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Can we prevent boom-bust cycles during euro area accession?

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Abstract

Euro-area accession caused boom-bust cycles in several catching-up economies. Declining interest rates and easier financing conditions fuelled spending and worsened the current account balance. Over time inflation deteriorated external competitiveness and lowered domestic demand, turning the boom into a bust. We ask whether such a scenario can be avoided using macroeconomic tools that are available in the period of joining a monetary union: central parity revaluation, fiscal tightening or increased taxation. While all these policies can be used to cool down the output boom, exchange rate revaluation seems the most attractive option. It simultaneously trims the expansion of output and domestic demand, reduces the cost pressure and ranks first in terms of welfare.

JEL: E52, E58, E63
Keywords: boom-bust cycles, euro area accession, dynamic general equilibrium models

Non-technical summary

Several countries witnessed a boom-bust cycle during their euro area accession. This pattern was particularly pronounced in relatively poor, catching-up economies, where nominal and real interest rates were relatively high before the monetary integration. One of the crucial features of a currency union is equalization of short-term interest rates as these are determined by the (now single) central bank. This means a substantial reduction of these rates in high-growth economies. Medium and long-term interest rates (e.g. on government bonds) need not be equal across the monetary union members. Nevertheless, in practice, they also tend to adjust substantially, the main reasons being elimination of the exchange rate risk and increased credibility. Moreover, for a small economy, entering a monetary union means accessing an almost inexhaustible pool of funds, which facilitates financing borrowing needs. Finally, joining the club of more developed economies may be (rightly or wrongly) perceived as a permanent boost to productivity. All these developments induce agents to increase spending. As a result, the economy enters a boom phase, characterised by expansion of consumption, investment and credit.

No boom lasts forever though and several mechanisms give an end to such one as well. First, higher demand raises the domestic price level. This lowers the purchasing power of agents and hence contributes to a fall in demand. Second, higher prices bring about an appreciation of the real exchange rate, deteriorating competitiveness of exports. Last but not least, growing external debt raises the risk perceived by foreign investors, increasing risk premia and, as a result, interest rates (except the short-term central bank rate). Consequently, consumption, investment and exports decline and the boom turns into bust.

This mechanism has been extensively described in the literature. In this paper we ask whether such a boom can be prevented using tools that remain available to policymakers in the process of euro adoption and thereafter. We concentrate our attention on Poland, by far the biggest new EU member country which is supposed to join the euro area in the future. At the same time, its GDP per capita is substantially below the euro area average and its interest rates are still much higher than in the euro area. As such, Poland is a model example of a potential boom-bust cycle victim. However, the analysis presented in this paper also applies to other new EU member states.

Our simulations are based on EAGLE, a four-region model developed by Gomes et al. (2010). Before doing them, however, we substantially modify the model and its calibration. First, the model is extended to allow for a non-zero import content of exports, which is a highly relevant feature for the new EU member states. Second, we incorporate public goods into households' utility function, which allows us to perform meaningful welfare comparisons across alternative fiscal policies. Third, the calibration of the model is changed so that it now includes Poland, the euro area, the United States and the rest of the world.

Having done this, we first generate the boom-bust scenario. A credibility shift, consisting of a lower accepted net foreign asset position and the resulting decline of interest rates generates a temporary boom that resembles the episodes described above. Next, we design four policy experiments that are supposed to trim the boom-bust cycle. First, we consider a revaluation of the exchange rate, a policy tool that is available only before joining the euro area. Second, we analyse the effects of increasing two tax rates: VAT and PIT. Finally, we experiment with cuts in government expenditures. To make our scenarios more realistic, we impose implementability constraints on all policies considered, i.e. we do not allow for repeated revaluations or changes in the fiscal parameters.

We find that all considered policies are able to substantially smooth the boom in output. However, they have differentiated effects on other macro variables, some of them being undesired. For example, fiscal contraction fuels the consumption boom, and a higher PIT rate increases inflation. From this point of view, the exchange rate revaluation cuts off relatively well, cooling down the output and inflation boom and substantially limiting booms in consumption and investment. Of course, this comes at a cost of somewhat increased volatility of exports.

Revaluation is also the preferred policy according to the welfare criterion. Importantly, its optimal magnitude coincides with that minimizing volatility of the output gap. This is in contrast to the other policies, for which the welfare analysis suggests a significantly lower size of intervention than that implied by the output gap criterion, or even no action at all.

Looking at the instrument adjustment minimizing output gap volatility, we find that the revaluation should amount to ca. 7%, VAT rate should be raised by 9 percentage points, the PIT rate by 12 percentage points and the fiscal contraction should amount to around 2% of GDP. Thus, from the political perspective, the analysed tax policies seem impossible to implement. On the other hand, both the exchange rate revaluation and fiscal contraction seem to be of reasonable magnitudes. Taking all these considerations together we conclude that revaluation is the most promising tool in smoothing out the boom-bust cycle.

1

1 Introduction

Several countries witnessed a boom-bust cycle during their euro area accession. This pattern was particularly pronounced in relatively poor, catching-up economies, where nominal and real interest rates were relatively high before the monetary integration. One of the crucial features of a currency union is equalization of short-term interest rates as these are determined by the (now single) central bank. This means a substantial reduction of these rates in high-growth economies. Medium and long-term interest rates (e.g. on government bonds) need not be equal across the monetary union members. Nevertheless, in practice, they also tend to adjust substantially, the main reasons being elimination of the exchange rate risk and increased credibility. Moreover, for a small economy, entering a monetary union means accessing an almost inexhaustible pool of funds, which facilitates financing borrowing needs. Finally, joining the club of more developed economies may be (rightly or wrongly) perceived as a permanent boost to productivity. All these developments induce agents to increase spending. As a result, the economy enters a boom phase, characterised by expansion of consumption, investment and credit.

No boom lasts forever though and several mechanisms give an end to such one as well. First, higher demand raises the domestic price level. This lowers the purchasing power of agents and hence contributes to a fall in demand. Second, higher prices bring about an appreciation of the real exchange rate, deteriorating competitiveness of exports. Last but not least, growing external debt raises the risk perceived by foreign investors, increasing risk premia and, as a result, interest rates (except the short-term central bank rate). Consequently, consumption, investment and exports decline and the boom turns into bust. Behaviour of the main macroeconomic variables of rich and catching-up euro area members in the period neighbouring their accession is presented in figure 1.[1] Clearly, the second group of economies experienced a substantial decrease in the real interest rates, appreciation of the real exchange rate, expansion in output and domestic demand, and deterioration in the external position.

This mechanism has been extensively described in the literature. Blanchard and Giavazzi (2002) presented a model which explained the diverging patterns of current account deficits in a monetary union. They show that a common currency offers an opportunity to break the high correlation between domestic savings and investment, known as the Feldstein-Horioka puzzle, allowing lower income economies to borrow more to increase their capital stock. ECB (2003) identified the reasons of inflation divergence in the monetary union and listed convergence of the nominal interest rates as one of the main factors.[2] Other papers were even more explicit about boom-bust cycles. Brzoza-Brzezina (2005) and Schadler et al. (2005) analysed the risk of lending booms during euro area accession of the new EU member states. Fagan and Gaspar (2007) documented the diverging patterns of main macroeconomic variables (i.a. real interest rates, consumption, lending and current account balances) between the core and converging countries of the euro area. They presented a general equilibrium framework based on Blanchard-Yari households that replicates the main features of the boom-bust scenario described above. Blanchard (2007) and Almeida et al. (2009) analysed the case of Portugal and ascribed its boom-bust pattern to the drop in interest rates related to the euro area accession, while Honohan and Leddin (2006) documented similar developments in Ireland. Eichengreen and Steiner (2008) analysed the potential of Poland to become a victim of the boom-bust scenario during

[1]These results are based not only on the experience of the official euro area members, but also of three new EU member countries that follow hard pegs against the euro: Estonia, Latvia and Lithuania. As described below, these countries witnessed similar boom-bust episodes in the period neighbouring pegging their currencies to the euro.

[2]The large literature on inflation divergence in the euro area is also closely related to the topic of boom-bust cycles (Angeloni and Ehrmann, 2004; Honohan and Lane, 2003; López-Salido et al., 2005; Zdárek and Aldasoro, 2009).

the euro adoption. They found that several features (relatively high interest rates, low credit to GDP ratio) place Poland on the list of potentially endangered countries. As mentioned above, the list of countries already affected by a boom-bust scenario is not restricted to official euro area members. Several new EU member states pegged their currencies to the euro. In particular, the three Baltic countries (Estonia, Latvia and Lithuania) experienced a dramatic overheating in the mid 2000s, with low interest rates imported from the euro area being one of the potential culprits (Brixiova et al., 2009; Kuodis and Ramanauskas, 2009). All in all, there is plenty of evidence that the euro area accession of catching-up economies might end up in unsustainable booms.

