

Interest premium and economic growth: the case of CEE*

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Abstract

This paper views the growth and convergence process of the four Visegrad economies - the Czech Republic, Hungary, Poland and Slovakia - through the lens of the open economy, stochastic neoclassical growth model. We estimate for these countries a version of the model augmented by simple financial frictions. Our main question is whether shocks to the growth rate of productivity (“trend”), or shocks to the external interest premium are more important to understand the volatility of GDP growth and its components. We find that while GDP growth fluctuations can be traced back to trend shocks, the composition of GDP - and the trade balance in particular - was driven by premium shocks. Investment specific and labor market shocks are also important, but we find a very limited role for transitory technology shocks. Our panel estimation allows us to separate global and local components for the productivity trend and interest premium shocks. Results indicate that the global trend component is well approximated by the growth rate of the advanced European Union economies, and we also find tentative evidence that recent investment behavior is driven to a large extent by European Union funds. When looking at the global component of the implicit interest rate recovered from the estimation, we find that it closely tracks the observed real interest rate in the EU 15 countries until 2008, but sharply diverges afterwards. This last finding is consistent with the hypothesis that various capital market wedges and non-price restrictions to lending became important during and after the global financial crisis.

Keywords: stochastic growth, technology shocks, interest premium, small open economy, Bayesian estimation.

JEL: E13, O11, O41, O47

1 Introduction

Our goal in this paper is to examine the growth and convergence process of the Visegrad countries (the Czech Republic, Hungary, Poland and Slovakia) through the lens of the stochastic neoclassical growth model. In this we follow Aguiar and Gopinath (2007) and García-Cicco, Pancrazi and Uribe (2010), who estimate similar models for Latin-American countries (Mexico and Argentina). We believe that the four Visegrad countries are a good laboratory for the neoclassical model. They are emerging economies, which are highly open both to international trade

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and external finance. Their performance is broadly in line with the predictions of the neoclassical model, where convergence is driven by improvements in total factor productivity (TFP) and capital accumulation. Openness allows countries to finance some of their additional investment and consumption from abroad, which is exactly what happened in the Visegrad countries after transition in the 1990s. Also, after the introduction of market reforms in the early 1990s, the Visegrad economies have reasonably similar institutions to the advanced market economies of Western Europe, the natural reference group.

The literature has identified two main shocks that drive stochastic growth in small, open economies like the Visegrad countries. Aguiar and Gopinath (2007) compare Mexico and Canada, and conclude that in the former shocks to trend productivity growth are more important than in the latter. The main reason is that in emerging economies, like Mexico, the trade balance is counter-cyclical. Transitory TFP shocks imply a pro-cyclical trade balance, since households want to save part of the temporary windfall gains. Permanent and lasting trend shocks, on the other hand, imply improving growth performance for a while, leading to increases in current and future permanent income. In that case, households want to consume some of the future gains now, which implies a trade deficit.

García-Cicco, Pancrazi and Uribe (2010) criticize Aguiar and Gopinath (2007) for ignoring the role of financial frictions and shocks. In particular, they argue that external financing conditions - which can be taken as exogenous for small, open emerging countries - are important growth determinants. They estimate a financial frictions augmented RBC model on a century of Argentine data, and conclude that including interest premium shocks in the estimation greatly reduces the importance of trend productivity shocks.. Increases in interest premia induce recessions and improve the trade balance at the same time, thus they can also explain the counter-cyclicity of the latter. Moreover, in the absence of financial frictions the trade balance is a random walk, which is at odds with the data in emerging economies. That said, García-Cicco et al. (2010) find that growth volatility is mainly due to transitory technology shocks, at least in Argentina and Mexico.

Other papers have also followed up on the technology vs. interest premium debate. Naoussi and Tripier (2013) and Guerron-Quintana (2013) showed that a common trend productivity component better explains medium-term GDP growth volatility in African countries than financial shocks. In contrast, Tastan (2013) finds that in Turkey financial shocks are more important. Many papers try to understand the role of financial intermediation more deeply. Zhao (2013) builds a model where agents face liquidity constraints, and it is the changes in liquidity that lead to fluctuations in the risk premium. Minetti and Peng (2013) assumes asymmetric information between domestic and foreign creditors, which becomes effective when income prospects worsen. This leads to a large response in external financing, which increases country risk and the effective foreign interest rate.

We contribute to this literature in a number of ways. First, we reevaluate the findings of Aguiar and Gopinath (2007) and García-Cicco et al. (2010) in the context of the Visegrad countries. We find that while interest premium shocks are important to understand the trade balance, shocks to the growth rate of productivity are the most important contributors to the volatility of GDP growth. In other words, productivity has a strong random walk component,

and transitory technology shocks turn out to be fairly unimportant. More generally, our estimation casts doubt on whether transitory technology shocks can be separately identified, especially once we include hours in the estimation, and allow for labor market disturbances. To paraphrase Aguiar and Gopinath (2007), in our countries *the trend is the financial frictions augmented cycle*.

Second and perhaps most interestingly, we estimate the exogenous driving forces of economic growth in a panel. While the time series are short, using a panel of four countries gives us degrees of freedom to identify the underlying shock processes. Using a panel we can separate “global” shocks that affect all countries from “local” shocks that are specific to a country. We show that the global components of both the trend productivity shock and the interest premium shock have a very nice economic interpretation. In particular, the global trend component co-moves very strongly with the growth rate of the “old” European Union countries (EU 15). The implicit common interest rate component also tracks the EU 15 average real interest rate until 2008, but diverges from it sharply afterwards. This finding is consistent with a narrative of the financial crisis in which wedges opened up both between the financial markets of advanced and emerging countries, and between benchmark interest rates and corporate/household lending rates.

We make a number of additional methodological contributions, mostly related to the model setup. We include external consumption habits, which is an alternative to the estimated very persistent preference shock used by García-Cicco et al. (2010). We use adjustment costs to investment instead of capital, and add an investment specific shocks. This specification was shown to capture investment dynamics better in a business cycle setting (Christiano, Eichenbaum and Evans, 2005). When we plot our estimated investment specific shock, we find an interesting co-movement between the shock and the magnitude of European Union funds flowing into the Visegrad countries. This suggests that in addition to the growth and financial environment, external funds were a major determinant of investment dynamics.

We use a labor market specification that is growth consistent and does not require the inclusion of an ad-hoc trend in the value of leisure. As we later explain, this necessitates adding a working capital channel and using a gross output production function to get reasonable predictions for interest premium shocks. In addition to the technical reasons, we also think that the working capital channel is an important propagation mechanism of changes in financial conditions. Finally, we use total labor hours as an observable, and we add a labor supply shock to the estimation. On the one hand, observing hours should make the identification of technology shocks more precise. On the other hand, changes in labor market regulation and taxes were important in the Visegrad countries.

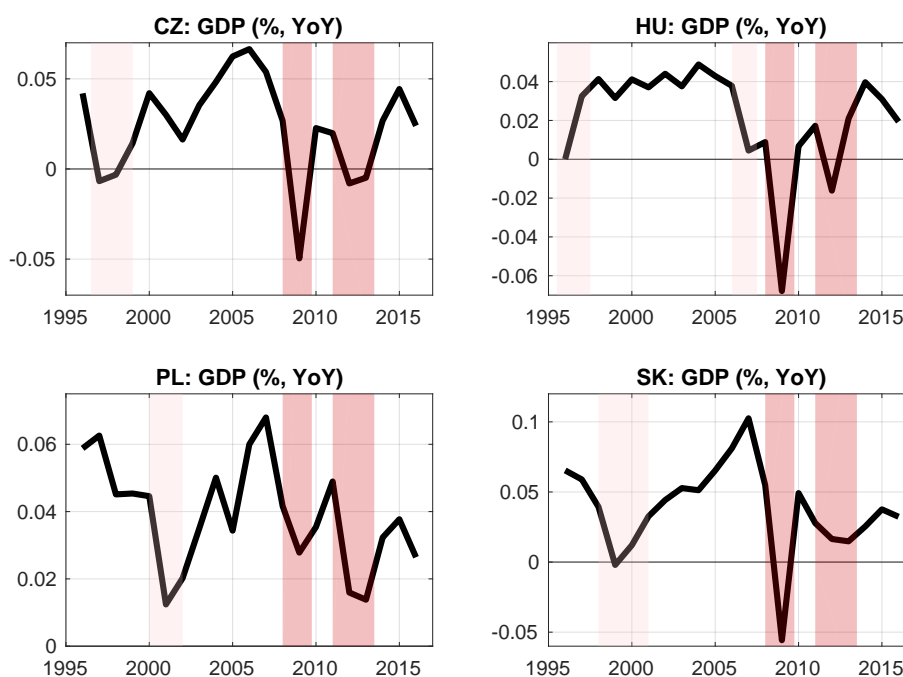
The paper proceeds as follows. In Section 2, we present the basic stylized facts of growth in the Visegrad countries in the 1996-2016 period. In Section 3, we describe the stochastic growth model. In Section 4, we estimate the stochastic version of the model and present results from historical shock decompositions. Using the estimation results, Section 5 presents interesting findings that we believe strongly validate our estimation results. Finally, Section 6 concludes and discusses future avenues for research.

2 Growth in the Visegrad countries

Before the modeling exercise we describe the main tendencies of the macroeconomic data. Our narrative is based on IMF Article IV reports which are useful for the interpretation of the estimation results.¹ Figure 1 plots the evolution of real GDP for the four countries. Lightly shaded periods are country-specific recessions or growth slowdowns, while the two darkly shaded periods are the global financial crisis and the subsequent European crisis, which were common to all countries.

The collapse of socialist regime fundamentally changed the economic performance of the Visegrad countries. From the middle of the 90s economic growth was boosted by structural reforms, a positive future economic outlook and supportive external economic developments. Massive inflows of foreign direct investment generated current account deficits, but the favorable investment climate and the good timing of fiscal consolidation eliminated pressures on country risk.

Figure 1: Growth in the Visegrad countries



The figure shows real GDP growth in the four Visegrad countries. Shaded regions indicate recessions or slowdowns. Source: Eurostat.

The start of the convergence period was different across Visegrad countries. Hungary was the first that implemented fiscal consolidation and a privatization plan. The start of the Bokros package² led to a temporary decline in GDP growth, but later from 1997 contributed to robust

¹Czech Republic: <http://www.imf.org/en/Countries/CZE>, Hungary: <http://www.imf.org/en/Countries/HUN>, Poland: <http://www.imf.org/en/Countries/POL>, Slovakia: <http://www.imf.org/en/Countries/SVK>.

²<https://www.mnb.hu/letoltes/wp1998-5.pdf>

growth. In the Czech Republic transition started later. In 1997 the Czech koruna experienced a currency crisis, and Czech growth slowed down markedly in the second half of the 90s. In Slovakia, the end of the Meciar era and the fiscal reforms of the new government³ led to a temporary slowdown in GDP growth. Due to subsequent labor market and fiscal reforms from the beginning of the 2000s, however, Slovakian growth became the highest among the Visegrad economies. Poland was the last country that decided on fiscal reforms (the Hausner plan⁴) and a reorientation of its foreign trade after the Russian crisis. Therefore, the Polish convergence path is significantly different from the pattern of its peer countries.

