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Trade and External Relations
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EDITORIAL

One of the key determinants of economic development in small open economies such as the Czech one is the external environment. Understanding the linkages to the external world is therefore of utmost importance for policymakers. It is not only international trade that is important. Capital flows and exchange rate fluctuations are also among the economic phenomena that should be monitored and analysed.

The accuracy of economic and inflation forecasts in a small open economy depends on reliable predictions of trade volumes and prices, and these variables should be forecasted on a regular basis. Nevertheless, understanding external relationships is important not only for the regular business of economic analysis and forecasting, but also for long-run strategic considerations such as joining a monetary union. The articles in this Research Bulletin represent a sample of the CNB's research dealing with modelling of trade and capital flows and exchange rate fluctuations.

The first article decomposes aggregate export growth in the Czech Republic in 2005–2014. The article finds that the intensive margin, i.e. the contribution of continuing firm-destination-product relationships, was the most important factor accounting for aggregate export growth.

The second article presents research aimed at improving the trade forecast. It applies and compares a set of empirical models for nowcasting and short-run forecasting trade volumes and prices. The third article also contains research relevant to economic forecasting. An empirical life-cycle model of foreign direct investment is used to construct scenarios for income items of the current account.

The fourth article studies the role of exchange rate movements. Are exchange rate movements a source of volatility or a buffer against shocks in an open economy? The answer to this question is a valuable input to the discussions about the welfare consequences of joining a monetary union.

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IN THIS ISSUE

Margins of Trade: Czech Firms Before, During and After the Crisis[1]

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Recent literature on international trade stresses the importance of firms' extensive margins – defined as newly established or terminated trade patterns by firm, destination and product type – in explaining the dynamics of trade. Distinguishing extensive and intensive margins of trade is important, as entering international markets is associated with fixed costs, which can be borne only by highly productive firms. The presence of fixed costs also means that when facing adverse demand shocks, firms usually respond by reducing sales in existing export relationships rather than by terminating them. The extensive margin is also important for emerging economies, since they diversify their product portfolio as they catch up with advanced economies (see Imbs and Wacziarg, 2013, and Mau, 2016). Margins of trade are also important in the analysis of current account imbalances. The presence of the extensive margin attenuates the need for trend real currency depreciation due to current account imbalances (Corsetti et al., 2013). The adjustment of current account imbalances with firm heterogeneity is addressed in Pappadà (2011) and with its implications for the euro area in di Mauro and Pappadà (2014).

The previous literature delivers mixed results on the importance of margins of trade. For example, Bricongne et al. (2012) find that the extensive margin explains 55% of French export dynamics in 2000–2007 and 11% during the crisis years of 2008–2009. For Portugal in 1996–2005, Amador and Opromolla (2013) show that both the extensive and intensive margins are important at the firm level in manufacturing in explaining the year-on-year variation in aggregate exports. For the Czech Republic, Beltramello et al. (2012) find that the extensive margin accounts for about 60% of total export growth in 1995–2007. They attribute the higher extensive margin found for emerging and Central and Eastern European economies to their integration into the European Union. Some other studies find a much lower contribution of the extensive margin. For example, Silgoner et al. (2013) show that the extensive margin of ten Central, Eastern and South-Eastern economies accounts for less than 10% of export growth in 2003–2005.

Recent literature on international trade highlights the importance of international organisation of production, labelled as global value chains, which manifests itself among other things in a high proportion of imported intermediate goods in the export value of goods. For example, Beltramello

[1] This article is based on Galuščák and Sutóris (2016).

et al. (2012) study the export performance of 39 economies since 1995, distinguishing the production of intermediate inputs and final products. They find a higher extensive margin in emerging and Central and Eastern European economies, particularly in intermediate goods. Furthermore, most of the trade collapse in 2007–2009 occurred at the intensive margin for most countries, being much larger in intermediates, while some countries experienced still positive export growth in final consumption goods. The faster response of trade in intermediates during adverse shocks has been labelled in the literature as a "bullwhip" effect. Altomonte et al. (2012) confirm its existence using transaction-level French data in 2007–2009. In particular, the intra-group trade in intermediates exhibited a faster drop followed by a faster recovery than the arm's length trade, as multinational firms better optimise inventories and do not suffer from large information asymmetries.