In this paper we ask whether such a boom in domestic demand can be prevented using tools that remain available to policymakers in the process of euro adoption and thereafter. We concentrate our attention on Poland, by far the biggest new EU member country which is supposed to join the euro area in the future. At the same time (in 2010, as this paper is being written), its GDP per capita amounts to approximately 60% of the euro area average and its interest rates are still substantially higher than in the euro area. As such, Poland is a model example of a potential boom-bust cycle victim. However, the analysis presented in this paper also applies to other new EU member states.

Our simulations are based on EAGLE, a multicountry model developed by Gomes et al. (2010). Before doing them, however, we substantially modify the model and its calibration. First, the model is extended to allow for a non-zero import content of exports. This feature, being relatively less important in the original setting of EAGLE, calibrated for Germany, the rest of the euro area, the United States and the rest of the world, is highly relevant for the new EU member states, where the import content of exports is relatively high. Second, we incorporate public goods into households' utility function, which allows us to perform meaningful welfare comparisons across alternative fiscal policies. Third, the calibration of the model is changed so that it now includes Poland, the euro area, the United States and the rest of the world.

After extending and recalibrating the model we design a series of simulations. Our baseline scenario consists of declining interest rates, driven by a boost to acceding country's borrowing opportunities, under a fixed exchange rate regime. This generates a boom, under which output expands by nearly 2.5% above the steady state, consumption grows by 5% and investment by above 12%. As a consequence, inflation increases, the real exchange rate appreciates and, after approximately two years, the boom turns into bust. We design four policy experiments that are supposed to trim the boom-bust cycle. First, we consider a revaluation of the exchange rate, a policy tool that is available only before joining the euro area. Second, we analyse the effects of increasing two tax rates: VAT and PIT. Finally, we experiment with cuts in government expenditures. To make our scenarios more realistic, we impose implementability constraints on all policies considered, i.e. we do not allow for repeated revaluations or changes in the fiscal parameters.

Our main findings are as follows. First, all considered policies are able to substantially smooth the output boom. Second, the alternative policy interventions have differentiated effects on other macro variables. In particular, fiscal contraction adds even more to the consumption boom, while other policies succeed in smoothing it. A higher PIT rate increases inflation, while the exchange rate revaluation smoothes the boom in consumer prices almost perfectly. Only these two policies lower the boom in investment. Overall, in this category, the exchange rate revaluation cuts off relatively well. Third, this policy ranks first when the model-consistent welfare criterion is applied.

When comparing the size of instrument adjustment minimising the output gap volatility, we find that the optimal revaluation amounts to ca. 7%, the VAT rate should be raised by 9 percentage points, the PIT rate by 12 percentage points and fiscal contraction should amount to around 2% of GDP. Thus, the analysed tax policies are not only relatively inefficient in smoothing the output boom, but also very difficult to implement from the political perspective. On the other hand, the fiscal contraction, and even more the exchange rate revaluation seem to be of acceptable magnitudes. Given these considerations, together with the results of the welfare analysis and the undesirable property of spending cuts which increase the consumption boom, we find the exchange rate revaluation the most promising tool in smoothing out the boom-bust cycle.

Having said this, one thing should be made explicit. In this paper we deal with the risk of a boom-bust cycle in domestic demand. One important issue that this study does not take into account is the possible emergence and bursting of asset price bubbles. EAGLE has a well developed structure of production, international linkages and government policies, which seem important when analysing issues related to the monetary union accession, exchange rate movements and policy intervention. However, this comes at a cost, being the model size. It seems hardly possible to extend such a model for the existence of asset price bubbles and regulatory policies. Second, we doubt whether policies available to the local authorities are able to stop an asset price bubble from emerging, due to potential regulatory arbitrage. Nevertheless, we believe that this is an important and interesting topic for further research.

The rest of the paper is structured as follows. In section two we present the model, its calibration and the main business cycle properties. Section three discusses our baseline boom-bust scenario. Section four describes how we define and design the optimal policy interventions. The scenarios implied by these policies are presented in section five and evaluated in section six. Section seven concludes the paper and the appendix presents the details of the model extension.

2 The model

2.1 EAGLE and its extension

The EAGLE (Euro Area and GLobal Economy) model is a four-country dynamic stochastic general equilibrium (DSGE) model of the euro area in a global economy. It includes Germany, the rest of the euro area (which are both in a monetary union), the US and the rest of the world. EAGLE, based on the NAWM (Coenen et al., 2008b), is also in the vein of the other international models such as GEM (Bayoumi et al., 2004) or SIGMA (Erceg et al., 2006). Thus, the new open economy macroeconomics paradigm constitutes its theoretical background. All country-bloc specifications are identical.

Households are infinitely lived, consume final goods and supply labour to all firms in a monopolistic manner. Wages are sticky à la Calvo with an indexation scheme. Households are distinguished according to their ability to access the financial market. Non-Ricardian agents that do not have this facility can only finance their consumption through labour income. At the opposite, Ricardian agents own domestic firms, rent the physical capital to them, and can buy or sell bonds: a government bond or a bond denominated in US dollars. The internationally traded bond is subject to transaction costs, meaning that households pay a premium to financial intermediaries. There are also adjustment costs on physical capital accumulation. Both capital and labour are internationally immobile.

On the supply side, there are two types of firms. Firms producing final goods for consumption or investment purposes use a constant elasticity of substitution (CES) technology assembling domestic intermediate goods and imports (that are subject to adjustment costs) and act under perfect competition. Firms producing intermediate goods operate under monopolistic competition. Intermediate goods can either be internationally traded (tradable sector) or not (non-tradable sector). Both sectors use a Cobb-Douglas production function combining domestic capital and domestic labour. Exporting firms set prices in the currency of the destination market (local currency pricing) to limit the exchange rate pass-through. Finally, staggered contracts à la Calvo (with indexation) introduce sluggishness in price adjustment.

The government purchases a public good (non-tradable only) and finances its expenditure by issuing bonds and levying taxes. These taxes can either be lump-sum or distortionary, with the latter based on consumption purchases, labour, capital or dividend incomes. Fiscal authorities make transfers to households and earn seigniorage on outstanding money holdings. The fiscal rule sets the lump-sum tax by targeting the debt-to-GDP ratio. Monetary authorities fix the short-term nominal interest rates with a Taylor rule.

The original structure of the model has been amended to better fit the Polish economy. In particular, the Polish economy features a much higher import content of exports than for instance the euro area or the United States. This feature can be important while running simulations in which international linkages play an important role. For this reason we extend the model for the import content of exports. Following Coenen and Vetlov (2009), we introduce a new type of good, i.e. the export good, which consists of domestic tradables and imported goods. This good is produced under monopolistic competition and priced in the currency of the destination market. Details of the derivation are given in the Appendix.

Another important modification of the original structure of EAGLE is related to our use of welfare as one of the criteria for evaluation of alternative policy interventions. It is standard in the DSGE literature to include government purchases neither in households' utility nor firms' production function. With such an assumption, however, public expenditures are wasteful and hence welfare can be increased by driving them to zero. To eliminate such corner prescriptions in our welfare analysis, we interpret government spending as provision of public goods and modify the utility function of each household type accordingly. Our aim is to make this modification as natural and neutral as possible. More specifically, the flow of government goods is assumed to be equally distributed (in per capita terms) across Ricardian and non-Ricardian households. Further, we assume that utility is separable in private consumption and public goods so that no first order conditions of households' optimization are affected by our modification. We also use the same functional forms for the utility components related to both types of goods. Finally, we follow Adam and Billi (2008) and calibrate the relative weight on the utility component including government spending such that for each type of households the steady state marginal utility of public goods provision and private goods consumption are equalized.

2.2 Calibration

As already mentioned, we are interested in examining the impact of euro area accession on a converging economy, and hence calibrate the model to Poland (PL), the euro area (EA), the United States (US) and the rest of the world (RW). Our strategy to calibrate EAGLE can be divided into two stages. First, we pin down a subset of parameters governing some key steady-state ratios, using their approximate empirical counterparts. Next, we calibrate the remaining parameters of the model, drawing heavily on the original version of EAGLE, which in turn can be traced back to the parametrisation of the NAWM or GEM, as well as estimated small scale DSGE models for the euro area (e.g. Smets and Wouters, 2003; Adolfson et al., 2005; Christoffel et al., 2008), the United States (e.g. Christiano et al., 2005) and Poland (Grabek et al., 2010; Kolasa, 2009; Gradzewicz and Makarski, 2009). The calibrated parameters are reported in Tables 1 - 7. Below we provide a brief discussion on our main choices and data sources.