The ‘Great Moderation’ was a period before the financial crisis with low inflation and low interest rates in developed economies. Due to the ex-ante positive growth outlook and favorable financial conditions, the growth of domestic demand was supported by cheap credit expansion and all countries experienced significant current account deficits.

In 2009, except for Poland, the Visegrad countries experienced a significant drop in economic growth and were forced to start a strong deleveraging process. After the crisis all countries recorded historically unprecedented trade surpluses. Deleveraging came with significant economic sacrifice and slowed down the growth of domestic demand components. Hungary was the most indebted country; hence Hungarian deleveraging was the most dramatic and long-lasting. In the past decade the growth of private investment remained subdued. Large inflows of EU funds, especially from 2010, compensated somewhat for external adjustment costs. The precautionary motive still dominates households’ consumption expenditure. In Hungary, for example, in 2016 real private consumption is still below its pre-crisis level. Other Visegrad countries were less heavily indebted, therefore they were more resilient, and recovered more quickly after the economic slack.

The convergence stories of the last 2 decades are the mix of global (common or regional specific) and local (country specific) events. To explore the fundamental stories and key shocks behind the data, we need to apply a structural model to decompose the data into different innovations. During the pre-crisis period productivity growth and favorable financial conditions led to strong economic growth, but the crisis and the post-crisis deleveraging fundamentally changed the previous patterns. Without structural models, however, it is hard to say anything about the core mechanism and compare the different growth stories.

3 The model

We use a modified version of the stochastic, neoclassical growth model described in Gracia-Cicco, Pancrazi and Uribe (2010), or GPU henceforth. This is a one-sector, small open economy, where output is used for household consumption, capital investment, net exports and government consumption. Production requires labor and capital. Final good and factor markets are competitive, with flexible prices. The engine of growth is exogenous improvements in productivity; we specify the productivity process later. For simplicity, and given the demographics of the Visegrad countries, we assume that there is no population growth.

³http://www.finance.gov.sk/en/Components/CategoryDocuments/s_LoadDocument.aspx?categoryId=347&documentId=433

⁴http://ec.europa.eu/economy_finance/publications/pages/publication10063_en.pdf

It is well known that aggregate variables are more persistent than the basic neoclassical model predicts, even at the annual frequency (Christiano, Eichenbaum and Evans, 2005). In our case, this is an important issue, since the convergence simulations start at an arbitrary initial condition, determined by data availability (typically 1995) and heavily influenced by the exact timing of economic transition in each country. For this reason we add a few real rigidities to the basic model, which capture the slow adjustment of the main macro variables. We therefore assume external habits in consumption and adjustment costs to investment.

An important deviation from GPU is that while they assume GHH preferences (Greenwood, Hercowitz and Huffman, 1988), we opt for a more standard separable specification (King, Plosser and Rebelo 2002; henceforth KPR). The reason for this is that GHH preferences have a counterfactual prediction for labor hours in catching-up economies. As we show below, however, our preference specification makes interest premium shocks expansionary, in contrast to GHH preferences. Therefore, we assume a working capital channel, which was shown to provide useful amplification for financial shocks (Mendoza, 2010) Moreover, we work with gross output, and impose financing requirements on intermediate inputs as well as the wage bill. Overall, we are able to construct a production structure that leads to plausible predictions both along the medium-run transition path and along the short-run business cycle.

3.1 Households

The representative household solves the following problem:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\log (C_t - \chi \bar{C}_{t-1}) - \frac{\theta_t h_t^\omega}{\omega} \right]$$

$$\text{s.t. } C_t + D_t = W_t h_t + \frac{D_{t+1}}{R_t} + \Pi_t + \Xi_t,$$

where C_t is consumption, h_t is hours worked, D_{t+1} is foreign debt carried into the next period, R_t is the gross interest rate on debt, and Ξ_t is government spending financed by lump-sum taxes.⁵ Households earn wages (W), and profits (Π) from the representative firm that they own. Note that consumption is subject to external habit formation (\bar{C}_{t-1}).

There are three structural shocks that affect household decisions. First, we take government spending to be exogenous and random:

$$\log \Xi_t = (1 - \rho_\xi) \log \bar{\Xi} + \rho_\xi \log \Xi_{t-1} + \nu_t^\xi.$$

Second, the interest rate on foreign bonds is subject to exogenous disturbances. The interest rate also has an endogenous component, which depends on the external indebtedness of the economy (Schmitt-Grohé and Uribe, 2003):

$$R_t = \bar{R} + \psi \left(e^{D_t/Y_t - d_y} - 1 \right) + e^{\epsilon_{r,t}} - 1,$$

⁵We assume that government consumption is purely wasteful. Equivalently, we could include it in the utility function in an additively separable form.

where

$$\epsilon_{r,t} = \rho_r \epsilon_{r,t-1} + \nu_{r,t}.$$

Finally, labor supply - or more broadly, the labor market - is influenced by an exogenous term θ_t , given as:

$$\log \theta_t = (1 - \rho_h) \log \bar{\theta} + \rho_h \log \theta_{t-1} + \nu_t^h$$

The first-order conditions of the problem are given as follows:

$$\begin{aligned} \frac{1}{C_t - \chi \bar{C}_{t-1}} &= \Lambda_t \\ \theta h_t^\eta &= \Lambda_t W_t \\ \Lambda_t &= \beta R_t \mathbb{E}_t \Lambda_{t+1}, \end{aligned}$$

where Λ_t is the Lagrange multiplier associated with the budget constraint.

3.2 Firms

Factor, intermediate and final good markets are perfectly competitive. We start with the specification of gross output for the representative firm:

$$Y_t^G = \left[\Upsilon e^{a_t} K_t^\alpha (X_t h_t)^{1-\alpha} \right]^{1-\mu} M_t^\mu, \quad (1)$$

where K_t is capital input, and M_t is the amount of intermediate inputs. The variable X_t represents the stochastic trend component of productivity, which evolves according to the following process:

$$\begin{aligned} \frac{X_t}{X_{t-1}} &= g_t \\ \log g_t &= (1 - \rho_g) \log \bar{g} + \rho_g \log g_{t-1} + \nu_t^g. \end{aligned}$$

In addition, we include a transitory productivity shock a_t , as in Aguiar-Gopinath (2007) and García-Cicco et al. (2010). Note that Υ is a constant that is included to be able to choose units conveniently (see below).

Firm profits are give as follows:

$$\Pi_t = \left[\Upsilon K_t^\alpha (X_t h_t)^{1-\alpha} \right]^{1-\mu} M_t^\mu - R_t M_t - R_t W_t h_t - I_t, \quad (2)$$

where I_t stands for gross investment, and

$$K_{t+1} = (1 - \delta) K_t + \left[1 - \frac{\phi}{2} \left(\frac{e^{\tilde{\epsilon}_{i,t}} I_t}{I_{t-1}} - \bar{g} \right)^2 \right] I_t. \quad (3)$$

Note that we impose a working capital financing requirement on the wage bill and on intermediate inputs, so that the firm has to pre-finance these fully. We also add a shock to gross investment ($\tilde{\epsilon}_{i,t}$). The purpose of this shock is to drive a wedge between the Euler equations of consumption and investment.

We derive the first-order conditions in two steps. First, we optimize out the use of intermediate inputs, which is given by

$$R_t M_t = \mu Y_t^G \quad (4)$$

Plugging this back into the gross output production function, we can express total production in terms of value added:

$$Y_t^G = \left(\frac{\mu}{R_t} \right)^{\frac{\mu}{1-\mu}} \Upsilon Y_t,$$

where $Y_t = e^{a_t} K_t^\alpha (X_t h_t)^{1-\alpha}$. Combining this expression with (4) and substituting it into (2), we can rewrite profits as

$$\begin{aligned} \Pi_t &= (1 - \mu) Y_t^G - R_t W_t h_t - I_t \\ &= (1 - \mu) \left(\frac{\mu}{R_t} \right)^{\frac{\mu}{1-\mu}} \Upsilon Y_t - R_t W_t h_t - I_t \\ &= R_t^{\frac{\mu}{1-\mu}} Y_t - R_t W_t h_t - I_t, \end{aligned}$$

where the second equality follows from a convenient normalization, $\Upsilon (1 - \mu) \mu^{\frac{\mu}{1-\mu}} = 1$.

The second step in solving the representative firm's problem is to find labor demand and capital investment. Using the derivation above, we can state the problem in value added form as follows:

$$\begin{aligned} \max \Pi_0 &= \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t}{\Lambda_0} \left[R_t^{\frac{\mu}{1-\mu}} K_t^\alpha (X_t h_t)^{1-\alpha} - R_t W_t h_t - I_t \right] \\ \text{s.t. } K_{t+1} &= (1 - \delta) K_t + \left[1 - \frac{\phi}{2} \left(\frac{I_t e^{\tilde{\epsilon}_{i,t}}}{I_{t-1}} - \bar{g} \right)^2 \right] I_t, \end{aligned}$$

where the appropriate stochastic discount factor reflects that households are the ultimate owners of firms. Using q_t for the usual Tobin's q multiplier for the capital accumulation constraint, the first order conditions are given by the following equations:

$$\begin{aligned} R_t^{\frac{1}{1-\mu}} W_t h_t &= (1 - \alpha) Y_t \\ q_t \epsilon &= \beta \mathbb{E}_t \left[R_{t+1}^{\frac{\mu}{1-\mu}} \frac{\alpha Y_{t+1}}{K_{t+1}} + (1 - \delta) q_{t+1} \right] \frac{\Lambda_{t+1}}{\Lambda_t} \\ 1 &= q_t \left[1 - \frac{\phi}{2} \left(\frac{I_t e^{\tilde{\epsilon}_{i,t}}}{I_{t-1}} - \bar{g} \right)^2 e^{\tilde{\epsilon}_{i,t}} - \phi \left(\frac{I_t e^{\tilde{\epsilon}_{i,t}}}{I_{t-1}} - \bar{g} \right) \frac{I_t e^{\tilde{\epsilon}_{i,t}}}{I_{t-1}} \right] \\ &\quad + \beta \mathbb{E}_t q_{t+1} \phi \left(\frac{I_{t+1} e^{\tilde{\epsilon}_{i,t+1}}}{I_t} - \bar{g} \right) \left(\frac{I_{t+1} e^{\tilde{\epsilon}_{i,t+1}}}{I_t} \right)^2 \frac{\Lambda_{t+1}}{\Lambda_t}. \end{aligned}$$

3.3 Equilibrium

Combining the household and firm first-order conditions, and writing down the aggregate resource constraint, the evolution of the model economy is given by the following set of equations:

$$\begin{aligned}
\theta_t h_t^\omega &= \frac{(1-\alpha) Y_t \Lambda_t}{R_t^{\frac{1}{1-\mu}}} \\
\Lambda_t &= \frac{1}{C_t - \chi \bar{C}_{t-1}} \\
1 &= \beta R_t \mathbb{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} \\
q_t &= \beta \mathbb{E}_t \left[R_{t+1}^{\frac{\mu}{\mu-1}} \frac{\alpha Y_{t+1}}{K_{t+1}} + (1-\delta) q_{t+1} \right] \frac{\Lambda_{t+1}}{\Lambda_t} \\
1 &= q_t \left[1 - \frac{\phi}{2} \left(\frac{I_t e^{\tilde{\epsilon}_{i,t}}}{I_{t-1}} - \bar{g} \right)^2 e^{\tilde{\epsilon}_{i,t}} - \phi \left(\frac{I_t e^{\tilde{\epsilon}_{i,t}}}{I_{t-1}} - \bar{g} \right) \frac{I_t}{I_{t-1}} e^{\tilde{\epsilon}_{i,t}} \right] \\
&\quad + \beta \mathbb{E}_t Q_{t+1} \phi \left(\frac{I_{t+1} e^{\tilde{\epsilon}_{i,t+1}}}{I_t} - \bar{g} \right) \left(\frac{I_{t+1} e^{\tilde{\epsilon}_{i,t+1}}}{I_t} \right)^2 \frac{\Lambda_{t+1}}{\Lambda_t} \\
Y_t &= C_t + I_t + D_t - \frac{D_{t+1}}{R_t} + \Xi_t \\
K_{t+1} &= (1-\delta) K_t + \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - \bar{g} \right)^2 \right] I_t \\
Y_t &= K_t^\alpha (X_t h_t)^{1-\alpha} \\
R_t &= \bar{R} + \psi \left(e^{D_{t+1}/Y_t - d_y} - 1 \right) + e^{\epsilon_t^r} - 1
\end{aligned}$$

The stochastic processes for the structural shocks were defined above.