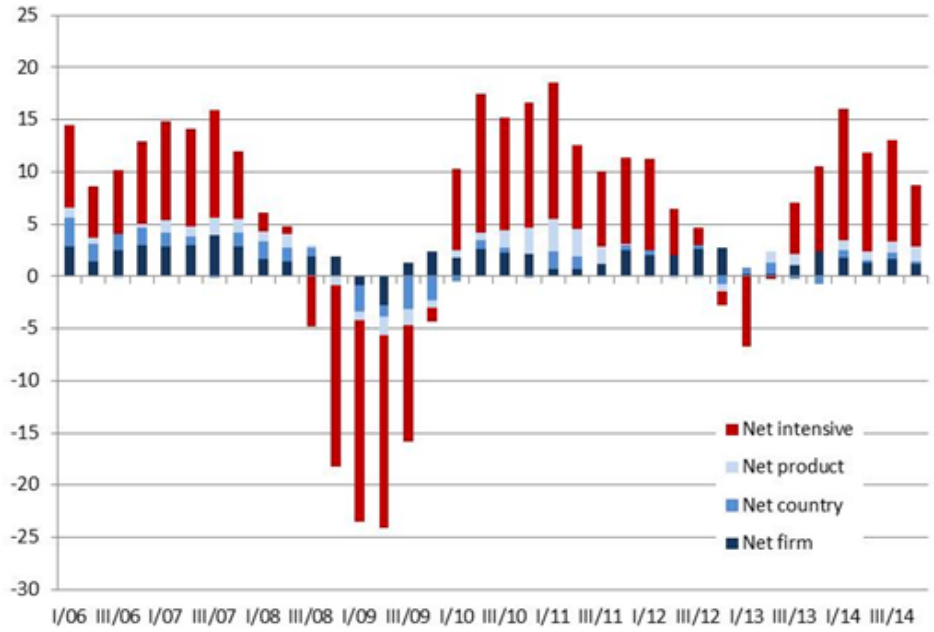
In Galuščák and Sutóris (2016) we investigate the role of the extensive and intensive margins of trade in aggregate export dynamics in the Czech Republic, focusing on the periods before, during and after the crisis of 2008–2009. We examine which margins are important in explaining total export growth and what impact the crisis had. As the Czech economy converges to the EU, we expect a significant contribution of the extensive margin. We also investigate the role of international production linkages using the import intensity of exports as a proxy for firms' participation in global value chains. In line with the previous literature for other countries, we expect a more negative impact of the crisis on exports of firms involved in international production chains.

We use quarterly Czech export data in 2005–2014 by firm, destination and product type and compute mid-point year-on-year growth rates which allow us to account for entries and exits in firm-destination-product combinations. We define the extensive margin along three dimensions: the firm extensive margin captures entries and exits of firms into and from exporting activity, the country extensive margin is defined as new and lost destinations of those firms which export in both periods, and the product extensive margin describes entries and exits of products for continuing firm-destination relationships. The intensive margin is then the contribution of the continuing firm-destination-product combinations.

Our results suggest that the intensive margin explains most of the aggregate export growth in 2006–2014 (see Figure 1). This is in line with previous findings for other countries, including Bernard et al. (2009) and Amador and Opromolla (2013). The contribution of the extensive margin is smaller, but not negligible. It explains on average 39% of the export growth in 2006–2007 and about 25% to 30% of that in the years after the 2008–2009 crisis. Comparing the pre-crisis and post-crisis periods, we observe a much lower net country contribution in 2010–2014, while the contribution of the net product extensive margin recovered to the pre-crisis level. The lower contribution of the extensive margin in the post-crisis recovery signals a lower rate of convergence of the Czech economy.

We apply a shift-share decomposition of the firm-destination-product export growth rates by estimating constrained linear regressions to investigate specific factors of export adjustment. The results suggest that in terms of destinations, Germany fared better than other destinations during the crisis, while exports to Poland and the rest of the EU were affected more severely. After the post-crisis recovery started, exports to the euro area countries other than Germany and Slovakia were below the average, while out-of-EU exports were growing faster than exports to the EU.

Figure 1. Contributions of net margins to mid-point growth rates



Note: Contributions of the net firm, country and product extensive margins and the net intensive margin.

Looking at the main System of National Accounts product types, capital and intermediate goods export growth was hit harder during the crisis, while exports of consumption and other goods performed better. The fall in capital goods exports seems to have arrived a couple quarters later than the drop in intermediate goods exports. On the other hand, the relative contribution of exports of consumption goods was positive in 2009, indicating that consumption goods exports are less sensitive to adverse demand shocks.

Other results suggest that the contribution of small firms to total exports was negative in the whole period of 2006–2014, while the negative contribution was even more pronounced during the crisis. The trough in the contribution of small firms is observed at the end of 2009, which means that the negative impact of the crisis lasted longer among smaller firms, while exports of large firms recovered faster. The estimates also show that firms with lower import intensity fared better during the crisis than firms with higher import intensity. This indicates that firms involved in international production chains were hit harder by the 2008–2009 crisis, in line with other studies on the impact of participation in international production linkages on firms' trade.

Our results are robust to various measurement issues such as the increased threshold for reporting export flows in intra-EU trade as of 2009 and the introduction of joint export declarations in 2009. The latter change in reporting means that firms are allowed to report jointly on their trade activity.

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Nowcasting the Czech Trade Balance[2]

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In recent years, nowcast models have become a popular econometric tool for current-quarter nowcasting and short-term forecasting of economic variables. A nowcast model is an empirical tool based on a broad range of time series possibly with different lengths and publication frequencies. Its purpose is to account for the most recent information, which is dispersed across series with possibly various patterns of publication lags. Although data-driven estimation can be considered a model weakness, fast incorporation of the latest information, good forecasting performance at shorter horizons and the use of a rich dataset are certainly big advantages of this technique.

GDP growth is the most frequently nowcasted indicator, as it is a key measure of economic activity published with a considerable delay.[3] For the Czech Republic, an aggregated GDP growth nowcast is prepared at the CNB and regularly used as an alternative forecast during the quarterly forecasting exercise. Several models have been developed for this purpose – see Arnoštová et al. (2011), Rusnák (2013) and Franta et al. (2014).

