credibility, all of which are typical features of the inflation-targeting regime. Transparency was also found to be crucial for monetary transmission in the empirical study by Neuenkirch (2011), while the theoretical work of Amato et al. (2002) emphasized the role of public information for coordination. For a survey on the evolution and role of central bank communication, see Blinder et al. (2008).

Furthermore, stress in the banking sector seems to disrupt the functioning of monetary policy transmission. The occurrence of banking crises shows a significant relationship with a weaker effect of monetary policy interest rate shocks on prices. In periods of banking crises, the response of the price level to a 1 p.p. monetary policy shock has been about 0.05–0.1 p.p. lower on average. This is probably because of disrupted pass-through from policy rates to client interest rates on loans, caused by elevated risk premia on both the interbank market and client loans. The financial-stress-related disruptions to the monetary policy transmission mechanism (Adrian and Shin, 2009) seem to outweigh the potential amplification effects of the financial accelerator, which would predict stronger transmission when frictions in the financial markets are more substantial (as is likely during banking crises). On the other hand, a higher ratio of domestic private credit to GDP is associated with stronger monetary policy transmission, as more leveraged economies respond more strongly to changes in interest rates through the credit and balance sheet channels, while the wealth effects of interest rate changes are also larger. This finding is in line with the suggestions of the financial accelerator literature (Bernanke et al., 1999; Carlstrom and Fuerst, 1997) and related empirical studies (Ciccarelli et al., 2013).

The fixed-effects regression using the full set of explanatory variables (the third column in Table 1) shows that other variables are of less relevance.

The cross-country variation suggests that more open economies (with higher trade-to-GDP ratios) seem to feature stronger monetary policy transmission. This is probably an effect of a stronger exchange rate channel. Euro area members have also seen stronger transmission. This may be an effect of country-specific unobserved factors, as euro area countries are among the nations with the most developed financial sectors in the sample.

Table 2 shows the correlates of the monetary policy sacrifice ratios with the explanatory variables. Notably, inflation targeting is shown to be associated with more favorable sacrifice ratios, i.e., lower output losses are needed for disinflation. This can again be attributed to the higher credibility and transparency associated with inflation targeting, although a similarly favorable (albeit slightly weaker) result applies to euro area members. In addition to generally weaker monetary policy transmission in banking crises, the analysis shows that banking stress (both crisis occurrence and an increased non-performing loans ratio) is also associated with higher output costs of monetary policy-induced disinflation. As these effects are symmetric, this result also offers an optimistic interpretation: during banking crises, monetary policy can help the real economy recover by means of monetary stimulus without increasing inflation too much.

6. Concluding Remarks

This paper mapped monetary policy transmission across time and space. Taking an aggregate view of the transmission from monetary policy interest rates to the price level, it documented the role of financial sector characteristics and the monetary policy regime on the strength and efficiency of monetary policy transmission. The aggregate approach allows for quantification of the effects.

I constructed a panel of time-varying impulse response functions for 33 countries, with the time span ranging from 1970 to 2010 where the data permitted. Estimating Bayesian TVP-VAR models with the same specification for all countries and identifying the monetary policy interest rate shock using a mixture of short-term and sign restrictions, I obtained time-varying impulse responses of the price level and GDP to a monetary policy shock for each country in the sample. The time-varying model suggests that the transmission of monetary policy has strengthened over time and the transmission lags have become shorter, while the monetary policy sacrifice ratios have gradually decreased.

Furthermore, I analyzed the possible determinants of the strength of monetary policy transmission. Exploiting both cross-country and within-country variance using panel regressions, the role of various financial and institutional characteristics of economies in the strength of monetary policy transmission was examined. The results suggest that inflation targeting is associated with stronger transmission and more favorable monetary policy sacrifice ratios. When a country adopted inflation targeting, the response of prices to a 1 p.p. policy interest rate shock became 0.1–0.2 p.p. stronger on average. On the other hand, stress in the banking sector is associated with disrupted monetary policy transmission and higher sacrifice ratios. In a banking crisis, the response of CPI to a 1 p.p. shock was about 0.05–0.1 p.p. lower. In addition, a higher domestic private credit to GDP ratio is associated with stronger transmission, as a higher leverage ratio implies that interest rate changes have a larger impact through the credit and balance sheet channels. Finally, more open economies feature stronger responses to monetary policy shocks, probably due to the exchange rate channel.

I am well aware that the observed relationships cannot be interpreted as causalities, as various forms of endogeneity may still be present even when time and country fixed effects are controlled for. Further work addressing endogeneity issues and exploring the quantitative implications of financial and institutional factors for transmission in a more structural framework could be valuable topics for future research.