The system is not stationary, since productivity has a stochastic trend. We introduce variables in effective form, that are constant in the deterministic steady state: $c_t = C_t/X_t$, $i_t = I_t/X_t$, $y_t = Y_t/X_t$, $k_{t+1} = K_{t+1}/X_t$, $d_{t+1} = D_{t+1}/X_t$, $\xi_t = \Xi_t/X_t$ and $\lambda_t = X_t \Lambda_t$. Using

these new variables, the equilibrium system is given as:

$$\begin{aligned}
\theta_t h_t^\omega &= \frac{(1-\alpha)y_t \lambda_t}{R_t^{\frac{1}{1-\mu}}} \\
\lambda_t &= \frac{1}{c_t - (\chi/g_t)\bar{c}_{t-1}} \\
1 &= \beta R_t \mathbb{E}_t \frac{1}{g_{t+1}} \frac{\lambda_{t+1}}{\lambda_t} \\
q_t &= \beta \mathbb{E}_t \frac{1}{g_{t+1}} \left[R_{t+1}^{\frac{\mu}{\mu-1}} \frac{\alpha g_{t+1} y_{t+1}}{k_{t+1}} + (1-\delta) q_{t+1} \right] \frac{\lambda_{t+1}}{\lambda_t} \\
1 &= q_t \left[1 - \frac{\phi}{2} \left(g_t \frac{i_t e^{\tilde{\epsilon}_{i,t}}}{i_{t-1}} - \bar{g} \right)^2 - \phi \left(g_t \frac{i_t e^{\tilde{\epsilon}_{i,t}}}{i_{t-1}} - \bar{g} \right) \frac{g_t i_t e^{\tilde{\epsilon}_{i,t}}}{i_{t-1}} \right] \\
&\quad + \beta \mathbb{E}_t Q_{t+1} \phi \left(g_{t+1} \frac{i_{t+1} e^{\tilde{\epsilon}_{i,t+1}}}{i_t} - \bar{g} \right) \left(\frac{g_{t+1} i_{t+1} e^{\tilde{\epsilon}_{i,t+1}}}{i_t} \right)^2 \frac{\lambda_{t+1}}{\lambda_t} \\
y_t &= c_t + i_t + \xi_t + tb_t \\
tb_t &= \frac{d_t}{g_t} - \frac{d_{t+1}}{R_t} \\
k_{t+1} &= (1-\delta) \frac{k_t}{g_t} + \left[1 - \frac{\phi}{2} \left(g_t \frac{i_t e^{\tilde{\epsilon}_{i,t}}}{i_{t-1}} - \bar{g} \right)^2 \right] i_t \\
y_t &= \left(\frac{k_t}{g_t} \right)^\alpha h_t^{1-\alpha} \\
R_t &= \bar{R} + \psi \left(e^{d_{t+1}/y_t - d_t} - 1 \right) + e^{\epsilon_t^r} - 1,
\end{aligned} \tag{5}$$

where tb_t is the normalized trade balance.

3.4 Interest premium shocks and the labor market

Before we move onto the estimation, we present some basic results that motivated our modeling choices. It is well-known that the labor market is central to the behavior of the RBC model. In our model the labor market equilibrium condition is written as follows:

$$\theta_t h_t^\omega = \frac{(1-\alpha)Y_t \Lambda_t}{R_t^{\frac{1}{1-\mu}}}.$$

Assume for simplicity that there are no habits in consumption, in which case $\Lambda_t = 1/C_t$, and:

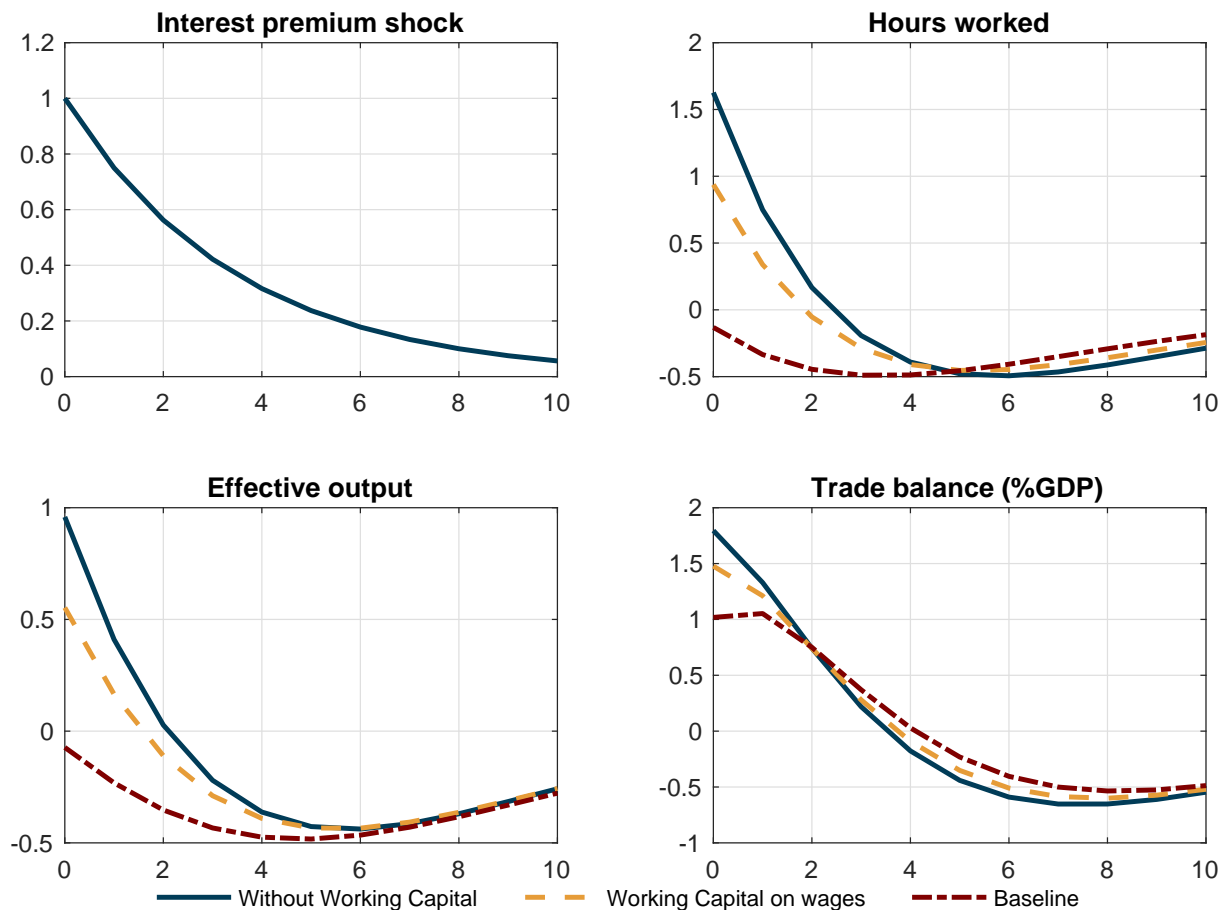
$$\theta_t h_t^\omega = \frac{1-\alpha}{R_t^{\frac{1}{1-\mu}} \cdot (C_t/Y_t)}. \tag{6}$$

The advantage of this specification is that it is consistent with the existence of a balanced growth path (BGP), since the consumption-output ratio C_t/Y_t is constant along the BGP. In our context, however, there is a disadvantage as well. In the absence of the working capital channel, hours are negatively correlated with the consumption-output ratio. This means that a positive interest premium shock, which leads to a decline in C_t/Y_t and in I_t/Y_t , leads to an increase in hours worked and output. The fact that labor supply increases to a negative income shock is not

necessarily unreasonable. On the other hand, the general equilibrium outcome that a tightening of financing conditions is expansionary in an open economy is implausible. To counter the labor supply effect, we introduce a working capital channel to create a negative labor demand effect.

The net effect of a risk premium shock on hours worked depends on the relative strength of the labor demand and labor supply channels. In our specification, the first one dominates, and an increase in the risk premium is contractionary. It is important to emphasize that having a working capital channel is not enough for this result. The cost increase has to be significant, which cannot be achieved with a standard value added production function alone. Using a gross output concept, and imposing the pre-financing condition on intermediate inputs is necessary to create a strong enough cost channel. This result was also found in Mendoza (2010), who constructs a more elaborate model of financial frictions where default is possible.

Figure 2: The effects of a risk premium shock



The figure shows model simulations without a working capital channel, with working capital financing imposed only on wages, or with working capital financing both on wages and intermediate inputs (the baseline).

Figure 3.4 illustrates these results. We plot the effect of a 1 percentage point temporary increase in the risk premium shock. The three lines correspond to (i) the baseline with gross output and working capital requirement for intermediate inputs and wages, (ii) a scenario where only wages need to be pre-financed, and (iii) a scenario without the working capital channel.

Both hours worked and output rise on impact, unless intermediate inputs are included in the working capital requirement. With a value added production function the working capital channel is simply not strong enough to counter the increase in labor supply. Notice, on the other hand, that the trade balance is not particularly sensitive to the working capital specification.

An alternative to the working capital channel is to use GHH preferences, as found in García-Cicco, Pancrazzi and Uribe (2010). Under the GHH specification (again ignoring habits and assuming a unitary intertemporal elasticity of substitution), period utility is written as

$$u_t = \log \left(C_t - \frac{\theta_t X_t h_t^\omega}{\omega} \right),$$

and the labor market equilibrium condition is

$$\theta_t h_t^\omega = (1 - \alpha) y_t. \tag{7}$$

In this case, an increase in the risk premium is contractionary, even without a working capital requirement. The cost of capital goes up, which decreases output and wages, and this leads to a decline in labor supply, since there is no opposing income effect.