In contrast to previous studies focused on GDP, this paper presents nowcast models for external trade. To the best of our knowledge, no nowcast model for trade has been described in the literature so far and we intend to fill this gap. Exports and imports are exposed to foreign shocks, which increases the importance of foreign variables for nowcast models. Furthermore, in contrast to GDP growth, which is mainly meaningful in real terms, in the case of trade both real and nominal developments (e.g. the balance of payments) are important. The research is therefore of practical importance for a central bank: once the model is set up, regular updates can be produced as new data become available. The set of models described in this paper is therefore also intended to be used for regular forecasting at the CNB as a complement to existing econometric models and as an input to the forecasting process.[4]

[2] This article is based on Babecká Kucharčuková and Brůha (2016).

[3] Camacho, Perez-Quiros and Poncela (2013) give an overview of empirical techniques that can be used for nowcasting and short-run forecasting.

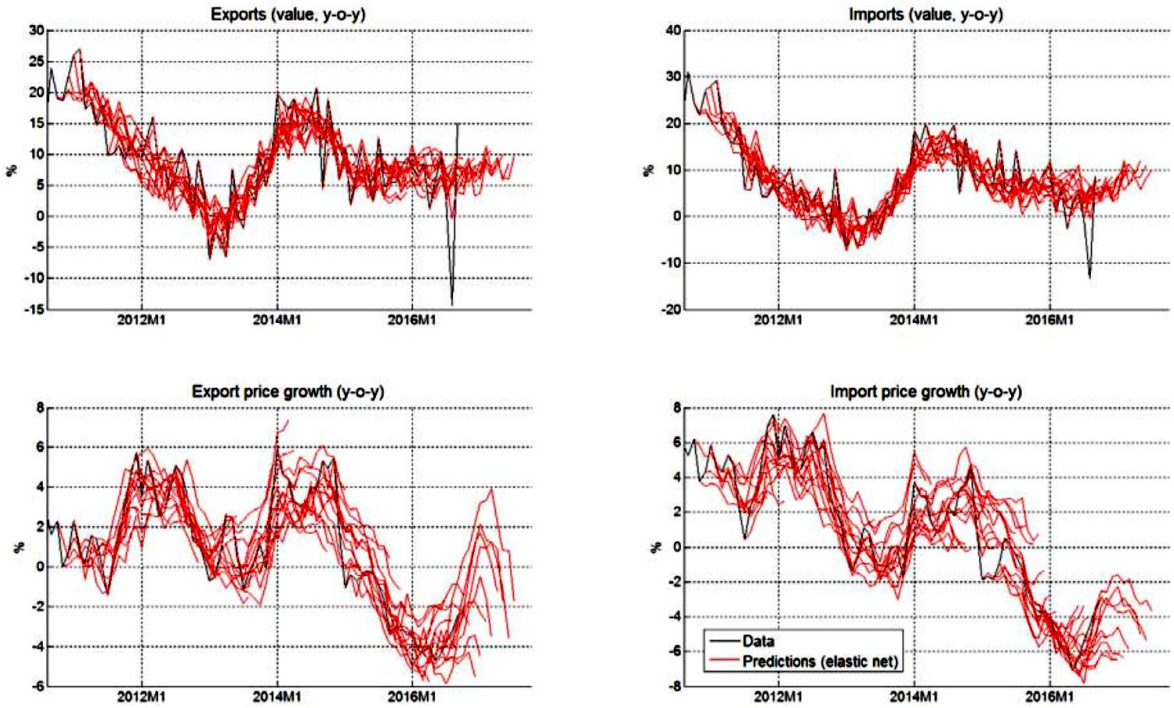
[4] It is well recognised (del Negro and Schorfheide, 2013) that current-period forecasts from nowcast models can serve as valuable inputs to DSGE model-based predictions, where a more precise forecast at the beginning of the forecasting horizon increases the accuracy of the forecast at its end. The main CNB forecasting tool is a DSGE model called g3 (Andrle et al., 2009), and nowcasts and near-term forecasts are discussed in depth at the beginning of each prediction round (Brůha et al., 2013).

The nowcast and short-term forecast methods can be characterised as an attempt to distil the information content from indicators, in particular from those which are available sooner than the data of interest. The methods selected for our analysis are also adapted to mixed-frequency frameworks and to asynchronous data releases. The quality of the nowcasts is evaluated using a pseudo-real time framework which mimics the actual publication lag structure and is compared across four **empirical models**: principal component regression, elastic net regression, the dynamic factor model and partial least squares. The **principal components** represent a low-dimensional object that spans the dynamics of a large set of indicators and therefore captures the information content available in them. The nowcast is then based on regression of the nowcasted variable on these principal components – see, for example, Stock and Watson (2002). The EM algorithm is used to deal with missing data, as described by Foroni and Marcellino (2013). The idea behind the **partial least squares** is similar to the principal components, i.e., to distil the useful pieces of information from a large set of series, and it is based on an iterative process (Vinzi et al., 2010). The **dynamic factor model** is formulated as the state space model in the time domain and the Kalman filter is used to deal with missing data and asynchronous data releases. While all these models – the principal component, partial least squares and dynamic factor approaches – attempt to solve the curse of dimensionality by constructing low dimensional objects, there are regularisation techniques that control the number and/or the magnitude of the regression coefficients of explanatory variables directly. In our research, we consider **elastic net regression** (Zou and Trevor, 2005), which is a linear regularised regression method allowing for the above-mentioned constraints. In addition, we compare all our models against six **univariate benchmark models**: (i) usual random-walk predictions, (ii) predictions based on the unconditional past mean of the series, (iii) predictions based on various forms of exponential smoothing (see Hyndman et al., 2008, for an overview), (iv) autoregressive (AR) models of various lags, (v) Bayesian AR models that shrink the coefficients towards zero, and (vi) time-varying AR models.