Steady-state ratios

The relative size of each region is calibrated to reflect its GDP share in the world economy. Consistently with the assumption that each region's steady-state trade balance is zero, we set the nominal output shares of consumption, government expenditures and investment to the respective domestic demand shares of private consumption, government consumption and gross capital formation. All this data corresponds to the averages for the period 1995-2008 and comes from the national accounts statistics collected in the Eurostat and World Development Indicators databases.

To obtain a more recent picture of international trade relations, we set the total import share of each region using the same data source, but averaged over a shorter sample (2004-2008). The structure of bilateral trade flows, including their final use breakdown (consumption, investment or intermediate), relies on flows of goods extracted from the CHELEM database and averaged over the years 2004-2008. The exception is Poland, for which we were able to collect data on bilateral trade in both goods and services provided by the National Bank of Poland. It is worth noting that more than half of Poland's imports of any type of goods come from the euro area.

The shares of domestic tradables in production of the export good (i.e. one minus the import content of exports) were set to 80% for the EA, 85% for the US, 55% for PL and 65% for the RW. For the former three regions this is consistent with estimates from the input/output matrices, while for the RW it is based on the proportion of intermediate goods imports to total exports (no input/output matrix is available). The quasi-shares of nontradables in the consumption and investment baskets are set to 75% and 35%, respectively, which together with the assumption of fully nontradable content of government expenditures implies the share of tradable output in GDP of about 35%. This number is roughly consistent with the values implied by the share of agriculture, mining and manufacturing in the total market economy, calculated for Poland, the euro area and the United States for the period 1995-2008 using the EU-KLEMS database.

Other parameters

We set the capital share in production functions in all countries to 30%. The tax structure for the euro area and the United States is taken directly from Gomes et al. (2010). The tax structure for Poland comes from national sources and tax wedges for the rest of the world are calibrated at the US level. The capital tax rate is treated as a free parameter and used to calibrate the region-specific investment shares in output. Price and wage mark-ups for the euro area, the United States and the rest of the world are in most cases left at the original levels, while the numbers for Poland are set at the EA level. These values imply lower competition in Poland and in the euro area region than in the rest of the global economy, both on the labour and the product market. At the same time we assume that markets for tradables are more competitive than for nontradables in all countries.

Most of the remaining key parameters are assumed to be the same across the four regions and broadly consistent with the original version of EAGLE or the calibrated version of NAWM. Calvo probabilities on the labour and domestic product markets are set to 0.75, implying an average time between wage and price reoptimisation of four quarters. Indexation parameters are set to 0.5 on the product market and 0.75 on the labour market. The elasticities of substitution used for aggregating various bundles of goods into final consumption goods are the same as those for final investment goods. In particular, the elasticity of substitution between nontradable goods and a bundle of domestic tradable and imported goods is set to 0.5, the elasticity of substitution between home-made and imported tradable baskets is calibrated at 2.5. The elasticity of substitution between domestic and imported goods in the production of export goods is set at a somewhat lower level of 1.5 and the parameter governing substitutability across imports from different countries is assumed to be 2.5.

The choices of adjustment cost parameters are taken directly from the original versions of EAGLE and NAWM as well. The response of the share of lump-sum taxes in nominal output to deviations of the public debt-to-output ratio from the target (60% on an annual basis) is set to 0.1. Only the parameter governing the international transaction cost (reaction of interest rates to net foreign assets (NFA)) is set specifically for this paper in a way that allows meeting simultaneously the assumptions on interest rates and NFA in our baseline scenario. This is explained in detail in section 3. We also maintain the NAWM assumption on asymmetric distribution of lump sum transfers and taxes across the two types of households, favouring those with limited access to capital markets in the proportion of 3 to 1. Finally, the long-run monetary policy response to inflation and output growth is calibrated at 1.7 and 1.25, respectively, while the weight on the lagged interest rate is set to 0.8.

Besides taking most parameters from the literature, we pay special attention to the short-term dynamic responses of the Polish economy to various shocks. This is crucial, taking into account the simulations to be performed. In particular, our goal was to bring the impulse response functions close to those from the estimated DSGE models of the Polish economy (Grabek et al., 2010; Kolasa, 2009; Gradzewicz and Makarski, 2009). In order to match the impulse responses, we run the model assuming independent monetary policy for Poland, as is currently the case. Given the calibration presented above, this did not require substantial changes to the parameters, an exception being a somewhat higher habit persistence parameter, helping to trim the volatility of consumption. The impulse response functions are presented in the next section.

2.3 Business cycle properties

In this section we document the main business cycle properties of the recalibrated model. We concentrate on the reaction of the Polish economy to a set of standard shocks.[3] As mentioned in the previous section, the calibration of several parameters was done so as to match the impulse responses to those from estimated DSGE models under the assumption of independent monetary policy. On the other hand, our boom-bust scenarios will be designed under the assumption of a fixed exchange rate against the euro. As a consequence, we present impulse responses under both monetary policy regimes.

Our analysis begins with the reaction to a standard technology shock, affecting to the same degree productivity in the tradable and nontradable sectors. Figure 2 shows the reaction of the main macroeconomic variables. The impulse responses are standard to a supply side shock. In particular, real variables increase while inflation declines. Under independent monetary policy, the central bank reacts to this by lowering interest rates. However, this reaction is muted since output and inflation move in opposite directions. Under the fixed exchange rate regime, domestic interest rates decline slightly as well due to improvement in the current account balance, the resulting lower risk premium and spillovers to the euro area. Given the weak reaction of the domestic central bank in the float case, the economy reacts similarly under both exchange rate regimes.

Monetary policy shocks constitute a more interesting case (Figure 3). Since under the peg regime domestic monetary policy does not control the short-term interest rates, in this case we present the reaction to a shock to the euro area interest rate. This should be kept in mind since the euro area interest rate affects also the euro area economy and so has an additional, indirect impact on Poland. In general, the shape of reaction functions is standard. Output, consumption and investment decline, so does inflation. The magnitude of reactions of the main variables under independent monetary policy is broadly consistent with that from other studies on the Polish economy. However, reactions under the peg are somewhat weaker. The reason is the exchange rate channel, which is an important component of the monetary transmission under the float. After pegging to the euro, the appreciation of the real effective exchange rate is weaker and so is the reaction of most variables.

Figure 4 presents the impulse responses to a risk premium shock. The reaction under the floating exchange rate comes primarily from the sharp depreciation of the exchange rate. As a result, exports surge and imports decline, generating a surplus in the current account and giving a boost to GDP. Following the exchange rate depreciation, inflation increases, which results in a monetary policy tightening. This contributes to a drop of consumption and investment. As before, the magnitude of reaction of the main variables is in line with other estimates for Poland. The transmission pattern is different under the peg. Since the possible exchange rate reaction is limited, the adjustment to the higher risk premium takes place in the domestic interest rate. This has a negative impact on consumption, investment, output and inflation. In particular, it is worth noting that the latter two variables move in opposite directions compared to the independent monetary policy case.

Finally, Figure 5 shows the responses to a government expenditure shock. As in the case of the technology shock, the reactions of most variables are similar under the floating and flexible exchange rate. This results from the relatively weak reaction of monetary policy. Output increases on impact and, taking into account the share of government expenditure in GDP, its response implies a fiscal multiplier of approximately one. Higher government expenditure crowds out private consumption and investment and brings about an appreciation of the real exchange rate. As a consequence, exports decline and imports increase. It should be noted that in the current model setting the government consumes only nontradable goods, so there is no direct impact of its spending on imports.

[3] For all shocks, the autoregressive coefficient is 0.9 and the standard deviation is 1%.

All in all, the reactions of the main variables to the presented shocks are in line with the literature and their magnitude seems comparable to that found in empirically underpinned studies of the Polish economy.

3 Permanent credibility shift

For a relatively poor economy, entering the euro area implies elimination of the exchange rate risk and a boost to credibility. This translates into better access to financial markets and a drop in interest rates. All in all, for a given level of external debt, borrowing from abroad becomes cheaper.