There are a few reasons why we do not use the GHH specification. First, the mechanism is not very convincing, and it is at odds with recent models of financial frictions, which emphasize labor demand. Second, hours are very strongly linked to effective output. With our calibrated value of $\omega = 1.6$, a 10% increase in output is associated with a 6% rise in total hours. Taken seriously, this implies that in converging economies (with effective output well below the steady state) we should observe much lower hours. This is again a prediction that is counterintuitive and seems to be at odds with the data. Finally, when we estimated the model with a GHH specification, the overall fit and the various diagnostics proved to be much worse than under the KPR setup with working capital.⁶ The shock decompositions, on the other hand, were fairly similar to the ones we present below.

4 Shock estimation

In order to estimate the stochastic shocks, we log-linearize the equilibrium conditions in (5) around the deterministic steady state. The observable variables are the growth rates of GDP, consumption, investment and hours, and the trade balance - GDP ratio. We use raw data as much as possible, so we only demean the growth rates (except for hours, which are stationary both in the model and in the data) with the country-specific average growth rates of GDP per capita.

An important point worth emphasizing is that we do not use an observed interest rate in the estimation. This is standard in RBC-type models, and the main reason is that the real interest rate that is relevant for household and firm decisions might be quite different from real interest rates calculated from policy or money market rates. In fact one of our goals is to compare our implicit, model-based interest rate to an observed time series. As we show in Section 5, this turns out to be a quite interesting and illuminating exercise.

⁶The results of this exercise are available from the authors upon request.

We calibrate most of the model parameters, and focus on the shock processes. It is well-known that DSGE models suffer from serious identification problems (Canova and Sala, 2009). Therefore we do not estimate parameters that are either easy to calibrate (such as the capital share), or which are hard to separately identify (such as various adjustment costs). For the latter, we use standard values from the literature (see details below).

The time series for the Visegrad countries are short, especially at the annual frequency.⁷ To strengthen identification, we therefore estimate the model on the panel of the four countries. We assume that the structural parameters are the same across the four economies, but we allow flexibility in the shock processes. We assume that for the trend productivity shock and the interest premium shock innovations contain both a common and a country-specific component:

$$\log g_t^j = \rho_g \log g_{t-1}^j + \nu_{g,t} + \nu_{g,t}^j \quad (8)$$

$$\epsilon_{r,t}^j = \rho_r \log \epsilon_{r,t-1}^j + \nu_{r,t} + \nu_{r,t}^j, \quad (9)$$

where j indexes countries. The innovations ν_g and ν_r represent the external growth and financial environment, which are likely to be important determinants of growth in the Visegrad countries. All other shocks are assumed only to have local innovations.⁸

We impose the same autoregressive parameter for the four countries for each shock. This is partly because these economies have a similar structure, and also because when estimating country-specific AR(1) terms, we cannot reject the hypothesis that they are the same. This might be the consequence of the short time series, which is an external constraint we cannot do much about. Even with the common AR term, we believe that our specification gives us enough flexibility to uncover common and country-specific drivers of the main macro series in question.

Returning to the structural parameters, we follow standard practice and use equations in the deterministic steady state to calibrate as many parameters as possible. The steady state

⁷We also experimented with quarterly data, but identification did not improve significantly. In any case, we believe that annual data is more informative to answer questions about medium-term growth.

⁸Note that in the log-linear representation of the model, we rescale the investment shock to $\epsilon_{i,t} = -\phi\bar{g}^2(1-\beta\rho)\tilde{\epsilon}_{i,t}$. This also implies that a positive innovation to $\epsilon_{i,t}$ is associated with a decrease in the cost of investment, i.e. the shock is expansionary.

conditions are given as follows:

$$\begin{aligned}
\bar{R} &= \frac{\bar{g}}{\beta} \\
\frac{\bar{k}}{\bar{g}\bar{y}} &= \frac{\bar{i}/\bar{y}}{\bar{g} - 1 + \delta} \\
\alpha &= \frac{\bar{g}/\beta - 1 + \delta}{\bar{R}^{\mu-1}} \frac{\bar{k}}{\bar{g}\bar{y}} \\
\frac{\bar{k}}{\bar{g}\bar{h}} &= \left(\frac{\bar{k}}{\bar{g}\bar{y}} \right)^{\frac{1}{1-\alpha}} \\
\frac{\bar{y}}{\bar{h}} &= \left(\frac{\bar{k}}{\bar{g}\bar{h}} \right)^{\frac{\alpha}{1-\alpha}} \\
\frac{\bar{t}\bar{b}}{\bar{y}} &= \left(\frac{1}{\bar{g}} - \frac{1}{\bar{R}} \right) \frac{\bar{d}}{\bar{y}} \\
\frac{\bar{c}}{\bar{y}} &= 1 - \frac{\bar{i}}{\bar{y}} - \frac{\bar{\xi}}{\bar{y}} - \frac{\bar{t}\bar{b}}{\bar{y}} \\
\bar{h} &= \left[\frac{1 - \alpha}{\bar{\theta}\bar{R}^{\frac{1}{1-\mu}} (1 - \chi/\bar{g}) \bar{c}/\bar{y}} \right]^{\frac{1}{\omega}}.
\end{aligned}$$

We set the discount factor to $\beta = 0.98$, and the long-run growth rate to $\bar{g} = 1.0159$, where the latter is the average per capita value for the EU 15 countries in the sample period. The long-run average interest rate is given as the ratio of the two values. We set the steady state investment-GDP ratio to the sample average for each country using the chain-linked volumes for investment and GDP.⁹ Assuming a depreciation rate of $\delta = 0.05$, we can then compute the adjusted capital-output ratio $\bar{k}/(\bar{g}\bar{y})$. This yields the capital share parameter α , which we allow to be country specific, and long-run GDP per hours.

The other expenditure items are set as follows. We impose a uniform government spending share of $\bar{\Xi}/\bar{Y} = 0.1$, which is in line with the data for the Visegrad countries. Since the long-run debt level is exogenous in the model, and average data from a short sample can be very misleading for these values, we simply set $\bar{d}/\bar{y} = 0$ for all three countries. This means that the long-run trade balance is also zero. Plugging the investment share, the trade balance and the share of government spending into the GDP identity then yields the steady state consumption-output ratio.

Recall that we use a gross output production function, therefore we also need to calibrate the share of intermediate inputs (μ). We use the 2017 update to the EU-KLEMS database¹⁰, which reports both gross output and value added for the four Visegrad countries. Our measure of intermediate share is simply given by

$$\mu = 1 - \frac{1}{T} \sum_{t=1}^T \frac{Y_t}{Y_t^G},$$

⁹An alternative is to use the nominal ratio, which is better from a statistical point of view. In the Visegrad countries, however, the relative price of investment declined significantly over the sample period. This means that investment expenditure in nominal terms does not adequately reflect the time series of the physical units of capital being created.

¹⁰<http://www.euklems.net/>

where Y and Y^G are observations of value added and gross output for the total economy at current prices. For the Czech Republic, Hungary and Slovakia the sample period is 1995-2015, while for Poland data is only available between 2003-2015.

We normalize the average level of hours to $\bar{h} = 0.3$, which is a standard value in the literature. This is without loss of generality, and the only role of this normalization is to pin down the parameter $\bar{\theta}$ as can be seen from the last steady state condition. We need a value for the inverse of the Frisch elasticity of labor supply, where we follow García-Cicco et al. (2010) and use $\omega = 1.6$. This leads to an elasticity of $1/0.6$, which is in line with the parameterization of RBC models that rely on an elastic labor supply to deliver volatilities for GDP and its components in line with the data.

There are dynamic parameters that do not appear in the steady state and hence cannot easily be calibrated. Since we reserve estimation for the structural shock processes described above, we use standard values from the literature for these parameters. Accordingly, we set $\chi = 0.5$, which is equivalent to a quarterly value of 0.84. This is at the high end of DSGE estimates, but given our annual frequency significantly lower values would mean habits are unimportant. For the investment adjustment cost parameter, we use $\phi = 2$. This is in line with Smets and Wouters (2003), whose mean estimate for the Euro Area is around 7 in a quarterly setting. Finally, we follow Benczúr and Kónya (2013) and set $\psi = 0.05$. This implies that when the debt/GDP ratio increases by 10 percentage points, the interest premium rises by 50 basis points.

We experimented with specifications where some or all of these parameters are estimated. There are a couple of reasons why we decided against using them in the main text. First, it is well-known that DSGE models suffer from identification problems. The same is true in our setup, and we found that the various adjustment cost parameters are difficult to disentangle both from each other and from the shock AR(1) parameters. The identification problem is exacerbated by the fact that we have a short time series. Second, the data indicates that our calibrated values are reasonable, as the posterior means are not very different from the prior means (calibrated values). This is not just because of weak identification, since the posteriors are clearly much less dispersed than the priors. The identification problem simply means that the data is useful to narrow the range of possible values, but cannot pin down individual parameters within these ranges.

Table 1 summarizes the calibrated parameters. Most of them are common across countries, except for the capital share, the share of intermediates, and the value of leisure. We now turn to the estimation of the shock processes.

4.1 Estimation results

The model is estimated using Bayesian techniques (An and Schorfheide, 2007). We impose flat (uniform) priors on all shock persistences on the the $[0, 0.99]$ interval, and assume that these parameters are the same across the four countries. We allow, however, for country-specific innovations. We use flat priors for all the standard deviations of the - global or local - innovations, with a range of $[0, 0.2]$.

Data includes chain linked annual growth rates for GDP, gross fixed capital formation, actual individual consumption for the Visegrad countries, downloaded from Eurostat. The trade

Table 1: Calibrated parameters

Parameter name		Value			
		<u>Common</u>			
Discount factor	β	0.98			
Depreciation rate	δ	0.05			
Consumption habit	χ	0.5			
Investment cost	ϕ	2			
Frisch elasticity	ω	1.6			
Debt elasticity of interest	ψ	0.05			
Steady state debt/GDP	d_y	0			
		<u>Country specific</u>			
		CZ	HU	PL	SK
Capital share	α	0.375	0.290	0.262	0.347
Share of intermediates	μ	0.603	0.576	0.562	0.604
Value of leisure	θ	12.25	12.78	12.95	12.40

balance is measured by the ratio of net exports to GDP at current prices (source: Eurostat). We use the growth rate of total hours to measure labor input, also downloaded from Eurostat. The sample period is 1996-2016 for all countries.

Table 2 contains the prior distributions and the estimation results. The shock processes are fairly precisely estimated. Except for the trend shock, the shocks are quite persistent, but clearly identified within the bounds. It is noteworthy to emphasize that although our sample period is short, and we use flat priors, the data is informative about the parameter values.

Notice that the data has a hard time disentangling the two technology shock components, the transitory shock a_t and the trend shock g_t . The former is extremely persistent, while the latter is not. This suggests that productivity growth in the Visegrad countries might be a random walk. In fact when we omit the transitory technology shock from the estimation entirely, the main results are almost identical. To preserve comparability with Aguiar-Gopinath (2007) and Gracia-Cicco et al. (2010), we present result with the technology shock included. As the variance decomposition analysis in the next section shows, however, find find a very limited role for this shock for most variables and most countries.