Nowcasts and short-term forecasts are prepared for nine **variables**. Four of them have quarterly frequency: exports and imports from the national accounts statistics at both constant and current prices. Monthly nowcasts are produced for nominal trade (exports and imports separately) and the relevant price indexes. In addition, given the high importance of the foreign PPI for the Czech economy, the result for the foreign effective PPI is also shown here. All variables are transformed into growth rates relative to the corresponding period of the previous year. This transformation is dictated by practical considerations, as this is how it is used in the forecasting process at the CNB.

As for explanatory variables, five groups of economic and financial indicators are used for this purpose. Roughly half of them describe domestic developments. The remaining half describe the foreign sector – mainly the euro area, but also Germany and the United States. The sample span starts in January 2006 and ends in September 2016, or 2006q1 and 2016q2 respectively in the case of quarterly data. We do not work with data prior to 2005 so as to avoid the structural break in the Czech trade data time series related to EU entry in May 2004. Figure 1 illustrates the nowcast results for elastic net prediction, which is taken as an example, being the most successful method. For monthly data, the forecasting horizon starts from the previous month and ends at nine months. The quarterly forecast horizon spans from -1 to 0 to 2 quarters.

Figure 1. Recursive forecasts using elastic net regression



Looking at the forecast evaluation for **nominal export** growth rates at monthly frequency, the RMSE strongly favours the prediction based on the elastic net, which is followed by the AR model with six lags and then by the PC prediction based on the first four principal components. For this time series, we thus prefer elastic net regression as the main forecasting method. Principal component prediction may be used as an alternative check. Despite quite similar trends in exports and imports, for **nominal import** growth rates at monthly frequency the best result was achieved using the principal component prediction based on the four first principal components for horizons up to one month, while elastic net regression is preferred for longer horizons. Results obtained on **quarterly national accounts** data in both nominal and real quantities show that the sophisticated models outperform the univariate benchmarks. As in the case of monthly data, the elastic net prediction is typically the winner of the forecasting contest, while the principal component prediction and the dynamic factor models also sometimes have excellent forecasting properties

Turning to **price indices**, for the yearly growth rate of export prices, the accuracy of the backcast and the nowcast is dominated by univariate models: random walk prediction and the AR(1) model, with the latter being slightly more accurate. At these horizons, all the sophisticated methods are worse than these two univariate benchmarks. At longer horizons, elastic net prediction outperforms all the other methods, followed by principal components and the dynamic factor model. For import prices the conclusion is roughly the same apart from the nowcast (i.e. horizon 0), where principal components nowcast wins over other methods.

Finally, for horizons of -1 to 1 month the prediction of the growth rates of the **foreign effective PPI** is dominated by univariate models (be it exponential smoothing or the AR(1) model), while at longer horizons, elastic net regression again dominates.

To summarise, for nominal quantities, elastic net regression (at all horizons) and principal component regression (for horizons up to 0 or 1) are clearly the preferable methods. For growth rates of price indexes, the univariate methods are the winners for backcasting and in some cases also for nowcasting, while for longer horizons the elastic net is typically the most accurate method. This difference may be caused by the large volatility of the time series of price changes. Overall, for exports and imports in both nominal and real terms, as well as for trade price indexes, the ultimate winner is elastic net regression. Interestingly, the forecasting performance of the elastic net is better even than that of the dynamic factor model, which is widely believed to produce the most accurate nowcasts, at least for GDP. The other methods could be used as alternative checks. In addition, the dynamic factor model could be used to create alternative scenarios using conditional forecasts.

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Profitability Life Cycle of Foreign Direct Investment and its Application to the Czech Republic[5]

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Foreign direct investment (FDI) as a form of private capital investment only started to penetrate the world economy in the 1980s. Although a vast amount of FDI still proceeds mostly within developed countries, FDI has been the symbol of economic restructuring and success in transition countries of Central and Eastern Europe.

The activities of foreign direct investors affect important accounts of the balance of payments. In the initial stage, when FDI flows into a country, the financial account is usually in surplus, causing local currency appreciation. In the next stage, with a time lag, the trade balance of the host country is affected depending on the type of FDI, i.e. market-seeking, efficiency-seeking, or resource-seeking (Dunning 1993). An improvement in the trade balance is usually observed as a result. On the other hand, as FDI – like other types of investment – is profit seeking, countries experience a deterioration in their income balance at the same time. FDI earnings make up a substantial part of the overall income balance of the current account in countries like the Czech Republic. Finally, the contrary effects on the trade balance and the income balance constitute the overall effect on the country's current account.

The existing theoretical and empirical literature considers FDI from various perspectives. It focuses mainly on the reasons for doing business in a foreign country and on the host and home country effects of multinational activity. We look at FDI from a different perspective. We analyse the profitability life-cycle of FDI, i.e. its duration and time profile, and use it to construct various scenarios for the evolution of future FDI earnings, i.e. the external vulnerability of the economy, depending on the existing and assumed future stock of FDI.

This analysis is especially important for transition countries, where FDI earnings account for almost the entire income balance and are moreover reflected in trade surpluses. Brada and Tomšík (2003) recognise three theoretical stages of the direct investment life cycle. The entry stage is characterised by investment and no profit, and potentially even a loss. The second stage is a growth phase characterised by gradually increasing profitability. This is followed by the final stage: stabilisation of profitability.