We use these insights in designing our baseline boom scenario. More specifically, we assume that joining the euro area by an emerging economy results in a permanent step decrease in its target (long-run) level of NFA. In other words, the amount of foreign debt accepted by financial market participants, i.e. the level considered as safe, increases. Since, as usually assumed in contemporaneous open economy models with incomplete financial markets, the interest rate paid on foreign loans depends positively on the difference between the current and long-run external debt, such a scenario leads to a drop in the cost of borrowing. It is important to note that this decrease in the interest rates is only temporary: once indebtedness of the new entrant achieves the new steady state, the cost of borrowing goes back to its initial level. We consider this feature of our scenario very attractive, given the recent aversion of financial markets to highly indebted peripheral euro area countries.

We calibrate Poland's entry to the euro area as follows. First, we set the size of the shift in the NFA position to 30% of annual GDP. This choice can be considered small as the average drop in this ratio in Greece, Spain, Portugal, Estonia, Latvia and Lithuania in the eight years surrounding their euro area accession(as presented in figure 1) amounted to almost 50%. However, we find it reasonable to assume that financial markets will become more cautious after the recent balance of payments tensions in some euro area countries and so less likely to tolerate as large increases in foreign debt as experienced by the acceding countries in the past. Second, we calibrate the link between the interest rate and the NFA position embeded in EAGLE so that it generates a drop in the acceding country's long-term interest rates of around 110 basis points, which corresponds to the historical (2005-2010) difference between the yields on 10-year Polish government bonds denominated in Polish zlotys and euro-denominated bonds of a similar maturity.[4]

The dynamic responses to the baseline boom scenario defined above are presented in Figure 6. Lower interest rates make Ricardian households increase their spending, so consumption and investment go up. Higher demand leads to an expansion in domestic output and imports, so the current account balance deteriorates significantly. The boom increases labour demand and improves the fiscal balance, which allows the government following the fiscal rule to cut lump sum taxes. As a result, income of non-Ricardian households improves and their spending grows. Increased cost pressure pushes prices up. As the nominal exchange rate is fixed and prices abroad hardly move, the real exchange rate appreciates.

The adjustment of the NFA position to its new steady state value is gradual, with half of it completed only in the seventh year after the euro adoption. As a result, the period of low interest rates is quite long, so it takes more than ten years for the expansion in domestic demand to die out. In contrast, the boom in output turns into bust already after approximately two years. The reason is the deterioration in international competitiveness, resulting in a contraction in exports. Only after the cost pressures decline somewhat and the competitiveness is restored do exports recover, which together with declining imports leads to a second, but smaller in magnitude, expansion in output.

[4]In EAGLE, taking a position in the international bond market is subject to an intermediation premium Γ_t, i.e. interest paid on foreign debt is equal to $R_t^*(1-\Gamma_t)$, where R_t^* is the (gross) risk-free return on foreign bonds. The premium is given by $\Gamma_t = \gamma_B \left(exp\left(B_{t+1}^* - \bar{B}^* \right) - 1 \right) - rp_t$, where γ_B is the elasticity parameter (international transaction costs in Table 7),B_{t+1}^* denotes the NFA to GDP ratio,$\bar{B}^*$ is its steady-state (target) level and rp_t is a risk premium shock. Our calibration sets γ_B such that the two assumptions underlying our baseline scenario (i.e. a shift in the NFA position and a drop in the long-term interest rates) are simultaneously satisfied.

As Poland is a small country, the spillovers from the credibility shift in this economy to other regions, even to the closely linked euro area, are very limited. Qualitatively, they will depend on how the decrease in Poland's long-run NFA position is absorbed abroad. In our baseline scenario, we assume that the whole adjustment can be attributed to the euro area and hence the international investment positions of the US and the rest of the world remain unchanged.[5] As increased lending to Poland is financed with higher savings of the euro area, our scenario implies a small contraction in the latter's output.

Finally, it might be instructive to analyse the long-run implications of our baseline scenario. A first look at Table 8 makes clear that the boom sparked by a credibility shift is not a free lunch. Higher external debt needs to be serviced, which requires the trade balance to be in surplus. This induces a shift in production towards tradable output and a decrease in imports. The disposable income of Ricardian households (i.e. those who run debt abroad) declines, so they cut their consumption and investment expenditures, and increase their labour supply. As revenues from distortionary taxes go down, lump sum taxes need to be increased to keep the public debt constant. This hits, though proportionally less, also non-Ricardian consumers. All these demand shifts lead to equilibrium changes in relative prices: terms of trade and the real exchange rate depreciate while the relative price of tradables goes up.

[5]This assumption does not have a significant effect on the dynamic responses of Polish macroaggregates.

4 Designing policies for the boom

The model we are using is not able to capture all channels making the boom-bust cycle harmful. In particular, our baseline scenario is not a typical bubble, resulting from overly optimistic expectations. Instead, it reflects dynamic responses of rational agents, subject to a set of constraints. Since the model includes a range of nominal and real rigidities, appropriately designed stabilization policies can be welfare improving. However, gains from applying them are known to be rather small in a standard quantitative business cycle framework, at least when model-consistent evaluation criteria are used (Lucas, 2003).

That said, one can list several reasons why smoothing the boom-bust cycle might be in practice more justified than the welfare analysis suggests. The most important one is that temporary but prolonged periods of prosperity can lead to excessive optimism, increasing the likelihood of bubbles building up and making the necessary adjustment of imbalances sudden and painful. Moreover, rapid expansions in output and consumption are usually accompanied by lending booms, which may have detrimental effects on the banking sector stability. Therefore, even though such effects are not incorporated in our workhorse model, it still might be relevant to analyse which policies are most successful in smoothing the boom.

For a small economy, adopting the euro means in practice giving up monetary autonomy as short-term interest rates are now set by the European Central Bank in response to area-wide developments. The only monetary parameter that can be used (but only prior to accession) is revaluation of the nominal exchange rate. In contrast, the new entrant can still use a full set of fiscal instruments. In theory, one can design many revenue and expenditure policies smoothing the boom completely. In practice, they would require changes of the fiscal instruments on a quarterly basis. While this might be feasible for some types of expenditures, it is difficult to imagine so frequent adjustments in such parameters as the tax rates or major spending components.

Therefore, we restrict our attention to those policies that can be considered implementable. In particular, we assume that the exchange rate can be revalued only once, and the tax rates can be changed twice (i.e. up and back to the original level) for full-year periods. We make a similar assumption for the government spending share in GDP, but additionally look at a variant allowing it to be adjusted every period.

For the reasons discussed before, we parameterize and evaluate alternative policies using two criteria. First, we consider a simple stabilization objective. While there are a number of economic indicators that could be used as potential targets for a countercyclical policy, we use the most natural one, i.e. the output gap volatility, defined as the root mean square deviation of output from its terminal steady state level and calculated over a 10-year horizon. Even though the focus on output gap stabilization seems natural given the common practice, this choice might be considered somewhat arbitrary. Therefore, we will also discuss the implications of the policies designed to minimise output gap volatility for other variables.

Second, we apply the welfare criterion. This is not straightforward as the steady state equilibrium in the model is not efficient and so the constrained optimal policies we consider imply non-zero interventions even if the credibility shift underlying our baseline scenario does not occur. Since we want to net such effects out, we proceed as follows. For each policy variant, we calculate the optimal change of policy parameters with and without the boom and define the best response to the boom from the welfare perspective as the difference between the two. Essentially, this indicator tells us how, taking the steady state as the reference point, the optimal policy should be modified if faced with the boom scenario.

5 Policy simulations

5.1 Exchange rate revaluation

The first policy scenario we consider relies on counteracting the boom with a one-off exchange rate revaluation. One can think of this policy as resulting from an agreement between the new entrant and the rest of the euro area to set the conversion rate at a stronger level than currently prevailing on the foreign exchange market. Interestingly, the magnitude of the revaluation minimising the output gap volatility roughly coincides with that implied by the welfare criterion and amounts to about 7%.[6]

The dynamic responses to this scenario are plotted in Figure 7. The exchange rate revaluation turns out quite successful in cooling down the boom. Compared to the baseline, the initial swing in output is dramatically reduced. This affects households' income, so the peak response of consumption and investment is delayed and decreased substantially. The contraction in exports is slightly deeper (by 0.7 percentage points) than under baseline so the current account deteriorates more, but only in the short run. The revaluation has an important effect on inflation, which is smoother and of different sign compared to the baseline. The stronger exchange rate increases price competitiveness of imports from the euro area so the short-run response of its output is now positive, though still very small.

5.2 VAT hike

We next analyse to what extent the boom can be smoothed with a temporary change in indirect taxes. To this effect, we search for the magnitude and duration of a VAT hike that minimises volatility of the output gap.[7] This turns out to be 9 percentage points for two years. On the other hand, the optimal shift in the VAT rate from the welfare perspective, if also applied for a two-year period, is twice lower and amounts to 4.5 percentage points.