4.2 Variance decomposition

Our main exercise is to decompose the growth rates of GDP, the demand side components and the trade-balance to GDP ratio into contributions of various shock innovations. We have 7 items: global trend (ν_g), local trend (ν_g^j), global premium (ν_r), local premium (ν_r^j), technology level (ν_a^j), government (ν_{gov}^j), investment (ν_i^j) and labor (ν_h^j) shocks. The variance decomposition shows the relative importance of the estimated structural shocks. Table 4.2 presents the results of the exercise where we simulate the model using the estimated shock persistences and standard deviations. Some of the discussion below is also based on historical shock decompositions, which shows how the model interprets a given variable in each year. To conserve space here, we relegate

Table 2: Bayesian estimation priors and results

	Prior mean	Post. mean	90% conf. int.		Prior	
<u>AR(1) parameters</u>						
ρ_a	0.495	0.9287	0.8652	0.99	Uniform	0 – 0.99
ρ_g	0.495	0.1488	0.0489	0.2487	Uniform	0 – 0.99
ρ_r	0.495	0.7972	0.7328	0.8671	Uniform	0 – 0.99
ρ_ξ	0.495	0.7974	0.654	0.9819	Uniform	0 – 0.99
ρ_i	0.495	0.6769	0.5314	0.8394	Uniform	0 – 0.99
ρ_h	0.495	0.9761	0.952	0.99	Uniform	0 – 0.99
<u>Standard deviations</u>						
Global						
ν_g	0.100	0.0203	0.0125	0.0288	Uniform	0 – 0.2
ν_r	0.100	0.0069	0.003	0.011	Uniform	0 – 0.2
Czech Republic						
ν_a^{cz}	0.100	0.0054	0	0.0111	Uniform	0 – 0.2
ν_g^{cz}	0.100	0.0301	0.0194	0.0416	Uniform	0 – 0.2
ν_r^{cz}	0.100	0.008	0.004	0.0122	Uniform	0 – 0.2
ν_ξ^{cz}	0.100	0.0732	0.0552	0.0914	Uniform	0 – 0.2
ν_i^{cz}	0.100	0.082	0.0589	0.1056	Uniform	0 – 0.2
ν_h^{cz}	0.100	0.0243	0.0177	0.0306	Uniform	0 – 0.2
Hungary						
ν_a^{hu}	0.100	0.0059	0	0.012	Uniform	0 – 0.2
ν_g^{hu}	0.100	0.0216	0.0097	0.034	Uniform	0 – 0.2
ν_r^{hu}	0.100	0.0113	0.0064	0.0158	Uniform	0 – 0.2
ν_ξ^{hu}	0.100	0.1512	0.1166	0.1867	Uniform	0 – 0.2
ν_i^{hu}	0.100	0.1197	0.0817	0.1564	Uniform	0 – 0.2
ν_h^{hu}	0.100	0.0432	0.0298	0.0555	Uniform	0 – 0.2
Poland						
ν_a^{pl}	0.100	0.0087	0	0.0156	Uniform	0 – 0.2
ν_g^{pl}	0.100	0.0138	0.0003	0.0229	Uniform	0 – 0.2
ν_r^{pl}	0.100	0.0083	0.0036	0.0135	Uniform	0 – 0.2
ν_ξ^{pl}	0.100	0.1169	0.0793	0.1536	Uniform	0 – 0.2
ν_i^{pl}	0.100	0.0959	0.0691	0.125	Uniform	0 – 0.2
ν_h^{pl}	0.100	0.0354	0.0248	0.045	Uniform	0 – 0.2
Slovakia						
ν_a^{sk}	0.100	0.0146	0.0028	0.0239	Uniform	0 – 0.2
ν_g^{sk}	0.100	0.0174	0	0.0323	Uniform	0 – 0.2
ν_r^{sk}	0.100	0.025	0.0164	0.0337	Uniform	0 – 0.2
ν_ξ^{sk}	0.100	0.1604	0.1316	0.1972	Uniform	0 – 0.2
ν_i^{sk}	0.100	0.1522	0.1195	0.1905	Uniform	0 – 0.2
ν_h^{sk}	0.100	0.0363	0.0262	0.0469	Uniform	0 – 0.2

the historical shock decomposition figures to the Appendix.

Table 3: Variance decomposition

	ν_g	ν_r	ν_a^j	ν_g^j	ν_r^j	ν_ξ^j	ν_i^j	ν_h^j
<u>GDP growth</u>								
CZ	23.14	1.12	5.76	50.84	1.5	0.67	3.24	13.73
HU	20.36	1.13	4.95	23.08	3.01	2.78	4.61	40.08
PL	27.19	1.75	13.63	12.57	2.54	2.31	3.52	36.48
SK	16.58	0.77	28.38	12.17	10.1	2.36	7.24	22.39
<u>Consumption growth</u>								
CZ	15.66	15.29	1.65	34.41	20.39	0.7	4.42	7.48
HU	14.36	11.06	1.45	16.28	29.44	1.93	4.28	21.19
PL	21.65	15.41	4.5	10.01	22.36	1.55	3.19	21.33
SK	5.81	5.26	4.16	4.26	68.82	1.1	4.46	6.13
<u>Investment growth</u>								
CZ	8.29	9.67	0.9	18.21	12.9	0.35	47.88	1.81
HU	5.46	4.99	0.64	6.19	13.29	0.69	64.32	4.41
PL	8.49	6.96	2.09	3.92	10.1	0.55	63.12	4.78
SK	2.58	2.92	2.04	1.89	38.23	0.48	50.5	1.34
<u>Trade Balance to GDP</u>								
CZ	0.72	31.16	0.82	1.59	41.57	1.33	21.29	1.51
HU	0.38	19.22	0.65	0.43	51.18	3.46	20.83	3.84
PL	0.55	29.3	2.19	0.26	42.52	3.11	17.85	4.22
SK	0.13	5.96	1.18	0.09	77.96	1.22	12.75	0.71

The table shows the shock variance decomposition of the four key variables based on model simulations. The simulations use the baseline calibration, together with the posterior means of shock persistences and standard errors.

In all countries global and local growth shocks explain around half of the volatility of GDP growth, and transitory technology shocks have a small weight. The distinct role of growth shocks is consistent with the idea that during the pre-crisis period convergence played a major role in the Visegrad economies. Changes in the external growth environment and in income expectations seem to have been the main drivers of aggregate GDP growth. Labor supply shocks were also important, especially in Hungary and Poland. Poland implemented its labor market reform in the middle of the 2000s. After the financial crisis Hungarian interventions made the labor market more flexible and those had a positive effect on Hungarian GDP growth.

Private consumption and investment are also functions of productivity growth, but the picture is more heterogeneous and other factors like premium shocks and investment shocks have a larger impact. Premium shocks influence the composition of aggregate demand, and they mostly explain the volatility of the trade-balance. The Hungarian economy was fueled by cheap credit before the crisis, and it had to go through a significant balance sheet adjustment post-crisis.

The local premium shock was also important for Slovakian domestic demand. This component explains the collapse of the Meciar era, but later the fiscal consolidation and euro adaptation resulted in a favorable investment climate and contributed to an increase in private consumption.

In the last decade investment might also have been strongly affected by the inflow of EU transfers. While the model does not have an explicit role for external funds, the investment specific shocks can capture at least some of these extra developments.

Overall, our results indicate that both trend productivity shocks and interest premium shocks are important to understand the growth experience of the Visegrad countries. As in Aguiar and Gopinath (2007), but in contrast to García-Cicco et al. (2010), we find that the volatility of GDP growth is mainly driven by shocks to the trend component of productivity. Interest premium shocks are important, however, to understand the evolution of the main GDP components, and the trade balance in particular. In addition, labor market shocks and investment specific shock have played a significant role. Restricting attention to productivity and interest premium shocks might thus be too restrictive, at least in the context of the Visegrad economies.

5 External model validation

After presenting the main results, we discuss additional findings that - while interesting in their own right - provide strong external validation for the estimation exercise. We compare the estimated global components of the trend shock and the interest premium shock to observable (EU) time series. We also study the investment specific shock innovations, and relate them to EU funding after the 2004 period.

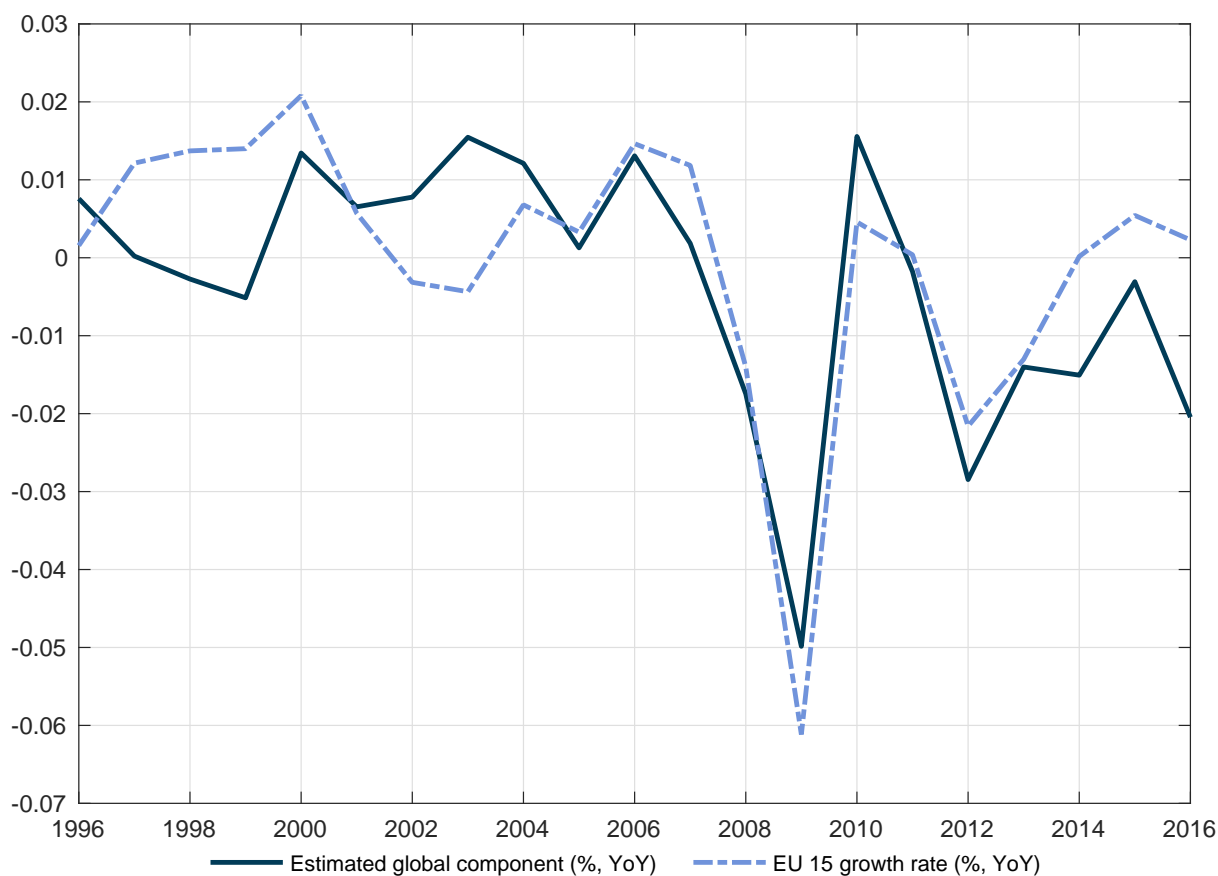
5.1 Trend growth and investment

First, we take a more detailed look at the estimated trend productivity shock. In particular, we want to look at the global component that the estimation uncovered, $\nu_{g,t}$. Figure 5.1 plots the global trend innovation against the growth rate of the EU 15 countries.¹¹ The rationale for this is that the Visegrad countries overwhelmingly trade with other EU countries, and the EU 15 represent the “core” economy of the group. Thus we expect that external common growth shocks are highly correlated with the growth rate of the EU 15 countries. This is indeed what we find, as Figure 5.1 shows. The global innovation $\nu_{g,t}$ tracks EU 15 growth very closely, especially since 2004, when the Visegrad countries joined the European Union. While only suggestive, this result gives us confidence that the estimation procedure “makes sense”.