Some stylised facts on the FDI investment cycle are described by Altzinger (2006). He measures the profitability of FDI by the median return on equity (RoE) in the current year (which is an

[5] This article is based on Novotný (2015).

approximation of the life cycle of FDI, as the return is not measured against the initial investment) in four different groups of countries. Geršl and Hlaváček (2007) use financial indicators calculated from firm-level data from the Deutsche Bundesbank's database of German FDI in the Czech Republic. Balance of payments macrodata are used by Brada and Tomšík (2009), who empirically test the FDI financial life-cycle hypothesis on a sample of eight transition countries with data coverage from 1999 to 2006. Their estimated FDI profitability time path follows a quadratic function. The results show that FDI profitability increases, though at a decreasing rate, and then declines. Novotný and Podpiera (2008) alleviate the problems with the measurement of the vintage structure of the total stock of FDI in a particular country. They calculate the cumulative profits which pertain to a particular stock of FDI of the same vintage. Partial linearisation of the cumulative profitability is employed to decompose the cumulative profits. In this way, the authors compute the profitability time profile for each FDI stock of the same vintage and use it to test its time dependence (a cubic polynomial function). Since this methodology enables the time profile of FDI profitability to be derived for both transition and developed countries, we build on a simplified version of their method in this paper.

We assume that the FDI profitability time path is non-linear and has a finite time horizon. Using annual data on the stock of FDI and earnings from the stock of FDI we calculate the FDI profitability in such a way that we ascribe FDI earnings to the particular stock of FDI of the same vintage. We then estimate the time dependence of the cumulative FDI profitability of all these individual stocks of FDI on a panel of mostly European countries. We control for annual PPI growth, real GDP growth, the real effective exchange rate and the short-term interest rate.

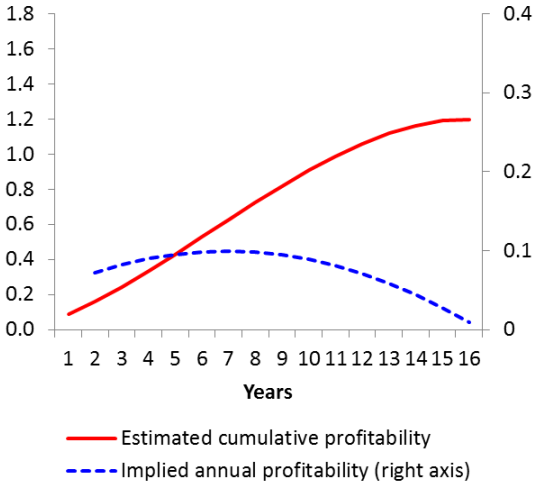
In the next step, the estimated coefficients of the linear, quadratic and cubic time profiles indicate that the FDI financial life cycle is completed in 16 years, when the cumulative profitability reaches its maximum and the implied annual profitability is nearly zero and then negative (Figure 1a). The implied annual profitability increases until the seventh year of investment (10% annual profitability) and then starts to decline. The results are in line with previous literature. Furthermore, when we look at the fixed investment business cycle, it typically lasts about 7 to 11 years.

The estimated time profile of the FDI cumulative profitability represents the general shape of the profitability across all countries under examination. Nevertheless, because we intend to apply the derived time profile to simulate the likely future evolution of profits from FDI in the case of the Czech Republic, and since profits from FDI represent the driving force of the overall income balance of the Czech Republic, we need to have a more specific estimation for that purpose.

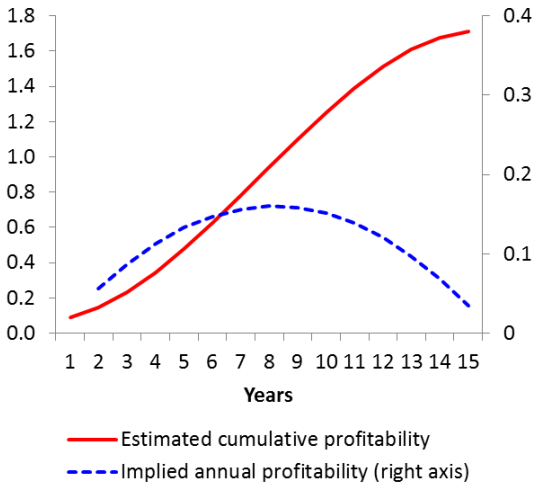
We therefore do a re-estimation for a subsample of CEE countries only. The subsample contains Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Serbia, Slovenia and Slovakia. Using these countries, we derived an FDI profitability time profile that is slightly different from that for all countries. The estimated life cycle is one year shorter compared to the whole sample. It lasts 15 years in total and is more dynamic. The implied annual profitability peaks at 16% in the eighth year of the cycle (Figure 1b). So, it takes a little longer to reap all the benefits of the initial investment compared to the whole sample of countries, but the implied annual profitability then goes down relatively quickly. Emerging countries of Central and Eastern Europe are characterised by higher yields, which could be explained by the convergence process.