We plot these two scenarios in Figure 8. A temporary increase in VAT affects the intertemporal substitution incentives, making households postpone their consumption decisions. As a result, the short-run increase in consumption is nearly eliminated if the rate goes up by 9 percentage points and substantially decreased if the change amounts 4.5 percentage points. However, in the former variant, once the tax rate is restored to its initial value, consumption expenditures quickly take off and in the medium run reach values exceeding those under the baseline. Given the smoothing motive implied by households' utility function, such swings in consumption are undesired and the welfare consistent criterion takes this into account. Since any VAT hike makes the relative price of investment goods cheaper, the boom in investment is magnified. Overall, the VAT policy successfully weakens the short run expansion in domestic demand, smoothing the boom in output and slightly decreasing the pace of current account deterioration. Inflation pressure, measured with the consumer price index at producer prices, is also reduced.[8]

[6] Since the parametrization of our policies is based on a grid search, the accuracy of our results is determined by the size of the search step, which we set to 0.5 percentage points for all policies considered in this section.

[7] We search over a two-dimensional grid of 0.5 to 15 percentage points (size of hikes) and 1 to 4 years (duration). The same grid is applied to the scenario based on PIT increases.

[8] Naturally, with a hike in VAT, market prices of consumption goods go up much more compared to the baseline scenario.

5.3 PIT hike

If the government wants to minimise output volatility by changing personal income taxes levied on labour income, it should increase the PIT rate by 12 percentage points for two years. In contrast, the welfare analysis prescribes virtually the same magnitude of intervention with and without the boom.

Figure 9 helps to understand this result. As can be seen, increasing the PIT rate is quite effective in stifling domestic demand. In particular, it cools down the boom in both consumption and investment. However, an increase in direct taxes decreases factor supply, hence firms' costs and inflation go up. This is costly in terms of welfare if prices are set in a staggered fashion. Also, increased cost pressure erodes firms' competitiveness. As a result, the real exchange rate appreciation is stronger and exports fall by more than under the baseline. Finally, while a PIT hike helps to cut the peak response of output, it also makes the subsequent bust larger.

5.4 Government spending cuts

If we apply similar implementation constraints to the government expenditure cuts as to the VAT and PIT rate hikes discussed above, the policy yielding the lowest output gap volatility is a three year reduction in public spending by around 2% of GDP.[9] Again, the welfare maximizing size of fiscal adjustment, also restricted to three years, is essentially zero.

We consider these scenarios in Figure 10. As government purchases affect aggregate demand directly, cutting them is quite successful in reducing the boom in output. However, the side effect of thus defined fiscal consolidation, undesired from the welfare perspective, is magnification of the consumption and investment booms. Cutting government expenditures also somewhat weakens the cost pressure, so the responses of inflation, the real exchange rate and hence the current account balance become smoother.

It can be argued that public spending is to a large extent at the discretion of the government and so faces less severe implementation lags compared to changes in the tax rates. Therefore, one can at least conceptually think of a policy that fine-tunes the government purchases so that output fluctuations are eliminated completely. Such a policy is illustrated with dotted lines in Figure 10. The required path of government expenditures (not shown) is roughly the rescaled mirror image of the output response in our baseline scenario. The magnitude of short-term spending cuts is substantial, reaching 20% (or around 3.5% of GDP) in the second year. The impact of this scenario on other macrocategories is qualitatively similar to its restricted variant.[10]

5.5 Other policies

Besides the variants described above, we have also considered a range of other policies that might be used to cool down the boom sparked by the euro adoption. These include changes in social security contributions, capital income taxes and the target public debt to GDP ratio. Overall, these alternative scenarios are either very ineffective in smoothing the cycle or generate outcomes very similar to one of our four main variants, so we do not report them in detail. In particular, hikes in social security contributions paid by employees are isomorphic to appropriate increases in

[9] We search over a two-dimensional grid of 0.5 to 5 percent of GDP (size of cuts) and 1 to 4 years (duration).

[10] The only important difference is that now the expansion in investment becomes weaker than under the baseline without any intervention. This is because government spending consists of nontradables only, so a reduction in demand for this type of goods results in a decrease in their relative price. As the nontradable content of investment is much lower than that of consumption, the relative demand for the former will go down as long as the shift in relative prices is expected not to be quickly reversed, which is the case in the variant fully stabilizing output.

the PIT rates as both are levied on labour income only. The results do not differ significantly if the government uses contributions levied on employers rather than employees. According to our simulations, only enormous and completely unrealistic increases in capital income taxes would achieve reductions in output volatility that come close to those obtained with the four policy instruments considered above. We have also checked how our results change if the fiscal surplus generated by the boom is used to permanently reduce the public debt. We have found no additional insights from this kind of exercises.[11]

[11]The results would change more if we assumed that the fiscal consolidation leads to an increase in the long run net foreign assets position (Faruqee et al., 2007; Coenen et al., 2008a). This would essentially undo some (though less than 20%, using the parametrisation from the literature) of our baseline impulse.

6 Evaluation of alternative policies

A natural question emerging from the simulations presented in the previous section is: which of these policies achieves the best outcome? The answer depends on the criteria applied and these are not straightforward to define, given that the model does not have all mechanisms that could make the boom scenario harmful.

We have already used output volatility and welfare to choose between different policy variants. The relative performance of the policies along this first dimension is summarised in the first column of Table 9. Obviously, if we assume that government purchases do not suffer from implementation lags or commitment problems, appropriately designed spending cuts can eliminate output fluctuations completely and so this policy ranks first. As regards other policies, their performance is far worse, which is not surprising as we assumed that they cannot be adjusted on a quarterly basis. One-off revaluation can at best reduce swings in GDP by nearly a third. Using the PIT rates as an instrument decreases output volatility by about a quarter. Temporary VAT hikes and government spending cuts, constrained in a similar way as the policies using tax rates, appear least attractive (less than 20% reduction).

As we have already discussed, while targeting the output gap is a standard goal of stabilisation policies, one can think of a number of other variables relevant to policy makers striving to prevent accumulation of imbalances and overly optimistic expectations. The remaining columns of Table 9 offer such a summary. Clearly, if the consumption boom is of concern, government spending cuts significantly lose in attractiveness. The VAT hike magnifies the boom in investment. The undesired effect of increases in the PIT rate are increased volatility of the real exchange rate and inflation. The main weakness of the revaluation is high volatility of the real exchange rate. Still, this is the only policy that cools down the boom in both private demand components and weakens the cost pressure.

6

The results of the second, welfare based approach are reported in Table 10. The exchange rate revaluation clearly ranks first, with a steady state consumption equivalent nearly five times larger than the VAT hike. Interestingly, both policy variants imply some redistribution of welfare between the two types of households, favouring non-Ricardian consumers. The reason is that this type of households has a very limited ability to smooth their consumption (they can only adjust money holdings) and countercyclical policies make their lack of access to asset markets less painful. Since the policies relying on changes in the PIT rate or government spending do not call for any significant adjustment, their welfare implications are negligible.

Finally, it should be noted that the considered policy variants are not equally implementable. It is difficult to imagine the government of an accession country raising personal income taxes by more than 10 percentage points. VAT hikes of the order suggested by our analysis would also be difficult to implement. The required magnitude of fiscal contraction does not look unreasonable, but would certainly also face political constraints. Given the size of historical swings in the Polish zloty and Slovakia's experience in the ERM-II system,[12] the exchange rate revaluation of 7% is by far the least problematic option. Overall, since this policy also performs relatively well along the other dimensions, we consider it the most promising.

[12] The Slovak koruna was revalued twice while in the ERM-II mechanism: by 8.5% in March 2007 and by 17.65% in May 2008.

7 Robustness check

Consistently with the literature discussed in the introduction, the driving force of our baseline scenario is a decrease in an acceding country's interest rates. However, there may be also other mechanisms explaining the boom-bust cycles observed during the euro adoption. We have already mentioned one of them, related to overly optimistic expectations. For instance, if agents in a catching-up economy expected that entering the eurozone would significantly speed up real convergence, this could result in a boom. This boom is bound to turn into bust if these expectations fail to materialize.

We consider such a scenario in this section, drawing on simulations described in Kolasa (2010). We associate the euro adoption with a positive but false news shock. More specifically, agents believe that two years after accession productivity in the tradable sector will start converging to a level that is 10% higher than under the baseline. The speed of convergence, i.e. the share of the remaining gap that is eliminated every period, is set to 5%.[13] After two years, however, productivity does not take off, which pricks the bubble and brings the expectations back to their pre-accession level.