To further investigate the role of the European Union in the growth process of the Visegrad countries, we now turn to investment. As we saw above, investment specific shocks are significant determinants of the volatilities of investment and the trade balance. For the latter, this is especially true after 2004, when the Visegrad countries joined the European Union (see the Appendix tables on historical shocks decompositions). A possible explanation for this is the presence of EU structural funds, which has become a significant source of investment spending in the four countries. Overall, net EU payments are on the scale of 2-5% of gross national

¹¹These are the “old” EU member states before the expansion of 2004: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

Figure 3: Global growth shock component and EU growth



The figure shows the estimated common (“global”) innovations to trend productivity growth $\nu_{g,t}$ together with the real GDP growth rate of the EU 15 countries.

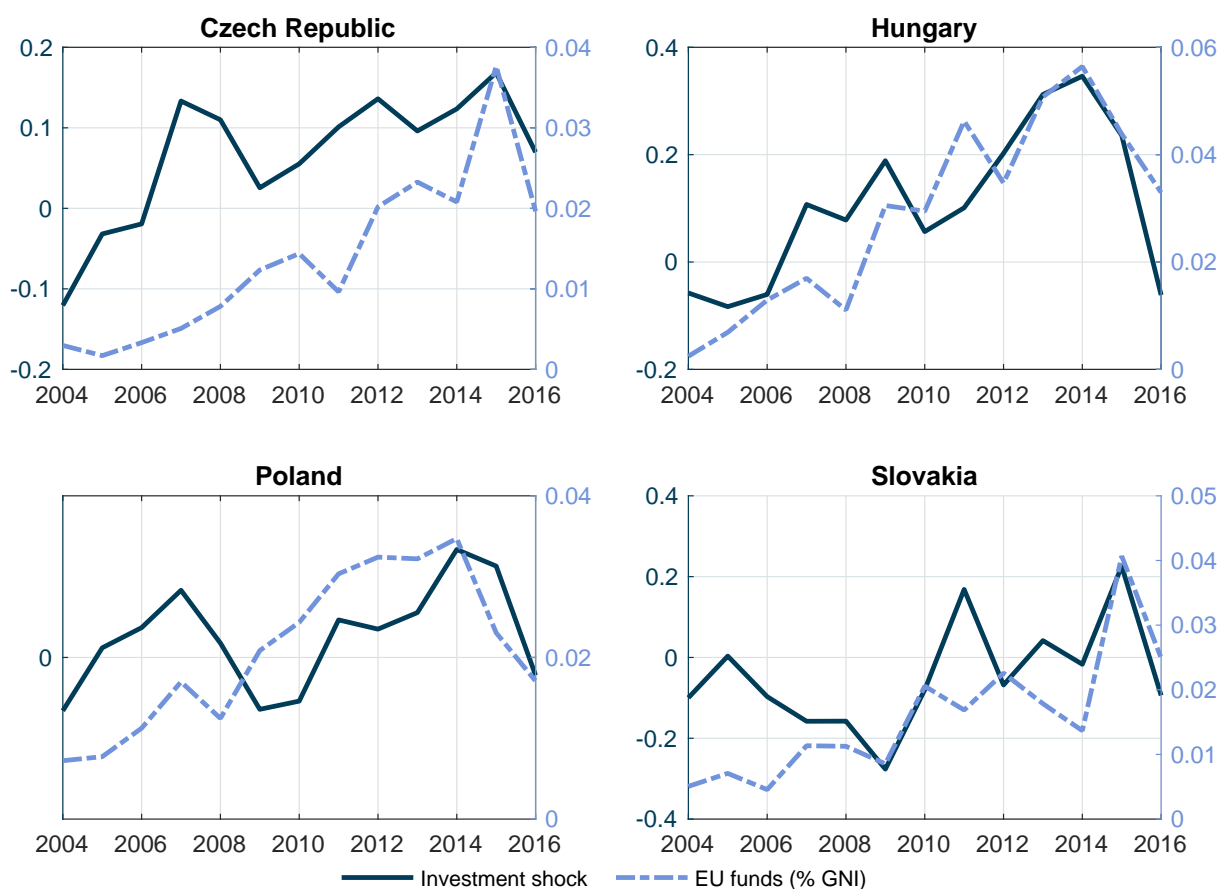
income, especially since 2010.

A detailed study of the role of EU funds is beyond the scope of this paper. For a proper understanding, we would need to build a model with external transfers and a proper government sector with its separate investment activity. Instead, we provide some preliminary evidence that EU funds are likely to be an important explanation for the idiosyncratic behavior of investment captured by its specific shock. Figure 4 plots the estimated investment shock ($\epsilon_{i,t}$, left scale) against European Union funds received annually (as a share of GNI, right scale). Data is available from the European Union¹² since 2004, when the Visegrad countries became members.

Once we adjust for the differences in measurement units, the two time series are remarkably similar in the four countries. This is particularly the case in Hungary, but the trends and the main turning points line up quite well in the other three economies, especially after 2009, when the bulk of EU finding started to arrive. While these charts are only suggestive, it is reassuring that the estimation recovers a stochastic shock that can be given a convincing empirical interpretation.

¹²http://ec.europa.eu/budget/figures/interactive/index_en.cfm

Figure 4: EU funding and investment specific shocks



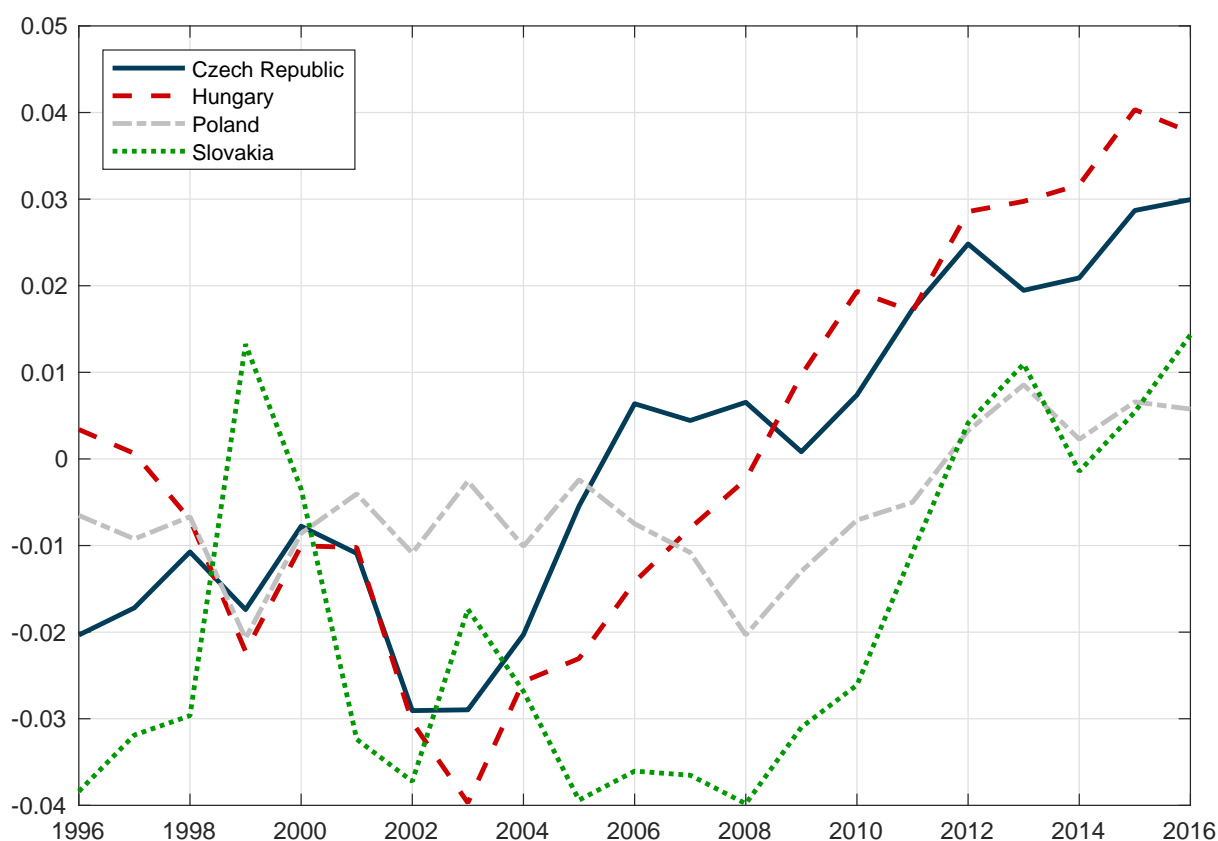
The figure shows the estimated investment specific shock ($\epsilon_{i,t}^j$) for each country, together with net EU funds received as a share of GNI.

5.2 Interest rate and interest premium

Recall that in our estimation we do not use observed interest rates, rather we back them out from the evolution of GDP components. It is interesting to see whether these implicit interest rates “make sense”, i.e. whether their paths are in line with our prior expectations. We would like to find the following patterns: high values in the 1990s, a gradual decline before the financial crisis (especially in the 2004-2008) period, and increased heterogeneity after the crisis. For the latter period, we expect interest rate increases for more heavily indebted countries (Hungary), and decreases for less indebted countries (the Czech Republic, and to a lesser extent Poland and Slovakia). It is important to note that our implicit interest rates condense price and non-price information that is relevant for intertemporal consumption and investment decisions, and thus can be quite different from the policy rate. This is especially relevant after the financial crisis, when quantitative restrictions on credit became much more important, and low headline interest rates may mask high effective borrowing rates by households and small enterprises.

Figure 5 present the results. These are broadly in line with our expectations, with some important exceptions. Before the crisis, interest rates were relatively low and indicated an accomodative financial stance in all countries, although there is a reversal in the Czech Republic

Figure 5: Estimated implicit interest rates



The figure shows the estimated implicit real interest rates for each country (as deviations from the steady state).

and Hungary after 2003. The crisis led to a significant increase in three countries. This was steepest in Hungary, which in the pre-crisis period enjoyed a positive investment climate and became the most heavily indebted economy, and was most exposed to financial market tightening and balance sheet adjustment subsequently. In Slovakia, following the fiscal stabilization in the end of 90s, the implicit rates gradually normalized. As a member of the Eurozone Slovakia was hit by the subsequent Euro crisis in 2011, but the implicit rate remained low. The Polish implicit rate increased by the beginning of 2000s that was consistent with the Russian crisis and postponed fiscal reforms, due to the stabilization package and trade liberalization the external financing normalized and the rates remained relatively low.