Figure 1. FDI profitability time profile

(a) Whole sample



(b) CEE countries



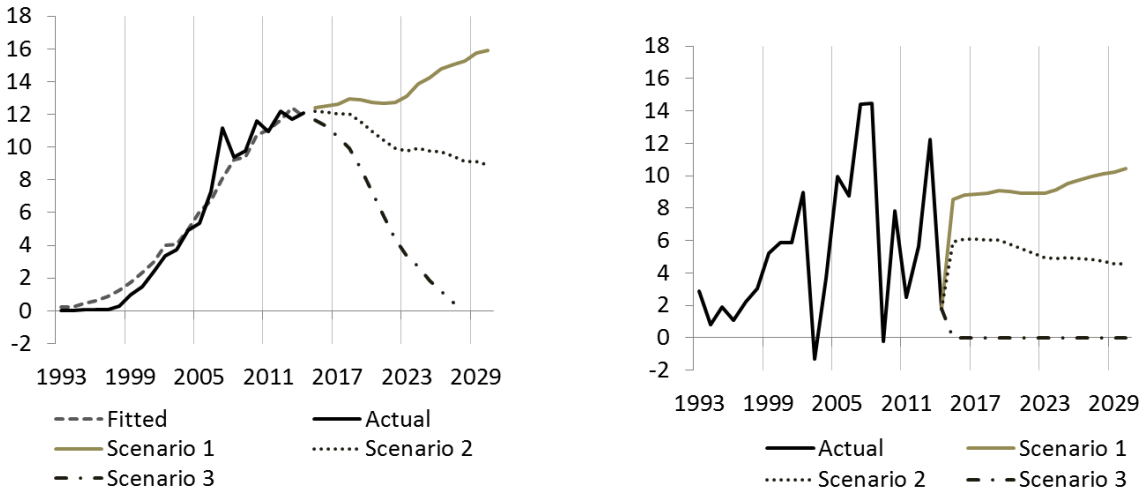
Note: The overall sample consists of Austria, Belgium, Brazil, Bulgaria, Chile, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Macedonia, the Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Turkey and the United Kingdom.

Knowing the FDI profitability life cycle enables us to construct various scenarios for the evolution of total FDI earnings depending on the future FDI inflows (changing FDI stock) assumed. Figure 2 shows three alternative scenarios for the Czech Republic. In the first one, we assume that the actual average yearly equity capital inflow in 2010–2014 (EUR 2.6 billion) will persist and, moreover, 50% of total FDI earnings from the previous year will be reinvested. The second scenario assumes FDI inflows take the form of reinvested earnings only, meaning that there will be no new green or brown-field FDI inflows. Specifically, 50% of total FDI earnings from the previous year will be reinvested. This is the most likely scenario in our view. Finally, the third scenario represents an extreme situation where neither new FDI equity inflows nor reinvested earnings are assumed. In this case, foreign investors decide to repatriate all FDI profits and, moreover, the Czech Republic becomes unattractive for new foreign investments as well (see Figure 2b). The two boundary scenarios (the first and third ones) serve as the expected borderlines for the possible future evolution of FDI earnings.

The underlying motivation for the central scenario is the following. After the initial period of strong inflows of FDI into the CEE countries, a tranquil period followed. In the Czech Republic, the potential for further privatisation FDI inflows and green or brown-field FDI inflows has been practically exhausted and reinvested earnings constitute the main source of FDI inflows since 2006. The income balance of the Czech Republic will therefore be influenced more by the changing term structure of the current stock of FDI in the economy and less by new FDI inflows, which in the central scenario are expected to take the form of reinvested earnings only. The estimated future FDI earnings of Scenario 1 and Scenario 3 delimitate the boundaries for hypothetical reinvested earnings. The estimated FDI earnings fit the actual historical FDI earnings in the period from 1993 to 2014 quite well. This fact supports the validity of our estimation (see Figure 2a).

Figure 2. Scenarios of future profits from FDI conditional on expected FDI inflows (EUR bn)

(a) Fitted FDI profits and their future evolution (b) Past and expected FDI inflows



Note: "Actual" depicts the actual historical FDI profits (earnings) data. "Fitted" is for a model simulation of past FDI earnings based on the results of our estimation. "Scenario 1", "Scenario 2" and "Scenario 3" represent our three different scenarios conditional on different assumptions about future FDI inflows.

We used a specific method to derive the profitability life cycle of FDI on a panel of both advanced and emerging mostly European countries. Our estimations prove that the cumulative profitability time profile is non-linear (in line with previous literature), implying that the annual profitability initially increases faster, then slows down, and then decreases. When the annual profitability is zero and the cumulative profitability is at its maximum, the FDI financial life cycle is completed. This process takes 16 years in the case of the panel of all the countries under investigation. Our method is universally applicable to other countries, and, having an assumption about the likely evolution of future FDI inflows, we are able to calculate the future path of FDI earnings, which represent potential financial outflows on a country's current account causing possible external vulnerability.

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Exchange Rate Dynamics and its Effect on Macroeconomic Volatility in Selected CEE Countries[6]

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There is a tradition in theoretical models to consider the real exchange rate a buffer against shocks. According to this view, if a shock hits an economy, the real exchange rate response helps re-establish equilibrium. However, the empirical evidence is mixed. In some economies, the real exchange rate could itself be a source of shocks that drives macroeconomic volatility. Studying the role of the exchange rate is closely related to the analysis of asymmetries between economies. The debate on the role of the real exchange rate becomes especially relevant when one considers a common currency area, as the real exchange rate should be an important adjustment mechanism for countries within the area.

When the home and foreign economies differ in economic structure, labour market flexibility or fiscal or monetary policy, their responses even to a common shock can go in opposite directions. If such asymmetries prevail, there is a need for shock absorption via the exchange rate when re-establishing equilibrium. However, when shocks with a symmetric response prevail, there is little need for shock absorption.