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Appendix A: Bayesian TVP-VAR Estimation: Some Technical Details

We use one lag in the VAR system, to keep the space of the estimated (time-varying) coefficients reasonably sized. The number of Gibbs sampler iterations varies across countries. Those with longer time series typically need more draws to reach convergence, as the paths of the time-varying parameters (or, equivalently, the respective errors) to be estimated are longer. Generally, we used 10,000 burn-in draws and 2,000–10,000 effective draws depending on whether a reasonable degree of convergence was reached. Convergence was diagnosed using the autocorrelation functions of the Markov chain and Raftery and Lewis (1992) convergence diagnostics. The priors on the parameters of the model and the hyperparameters are set according to Primiceri (2005). Specifically,

$$\beta_0 \sim \mathcal{N}(\hat{\beta}_{OLS}, 4.\mathrm{var}[\hat{\beta}_{OLS}])$$

$$A_0 \sim \mathcal{N}(\hat{A}_{OLS}, 4.\mathrm{var}[\hat{A}_{OLS}])$$

$$\log \sigma_0 \sim \mathcal{N}(\log \hat{\sigma}_{OLS}, 4I_n)$$

i.e., the prior distributions are normal for matrices Z and A and log-normal for vector σ, where the means are the OLS estimates of Z, A, and σ from a time-invariant VAR. The prior variances on Z and A are set at four times the variances from a time-invariant VAR, while the prior variance on $\log \sigma$ is four times the identity matrix. The priors on the hyperparameters are set as follows:

$$Q \sim \mathscr{IW}(k_Q^2.\tau.\mathrm{var}[\hat{Z}_{OLS}], \tau)$$

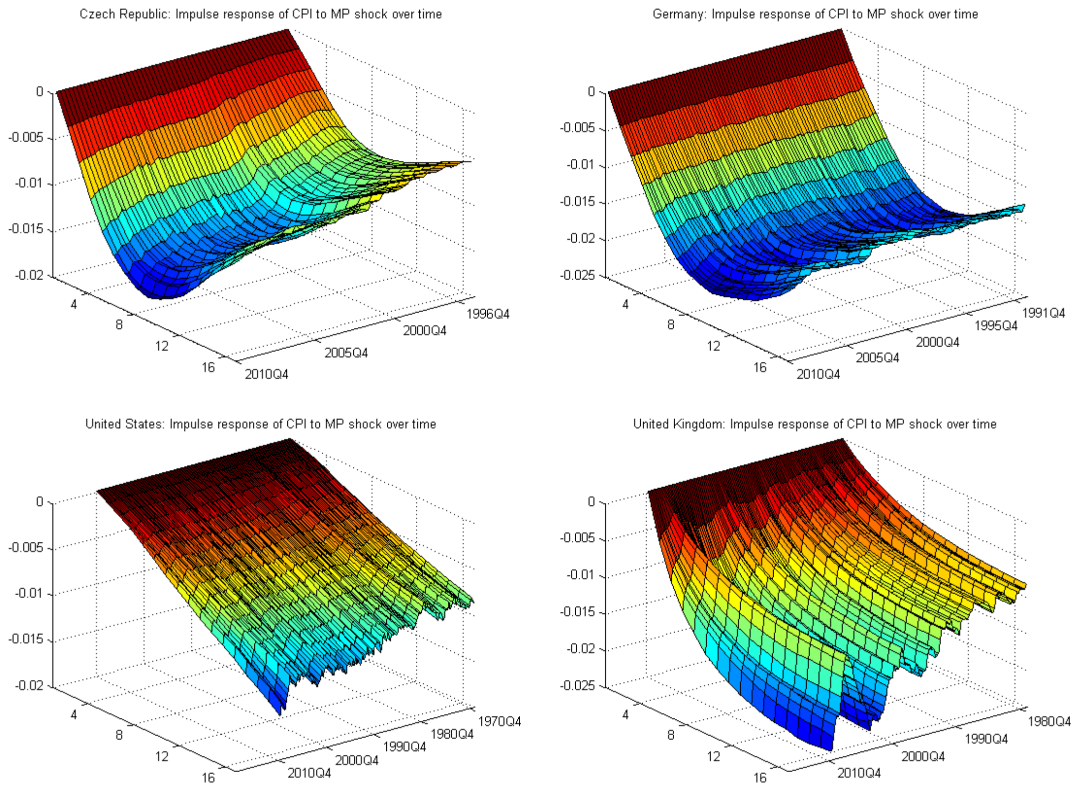
$$W \sim \mathscr{IG}(k_W^2.(1+\dim(W)).I_n, (1+\dim(W)))$$

$$S_\tau \sim \mathscr{IW}(k_S^2.(1+\dim(S_\tau)).\mathrm{var}[\hat{A}_{\tau,OLS}], (1+\dim(S_\tau)))$$

where τ is the size of the training sample, and S_τ and $\hat{A}_{\tau,OLS}$ are the corresponding parts of the respective matrices. We use the whole time series as the training sample. The prior hyperparameter mean factors are set to $k_Q = 0.01$, so that we attribute 1% of the uncertainty around the time-invariant OLS estimate to time variation. Also, $k_W = 0.01$ and $k_S = 0.1$ – we again follow Primiceri (2005) here.

Appendix B: Additional Results

Figure B1: Evolution of the IRFs of CPI to an MP Shock in Different Countries



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