Similarly to the stochastic productivity trend, we estimated the interest rate innovations with a global and local component. We expect the global component to pick up changes in external financial conditions that effect all Visegrad countries similarly. As before, we use the EU 15 countries as a benchmark to see if the global interest rate component is related to the evolution of a real interest rate observed in the relevant external financial market. For this purpose, we use the short-run real interest rate constructed by the AMECO database¹³ for the EU 15 countries. This is a GDP weighted average of the 15 countries, and uses the GDP deflator as its measure of inflation.

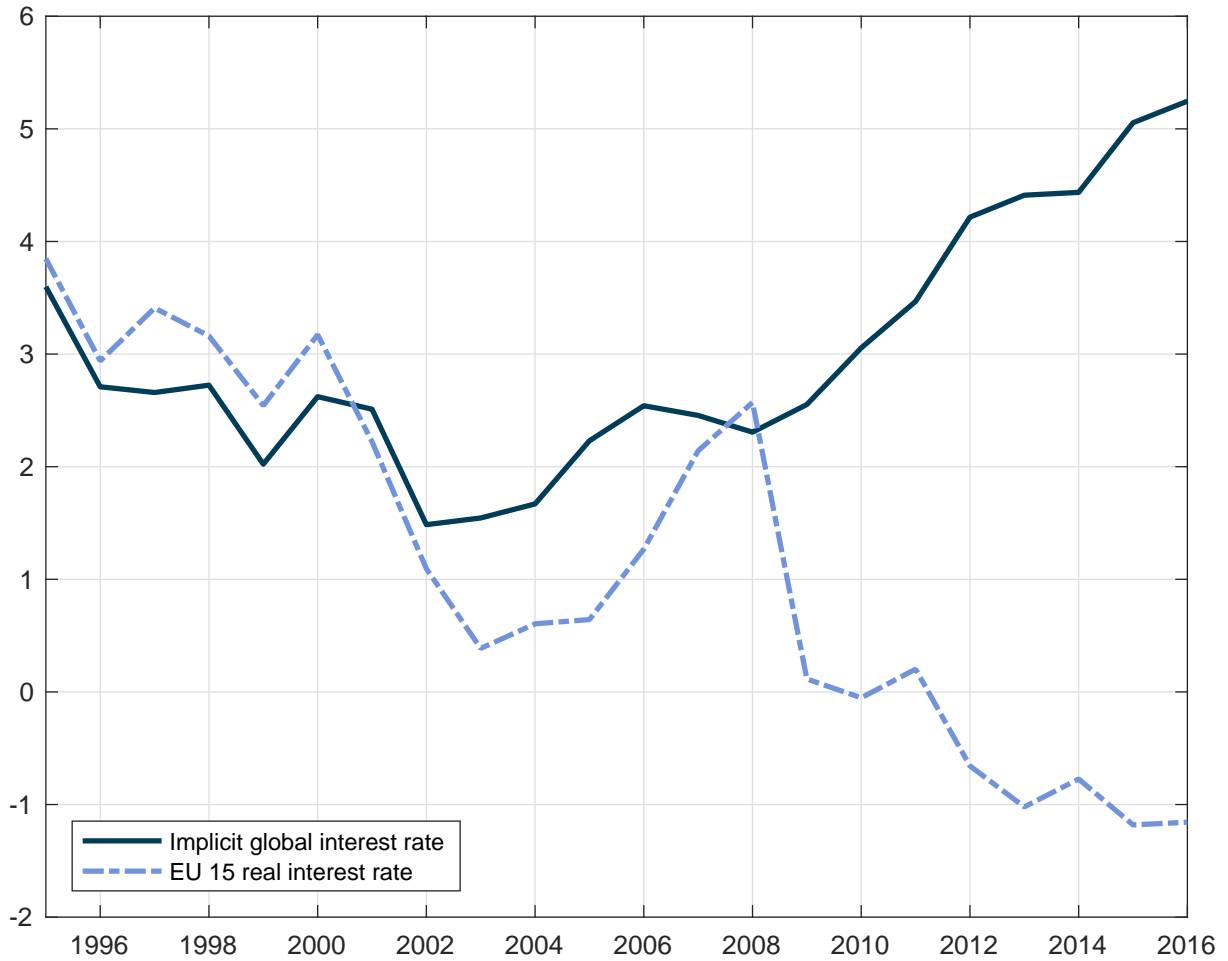
¹³http://ec.europa.eu/economy_finance/ameco/user/serie/SelectSerie.cfm

To construct a “global” implicit interest rate relevant for the Visegrad countries, we use the following procedure. Let r_t^g indicate the implicit interest rate that only includes the global innovation. We define this interest rate as follows:

$$r_t^g = \rho_r \rho_t^g + \nu_{r,t}, \quad (10)$$

where ρ_r is the (common) estimated persistence of the interest premium shock, and $\nu_{r,t}$ is the estimated global component of the shock innovation. Our sample starts in 1996, and we simply assume that $r_{1995}^g = \bar{r}$.¹⁴

Figure 6: Global interest rate and the observed EU 15 real interest rate



The figure shows the observed average real interest rate for the EU 15 countries (source:AMECO), together with the estimated common (“global”) interest rate for the Visegrad countries.

Figure 6 presents the estimated implicit global interest rate and the real interest rate in the EU 15 countries. Two key patterns stand out. First, before the financial crisis (2008), the implicit interest rate tracks the actual EU 15 real interest rate very well. We think this is a

¹⁴We could have followed a similar procedure when comparing the global trend component to growth in the EU 15. Since the estimated trend shock is close to a random walk, this does not matter for the trend shock. The interest premium shock is persistent, however, so it is important to take into account autoregressive behavior.

remarkable finding, since our implicit interest rate is estimated only from GDP components.¹⁵

Second, the two series diverge dramatically from 2008. It is beyond the scope of this paper to examine the reasons, but we offer two (probably complementary) possible explanations. On the one hand, the implicit interest rate influencing investment and savings might have diverged from the money market rate during and after the crisis. This can happen for various reasons, such as an increase in the risk premium associated with household and corporate lending, or an increase in credit rationing and other non-price restrictions. On the other hand, the “global” rate relevant for the Visegrad countries might have gone up relative to the EU15 countries, due to the general increase in risk aversion and the flight to safety by investors away from emerging markets.

6 Conclusion

In this paper we used a version of the neoclassical growth model to understand the stochastic convergence process of the Visegrad economies in a unified framework. We estimate a version of the model with simple financial frictions and a working capital channel. We find that trend productivity shocks are the most important component behind fluctuations in GDP growth, and transitory technology shocks play a limited role. Interest premium shocks explain the trade balance, and labor and investment specific shocks are important as well.

We allow for a common component for the trend and interest premium shocks. We show that these can be related to observed EU 15 time series. We also find some preliminary evidence that EU funds played a major role in investment dynamics after 2004. Studying the role of EU funding in more detail is an important future research direction.

Many other questions remain, including the role of government spending and investment, the possibility of a structural break associated with the global financial crisis, and the role of expectations about the future growth prospects. Our results nevertheless show that the stochastic neoclassical growth model, augmented with a few key frictions, is a useful tool to examine the growth process of emerging economies, and the Visegrad countries in particular.

References

- Aguiar, M. és Gopinath, G. (2007). “Emerging Market Business Cycles: The Cycle Is the Trend.” *Journal of Political Economy*, **115**: 69–102.
- An, S. és Schorfheide, F. (2007). “Bayesian Analysis of DSGE Models.” *Econometric Reviews*, **26**: 113–172.
- Benczúr, P. and I. Kónya (2016). “Interest premium, sudden stop, and adjustment in a small open economy.” *Eastern European Economics*, **54**: 271–295.

¹⁵The fact that the interest rate levels are very similar until 2008 is due to our calibration choice for $\beta = 0.98$. With a lower discount factor, the implicit interest rate would be a level shift of the EU 15 real interest rate, but the dynamics of the two series remains as seen on the figure. We verified this to be the case for $\beta = 0.96$, which also shows that the other results are robust to this change in the calibration. We opted for $\beta = 0.98$ mostly because the estimation diagnostics clearly prefer this value to the lower one.

- Brzoza-Brzezina, M. and J. Kotlowski (2016). “The nonlinear nature of country risk.” National Bank of Poland, Mimeo.
- Canova, F. and L. Sala (2009). “Back to square one: identification issues in DSGE models.” *Journal of Monetary Economics*, **56**: 431-449.
- Christiano, L., M. Eichenbaum and C. Evans (2005). “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy.” *Journal of Political Economy*, **113**: 1-45.
- García-Cicco, J., Pancrazi, R. és Uribe, M. (2010). “Real Business Cycles in Emerging Countries?” *American Economic Review*, **100**: 2510–2531.
- Gollin, D (2002). “Getting Income Shares Right.” *Journal of Political Economy*, **110**: 458-474.
- Greenwood, J., Z. Hercowitz and G. Huffman (1988). “Investment, capacity utilization, and the real business cycle.” *American Economic Review*, **78**: 402-17.
- Guerron-Quintana, P. (2013). “Common and idiosyncratic disturbances in developed small open economies.” *Journal of International Economics*, **90**: 33-49.
- R. King, C. Plosser and S. Rebelo (1988). “Production, Growth and Business Cycles I. The Basic Neoclassical Model.” *Journal of Monetary Economics*, **21**: 195–232.
- Kónya, I. (2013). “Development Accounting with Wedges: the Experience of Six European Countries.” *The B.E. Journal of Macroeconomics (Contributions)*, **13**:245-286
- Mehra, R. and E. Prescott (1985). “The equity premium: A puzzle.” *Journal of Monetary Economics*, **2**: 145-161.
- Mendoza, E. (2010). “Sudden Stops, Financial Crises, and Leverage.” *American Economic Review*, **100**: 1941-1966.
- Minetti, R. és T. Peng (2013). “Lending constraints, real estate prices and business cycles in emerging economies.” *Journal of Economic Dynamics & Control*, **37**: 2397–2416.
- Naoussi, C. és F. Tripier (2013). „Trend shocks and economic development.” *Journal of Development Economics*, **103**: 29-42.
- Schmitt-Grohé, S. és Uribe, M. (2003). „Closing small open economy models.” *Journal of International Economics*, **61**: 163–185.
- Tastan, H. (2013). “Real business cycles in emerging economies: Turkish case.” *Economic Modelling*, **34**: 106-113.
- Valentinyi, Á. and B. Herrendorf (2008). “Measuring Factor Income Shares at the Sector Level.” *Review of Economic Dynamics*, **11**: 820-835.
- Zhao, Y. (2013). “Borrowing constraints and the trade balance–output comovement.” *Economic Modelling*, **32**: 34-41.