In this article, we assess the importance of symmetric and asymmetric shocks for the business cycles of CEE economies and address the role of real exchange rate shocks in volatility. Some of the countries considered are already members of the Eurozone, while others are obliged to enter it in the near future and the question of entry has become a hot political and economic topic there. In this work, we study the following European Union member states: the Czech Republic, Slovakia, Poland, Hungary, Lithuania, Latvia, Estonia, Slovenia, Bulgaria and Romania.

We address the role of the exchange rate using a two-country structural vector autoregressive model (SVAR) identified by the sign restriction method. This method was introduced by Uhlig (2005) and has become a standard analytical tool of modern macroeconomics. Recently, Peersman (2011) employed this methodology to analyse the contribution of nominal shocks to macroeconomic volatility.

For our sign restriction identification scheme, we modify the approach sketched by Peersman (2011) and define the sign restrictions so that the contribution of symmetric and asymmetric shocks can be identified, while keeping consistency with the identification scheme for models formulated in relative terms. Our modification is based on Fry and Pagan (2011), who criticise the popular approach of reporting the median response at each horizon separately for

[6] This article is based on Audzei and Brázdik (2016).

each variable, which makes the responses of such models inconsistent across all variables. We employ the closest-to-median approach applied over all variables simultaneously and we are able to identify the sole model.

A major concern of the optimal currency area literature when assessing the application of a single monetary policy stance is the similarity of the business cycles of the participating economies. Synchronisation of shocks and cycles is required if those economies are to benefit from having a single monetary policy stance. As our shocks are defined via their impact on the economy irrespective their common or idiosyncratic origin, we can assess the relative importance of symmetric and asymmetric shocks to provide guidelines on dissimilarities between economies.

Our variance decomposition analysis shows a large influence of asymmetric shocks for the group of economies considered. Even though asymmetric responses are not frequent in the data, together they account for a significant portion of output and price volatility. Due to their relative importance for the volatilities of the variables considered, the frequency of occurrence must be offset by their amplitude. The presence of substantial asymmetry stems from asymmetries across the economies considered in terms of productivity and monetary and exchange rate policies. There are striking differences in the relative contributions of asymmetric shocks across countries to output volatility – these contributions vary from 10% to 80%. The results are important for the formation of an OCA within the region and the Eurozone. The large relative influence of asymmetric shocks suggests low synchronisation of business cycles and complicates common monetary and exchange rate policy implementation.

Studying the role of the real exchange and assessing how much volatility it generates or absorbs is not a straightforward exercise and could be subject to debate. In this paper, we pursue the approach developed in the literature (Peersman, 2011; Clarida and Gali, 1994; Farrant and Peersman, 2006), where authors study what fraction of the exchange rate volatility is driven by the exchange rate shock. The intuition behind this approach is the following. If exchange rate volatility is driven mostly by, for example, the supply shock, it is a sign that the exchange rate largely reacts to the supply shock. This could be interpreted as the exchange rate absorbing the supply shock. If, however, the exchange rate is driven mostly by the idiosyncratic shock, it could be interpreted as fuelling business cycle volatility. Another question related to the analysis is what to consider a "large" reaction to a shock. In related literature, and in line with common sense, less than 10% is not considered to be an important source of volatility, while more than 20% is an important source of volatility.

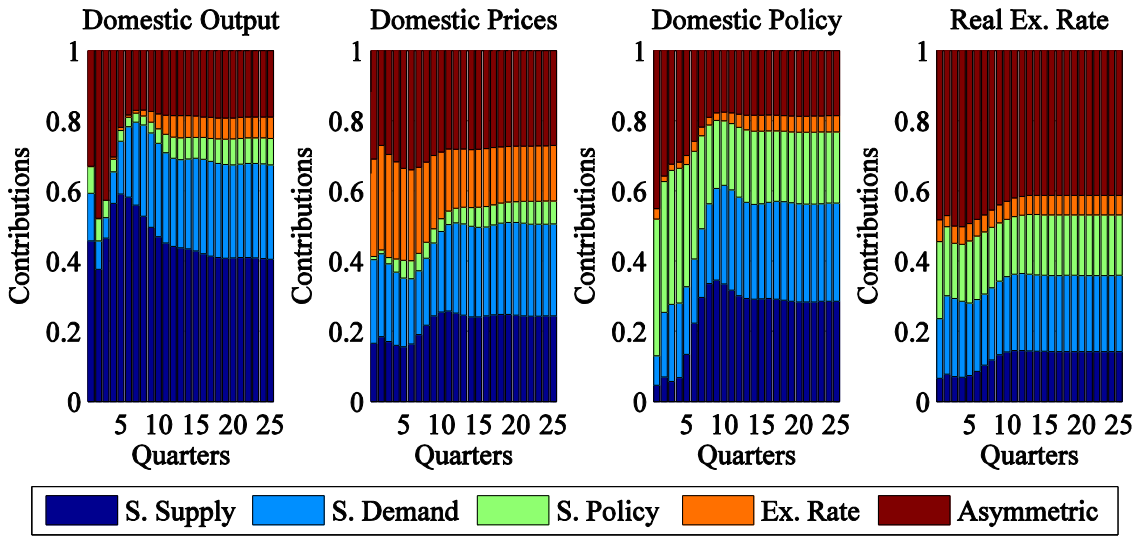
Figure 1 shows the variance decomposition for the Czech Republic.[7] We show the variance decomposition of volatility in domestic output, domestic prices, domestic monetary policy and the real exchange rate in response to the four shocks identified. These shocks are a symmetric[8] supply shock, a symmetric demand shock, a symmetric monetary policy shock and an exchange rate shock. The rest of the shocks form the group of asymmetric shocks.