The dynamic responses to this scenario are plotted in Figure 11. A favourable news shock drives private demand and output up, the current account deteriorates and inflation pressure translates into depreciation of the real exchange rate. Once it becomes clear that the news was false, agents' plans get revised, turning the boom into a sharp contraction.

There are at least two features of this scenario that make it less appealing as a candidate for replicating a typical euro-related boom-bust episode. First, the magnitude of the boom is small given the stylized facts discussed before, even though the calibrated scale of the news shock cannot be considered low. Second, in contrast to convergence in nominal interest rates observed prior to euro adoption, they barely move under the overly optimistic expectations scenario. This leads us to a conclusion that this variant is not a fully convincing alternative to our baseline. Still, as the mechanisms it describes may intensify in a catching-up economy entering the euro area, an investigation of its impact on the desired policy responses certainly warrants attention. Nevertheless, given its weakness as an alternative, this scenario should be rather thought of as complementary to our main simulations.

To this effect, we repeat the search for optimal policy interventions to the overly optimistic expectations scenario. The results are summarized in Table 11. Both our evaluation criteria suggest that some exchange rate revaluation is desired. In contrast to our baseline case, however, the effectiveness of this policy is low: output gap volatility is only marginally reduced and welfare gains are very small. This is because the effects of revaluation are spread over time, which means that it can smooth the (relatively short-lived) boom only at the expense of making the following bust deeper. For a similar reason, one can achieve little in terms of output gap volatility reduction by changing the PIT rates, even though such an intervention cuts out relatively well if the welfare criterion is applied. Interestingly, in the case of this policy a decrease rather than an increase in the tax burden is recommended. Smoothing the output boom with a hike in VAT rates is somewhat more successful. However, the implied welfare gains are as small as in the case of revaluation. Finally, while adjusting government spending looks attractive as a policy reducing swings in output, this action is not recommended by the welfare criterion. Overall, when we simultaneously apply both of our evaluation criteria, neither of the interventions considered are efficient in smoothing a boom-bust cycle generated by overly optimistic expectations.

[13] Parametrization of our scenario is based on Daras and Hagemejer (2009), who estimate the long-run effect of the euro adoption on Poland's GDP at 7.5% (which is consistent with an increase in tradable sector productivity by 10%), of which around 90% is realized in the first 10 years (consistently with our calibration of the speed of convergence at 5% quarterly).

Nevertheless, as mentioned above, this scenario cannot be considered a standalone boom-bust generator, but rather an addition to our main scenario. In this respect one should note that, with the exception of a change in PIT rates, the recommendations presented above are broadly in line with those from our baseline. In particular, they make the case for revaluation and a VAT hike. If the credibility shift and overly optimistic expectations scenarios are merged, the effects of an increase in VAT are somewhat closer to those of revaluation, but the latter still ranks first according to both optimality criteria. Needless to say, while the implied joint size of revaluation (8-8.5%) still looks acceptable from a political perspective, increasing the VAT rates by another 3 pp. over what is implied by our baseline is even more difficult to imagine. All in all, the presented robustness check does not change our main conclusion of the attractiveness of revaluation.

8 Conclusions

In this paper we investigate whether boom-bust episodes that have plagued several catching-up economies during their euro-area accession (or pegging to the euro) can be avoided by an appropriate use of macroeconomic policy tools. The boom-bust cycles are a result of sharply declining interest rates in the period shortly preceding the euro area accession. Lower interest rates boost domestic demand, output and imports. Over time this brings about higher inflation and deterioration in competitiveness. As a result, domestic demand as well as exports decline and the boom turns into bust. This process can lead to unwelcome developments that are hard to model, but emerge in real life: overly optimistic expectations creating lending booms (and possible related problems in the banking sector) as well as asset price bubbles.

To analyse the ability of monetary and fiscal authorities to smooth the boom, we use EAGLE, a four country model developed by Gomes et al. (2010). The model is changed in three areas in order to fit our needs. First, we calibrate the model to include Poland - one of the potential victims of the boom-bust scenario. The second adjustment is related to a specific feature of the Polish economy - a relatively high import content of its exports (45%). Since in the original version of EAGLE exports are produced only domestically, we reconstruct the model so that it now reflects a foreign input into the production of export goods. Third, in order to perform meaningful welfare comparisons across alternative fiscal policies, we incorporate public goods into households' utility function.

Having done this, we first generate the boom-bust scenario. A credibility shift, consisting of a lower accepted net foreign asset position and the resulting decline of interest rates generates a temporary boom that resembles the episodes described above. Next, we analyse the impact of four policies (exchange rate revaluation, PIT increase, VAT increase and fiscal contraction) designed to cool down the boom.

We find that all considered policies are able to substantially smooth the boom in output. However, they have differentiated effects on other macro variables, some of them being undesired. For example, fiscal contraction fuels the consumption boom, and a higher PIT rate increases inflation. From this point of view, the exchange rate revaluation cuts off relatively well, cooling down the output and inflation boom and substantially limiting booms in consumption and investment. Of course, this comes at a cost of somewhat increased volatility of exports.

Revaluation is also the preferred policy according to the welfare criterion. Importantly, its optimal magnitude coincides with that minimizing volatility of the output gap. This is in contrast to the other policies, for which the welfare analysis suggests a significantly lower size of intervention than that implied by the output gap criterion, or even no action at all.

Looking at the instrument adjustment minimizing output gap volatility, we find that the optimal revaluation would amount to ca. 7%, VAT rate would be raised by 9 percentage points, the PIT rate by 12 percentage points and the optimal fiscal contraction would amount to 2% of GDP. Thus, from the political perspective, the analysed tax policies seem impossible to implement. On the other hand, both the exchange rate revaluation and fiscal contraction seem to be of reasonable magnitudes. All these considerations put together strongly suggest that the revaluation would be the most promising tool in smoothing out the boom-bust cycle. This conclusion still holds when we allow for the fact that the boom-bust episodes observed in catching-up economies during their euro accession may additionally reflect a build-up of overly optimistic expectations about the real convergence processes.

One should keep in mind that all policies considered in this paper have been designed to trim a boom-bust cycle in domestic demand. They should not be expected to prevent asset price bubbles, if these are going to emerge after euro area accession. This important and interesting problem would require a different approachis and is left for further research.

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Tables and figures

Table 1: Steady state ratios

	PL	EA	US	RW
GDP share in world GDP	1.0	22.0	28.0	49.0
Consumption share in GDP	61.3	58.1	66.6	58.3
Government expenditures share in GDP	17.4	20.5	14.7	16.6
Investment share in GDP	21.2	21.4	18.7	25.1
Imported consumption goods share in GDP	11.3	8.2	7.7	3.6
Imported investment goods share in GDP	13.9	8.4	7.6	4.5

Table 2: International linkages

to \ from	PL	EA	US	RW
consumption goods				
PL	.	52.1	2.9	45.0
EA	4.4	.	7.8	87.8
US	0.2	14.7	.	85.1
RW	2.3	58.3	39.4	.
investment goods				
PL	.	51.2	3.7	45.1
EA	3.0	.	11.6	85.4
US	0.2	14.9	.	84.9
RW	1.0	47.0	52.0	.
intermediate goods				
PL	.	51.5	2.3	46.2
EA	3.4	.	6.0	90.7
US	0.2	11.7	.	88.1
RW	1.6	45.3	53.1	.

Note: the numbers refer to percentage shares of imports from column country to row country in total imports to row country of consumption, investment or intermediate goods respectively.