Appendix - Historical shock decompositions

Figure 7: Czech Republic

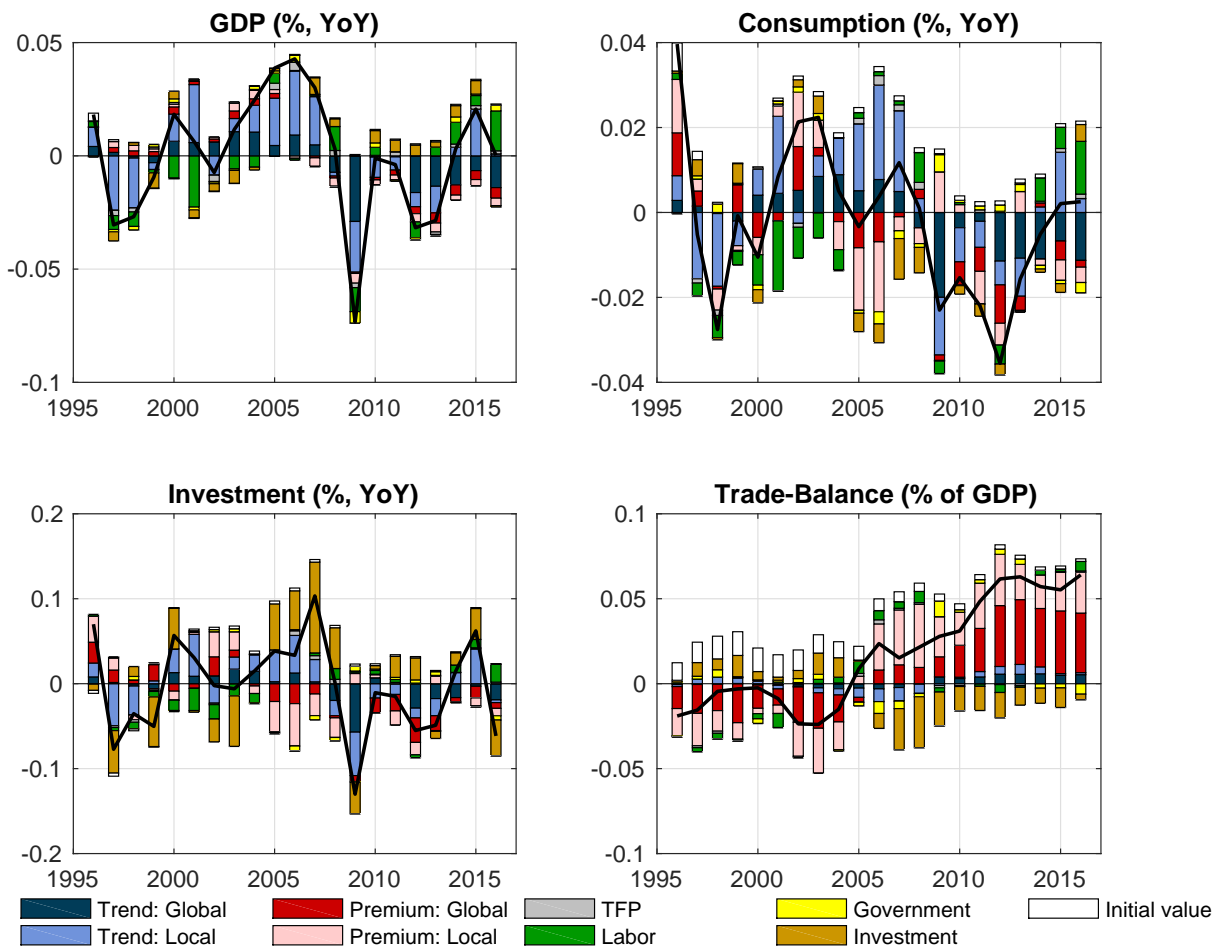


Figure 8: Hungary

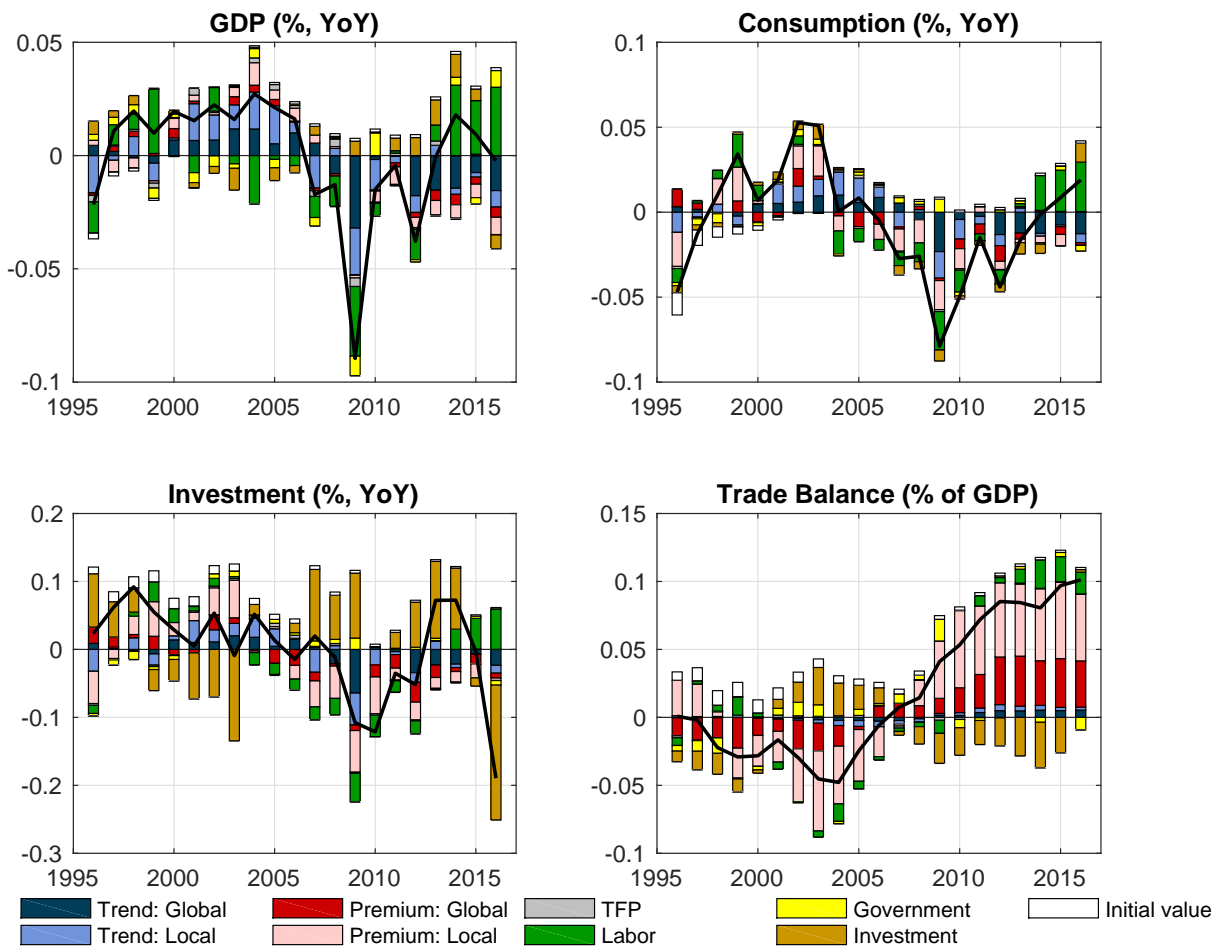


Figure 9: Poland

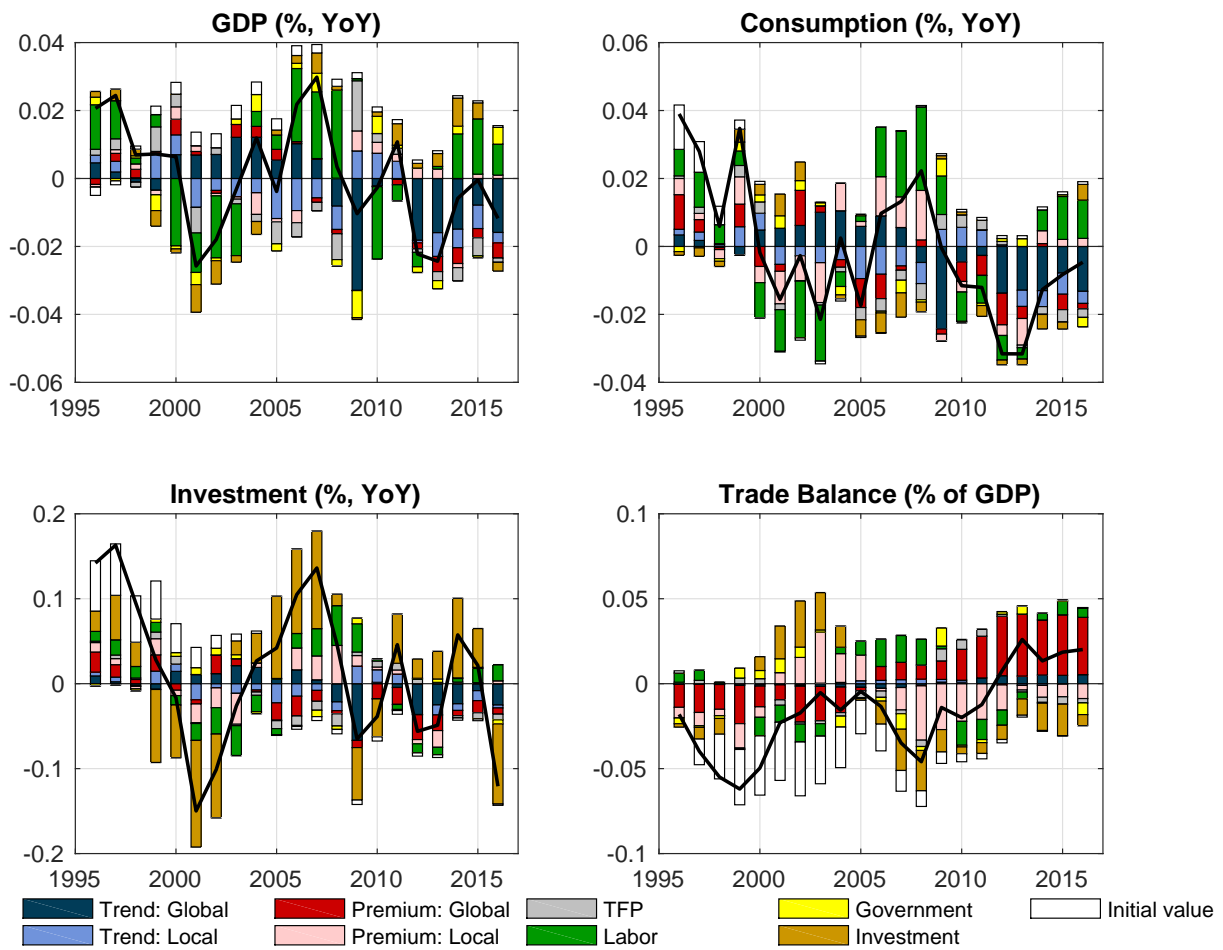


Figure 10: Slovakia