[7] Detailed variance decompositions for all the economies considered are presented in Figures 14–23 in Audzei and Brazdik (2015).

[8] By symmetric shock we mean a shock causing responses of the same sign in both the home and foreign countries. For example, a positive symmetric supply shock produces an increase in output in both the home and foreign economy, while an asymmetric shock leads to an increase in domestic output but a decline in foreign output.

For the Czech Republic, both the short- and medium-run contributions of the idiosyncratic real exchange rate shock (orange bars) to real exchange rate volatility (Real Ex. Rate) are approximately 5%. This is far below the 45% of sterling-euro fluctuations explained by the idiosyncratic shock in the short run as identified by Peersman (2011). Our results suggest that symmetric monetary policy shocks (green bars) deliver an important part of the real exchange rate volatility and are responsible for about 20% of its fluctuations. This contrasts with Clarida and Gali (1994) and Eichenbaum and Evans (1995), who often find that monetary policy shocks are unimportant. Thus, we can support the conclusion reached by Rogers (1999) that monetary policy shocks matter and that the focus on monetary shocks in the recent dynamic general equilibrium literature is empirically well-founded. Concerning the transmission of real exchange rate shocks to domestic output (Domestic Output), there is no effect in the short run and only a small effect (less than 5%) in the medium run. The volatility of domestic prices (Domestic Prices) is significantly affected by the exchange rate shock in the short run (about 20%), with the contribution declining to 10% in the medium run. Note that exchange rate shocks make almost no contribution to monetary policy volatility (Domestic Policy).

Figure 1. Variance decomposition: Czech Republic



When considering the potential of the real exchange rate to act as a shock absorber, attention should be paid to the variance decomposition of the real exchange rate. When the contribution of shocks other than idiosyncratic shocks is large, this could be interpreted as a sign of shock absorption. For the Czech Republic, real exchange volatility is mostly due to asymmetric shocks (brown bars). Their long-term contribution is about 50%.

For the other countries in our sample, except for Bulgaria, Poland and Slovakia,[9] the results reveal that the real exchange rate shock does not significantly contribute to the volatility of domestic variables. Generally, the most significant effect of the exchange rate shock is identified for domestic prices. This is not surprising given that most of the economies are small and open (to their foreign counterparts in the study); movements in the real exchange rate pass through to

[9] In Poland, the long-run contribution to the volatility of domestic prices is 30%, while for Bulgaria and Slovakia about 35% of the volatility in domestic output is driven by the exchange rate shock.

prices, as these are more responsive than output. The transmission of the real exchange rate shock is lagged and reaches its long-term contribution value only slowly. For most of the economies, real exchange rate volatility is mostly due to asymmetric shocks. Thus, in the selected economies exchange rate volatility is mostly driven by symmetric and asymmetric shocks rather than by real exchange rate shocks. The low contribution of idiosyncratic shock to the exchange rate variance indicates that the exchange rate does not generate much volatility on its own, but rather responds to domestic and foreign shocks. For economies with a very low impact of exchange rate shocks on other domestic variables, this may imply that the exchange rate is not a source of volatility. At the same time, the real exchange rate volatility is fuelled by shocks other than idiosyncratic shocks. This finding is interpreted as a shock-absorbing property of the real exchange rate.

Conclusion

We identify economies with a significant long-run relative contribution of asymmetric shocks to exchange rate volatility: in Romania, Lithuania, Bulgaria, Slovakia and the Czech Republic this contribution is over 40%, and for the rest of the group it is around 30%. Our findings also show that economies in the region exhibit heterogeneous monetary policy responses due to asymmetries present both within the region and vis-à-vis the rest of the economies considered. These asymmetries are partially due to different monetary policy and exchange rate regimes (for non-member countries) and to structural differences (for example, TFP levels and levels of nominal prices). At the same time, our results are consistent with the real exchange rate having a shock absorption role in CEE countries.

Our results are consistent with the conclusion that the real exchange rate is a shock absorber rather than a shock generator, as we are not able to find an economy where the majority of business cycle volatility originates in the real exchange rate shock.

The results suggest that the CEE region consists of heterogeneous economies. This heterogeneity can be attributed to differences in monetary policy and exchange rate regimes, as well as to structural differences. Quantification of shock contributions allows us to conclude that for prices and interest rates, symmetric shocks prevail, so the economies considered can be clustered with respect to the extent of the contribution of symmetric shocks. The most distinct clusters can be identified when one considers the contributions to output volatility. For Romania the asymmetric shock prevails, while for Bulgaria, Latvia and Slovakia the symmetric and asymmetric shocks contribute with almost equal weights. For the rest of the economies the symmetric shock prevails.

The role of monetary policy in the Czech Republic in the evolution of output over the period 2005–2011 should also be noted. In the initial stage, the symmetric policy shock contributes positively to growth. However, as the output deviation becomes too large (early 2007) it turns restrictive. After a slowdown hit the economy (in early 2009), policy was eased again to support the recovery. A similar pattern is observed for domestic prices. Analogous behaviour of domestic output within this group is found for Poland and Latvia.

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