Table 3: Final goods

	PL	EA	US	RW
Quasi-share of nontradables in final consumption goods (%)	65.0	65.0	65.0	65.0
Quasi-share of nontradables in final investment goods (%)	25.0	25.0	25.0	25.0
Quasi-share of imports in export good (%)	45.0	20.0	15.0	35.0
Quasi-share of imports in tradable consumption goods (%)	66.1	44.3	40.4	17.3
Quasi-share of imports in tradable investment goods (%)	90.9	56.1	60.4	23.0
Elasticity of substitution between tradable and nontradable goods	0.5	0.5	0.5	0.5
Elasticity of substitution between domestic goods and imports (production of consumption and investment goods)	2.5	2.5	2.5	2.5
Elasticity of substitution between domestic goods and imports (production of export good)	1.5	1.5	1.5	1.5
Elasticity of substitution between imported goods	2.5	2.5	2.5	2.5

Table 4: Intermediate goods

	PL	EA	US	RW
Capital share in nontradable production	0.30	0.30	0.30	0.30
Capital share in tradable production	0.30	0.30	0.30	0.30
Elasticity of substitution between intermediate nontradable varieties	3.0	3.0	4.3	4.3
Elasticity of substitution between intermediate tradable varieties	4.3	4.3	6.0	6.0
Elasticity of substitution between imported varieties	4.3	4.3	6.0	6.0
Calvo probability for goods sold domestically	0.75	0.75	0.75	0.75
Calvo probability for exported goods	0.75	0.75	0.75	0.75
Price indexation	0.50	0.50	0.50	0.50

Table 5: Households

	PL	EA	US	RW
Share of non-Ricardian households	0.25	0.25	0.25	0.25
Inverse of the intertemporal elasticity of substitution	2.0	2.0	2.0	2.0
Habit persistence	0.8	0.7	0.7	0.7
Inverse of the elasticity of labour supply	2.0	2.0	2.0	2.0
Elasticity of substitution between labour varieties	4.33	4.33	7.25	7.25
Calvo probability for wages	0.75	0.75	0.75	0.75
Wage indexation	0.75	0.75	0.75	0.75
Depreciation rate	0.025	0.025	0.025	0.025

Table 6: Fiscal and monetary authorities

	PL	EA	US	RW
Target government debt to quarterly GDP ratio	2.4	2.4	2.4	2.4
Response of lump sum taxes to deviation of public debt from target	0.1	0.1	0.1	0.1
Consumption tax rate (%)	15.8	18.3	7.7	7.7
Personal income tax rate (%)	9.3	12.2	15.4	15.4
Social security contribution tax paid by employees (%)	11.9	21.9	7.1	7.1
Social security contribution tax paid by employers (%)	14.3	11.9	7.1	7.1
Interest rate smoothing	0.8	0.8	0.8	0.8
Long-run response of interest rates to inflation	1.70	1.70	1.70	1.70
Long-run response of interest rates to output growth	1.25	1.25	1.25	1.25

Table 7: Adjustment costs

	PL	EA	US	RW
Capacity utilisation cost	2000	2000	2000	2000
Investment adjustment cost	6.0	6.0	6.0	6.0
Import adjustment cost for consumption goods	5.0	5.0	5.0	5.0
Import adjustment cost for investment goods	2.0	2.0	2.0	2.0
Import adjustment cost for intermediate goods	2.0	2.0	2.0	2.0
International transaction cost	0.0025	0.0025	.	0.0025

Table 8: Permanent credibility shift - long run effects

Variable	Long-run effect
Total output, of which:	0.04
Tradable	2.66
Nontradable	-1.67
Labour input	0.59
Consumption, of which:	-2.88
Ricardian households	-3.16
Non-Ricardian households	-0.85
Investment	-1.25
Exports	3.07
Imports	-2.18
Trade balance	1.48
Net foreign assets	-30.00
Terms of trade	1.22
Real effective exchange rate	1.60
Internal real exchange rate	-1.00
EA output	-0.01
EA consumption	0.11

Note: The trade balance and net foreign assets are expressed relative to nominal output.
All variables are reported as per cent or percentage point deviations from their initial steady state values.

Table 9: Volatility reduction of the main macrovariables - policies minimizing output fluctuations

	Output	Consump.	Investment	Cur. acc.	Real ER	In
Revaluation (7%)	31.0	13.9	11.8	1.6	-36.2	
VAT hike (9 pp, 2y)	17.6	14.1	-10.2	1.5	6.3	
PIT hike (12 pp, 2y)	25.5	11.9	9.6	-2.1	-21.6	
Gov. exp. cuts (2% of GDP, 3y)	16.1	-6.4	-4.2	0.7	11.2	
Gov. exp. cuts (full GDP stabil.)	100.0	-34.2	12.1	7.1	16.9	

Note: Volatility reductions are relative to the baseline scenario and expressed in per cent. Inflation is measured as CPI at producer prices.

Table 10: Welfare gains - policies maximizing households' utility

	Welfare gain, of which households:		
	Ricardian	Non-Ricardian	All
Revaluation (7%)	-0.022	0.187	0.029
VAT hike (4.5 pp, 2y)	-0.033	0.127	0.006
PIT hike (0 pp, 2y)	0.000	0.000	0.000
Gov. exp. cuts (0% of GDP, 3y)	0.000	0.000	0.000

Note: Welfare gains are defined as the difference (in per cent of steady state consumption) between welfare under the optimal response to the boom and welfare achieved by applying during the boom a policy that is optimal in normal times. Aggregation of the two types of households uses their shares in population.

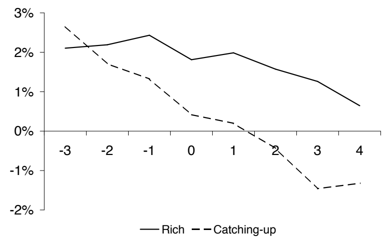
Table 11: False news scenario - evaluation of policies

	Output volatility criterion		Welfare criterion	
	Optimal size	Vol. reduction	Optimal size	Welfare gain
Revaluation	1%	2.1	1.5%	0.001
VAT hike	3 pp, 1y	12.5	3 pp, 1y	0.001
PIT hike	-2 pp, 2y	6.2	-7 pp, 2y	0.005
Gov. exp. cuts	1% of GDP, 2y	22.0	0% of GDP, 2y	0.000

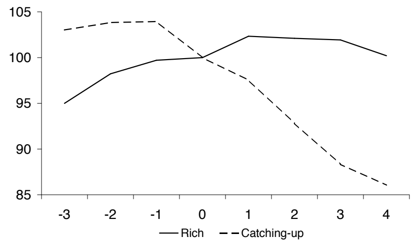
Note: Output volatility reduction is relative to the baseline scenario and expressed in per cent. Welfare gains are defined as the difference (in per cent of steady state consumption) between welfare under the optimal response to the boom and welfare achieved by applying during the boom a policy that is optimal in normal times. Aggregation of the two types of households uses their shares in population.

Figure 1: Stylised facts for boom-bust cycles

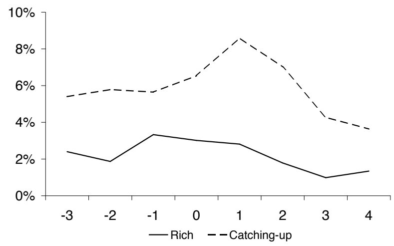
(a) Real interest rate



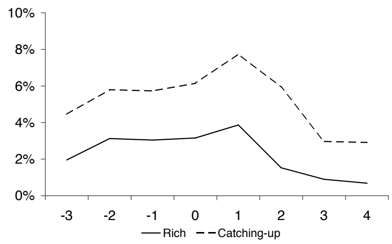
(b) Real effective exchange rate (ULC)



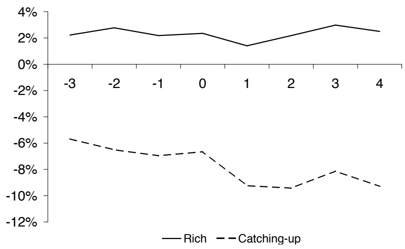
(c) Consumption



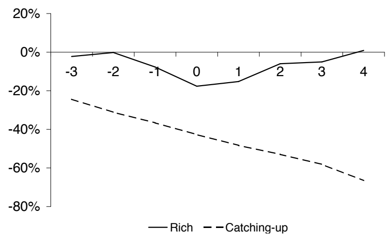
(d) GDP



(e) Current account balance



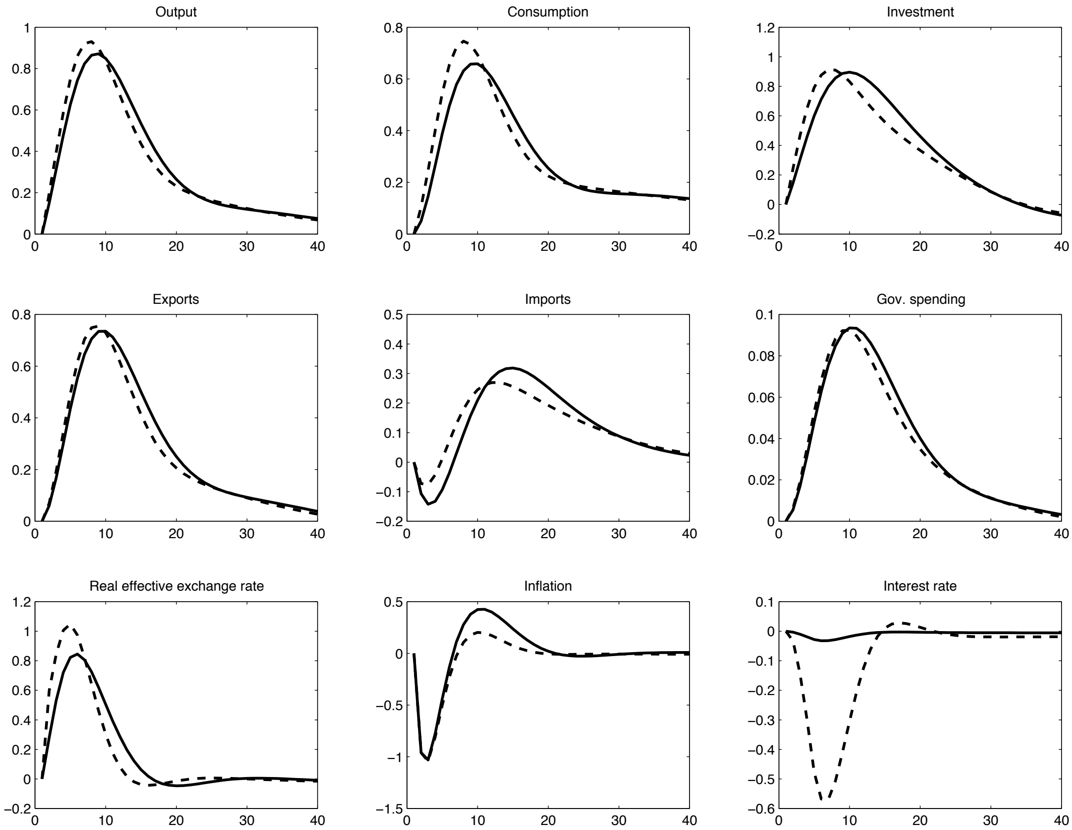
(f) Net foreign assets



Note: The figures present unweighted averages of rich (Austria, Belgium, Finland, France, Germany, Italy and Netherlands) and catching-up (Estonia, Greece, Latvia, Lihuania, Portugal and Spain) euro area members and countries with a hard peg against the euro. The plots are centred around the year (denoted as zero) of each country's accession or pegging (Estonia - 1999, Latvia - 2004, Lithuania - 2002). We drop the observations that were substantially affected by factors unrelated to these processes, e.g. the Russian crisis of 1998 and the financial crisis of 2008-09. These include i.a. GDP and consumption growth rates in Estonia and Lithuania in 1999 and all data for Latvia in 2009. GDP and consumption are presented as growth rates, while the current account balance and net foreign assets as percent of GDP. The real effective exchange rate is deflated using unit labour costs (EA accession or pegging year = 100, growth denotes depreciation).

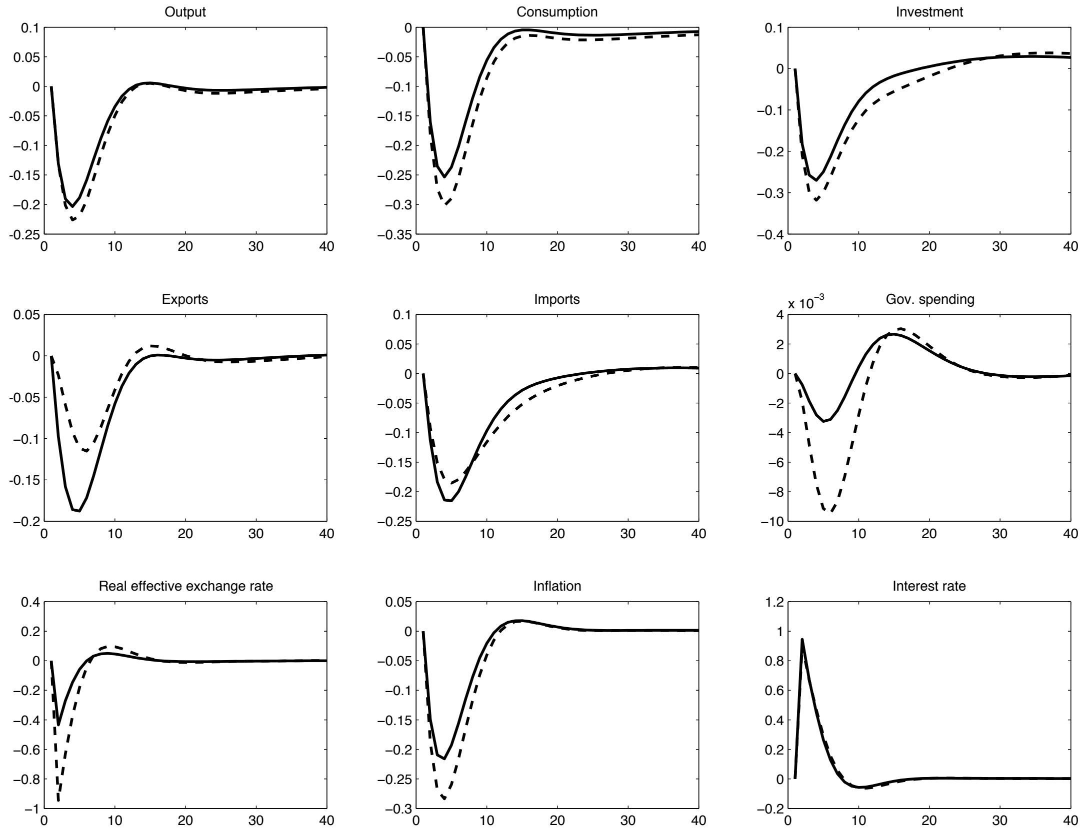
Source: Eurostat and IFS.

Figure 2: Impulse responses to a technology shock



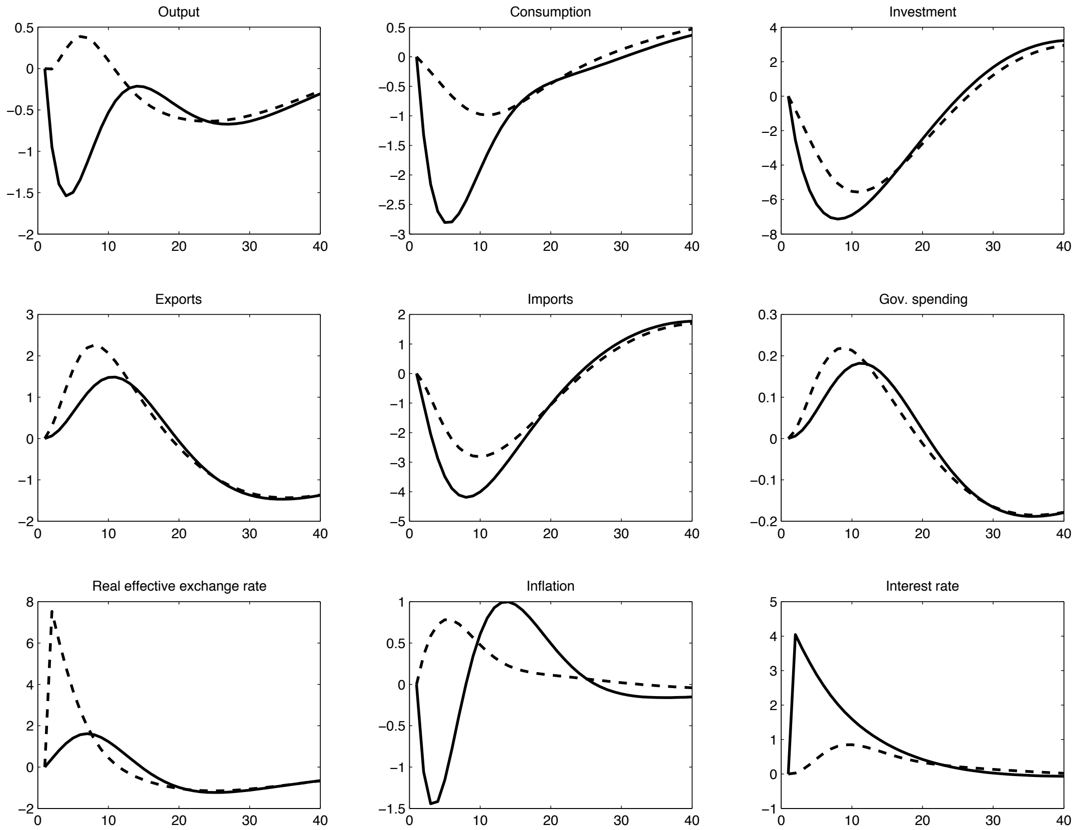
Note: Solid line - peg, dashed line - independent monetary policy. Both responses for Poland. All values in per cent deviations from steady state except inflation and interest rate, which are given in annualised percentage point deviations.

Figure 3: Impulse responses to a monetary policy shock



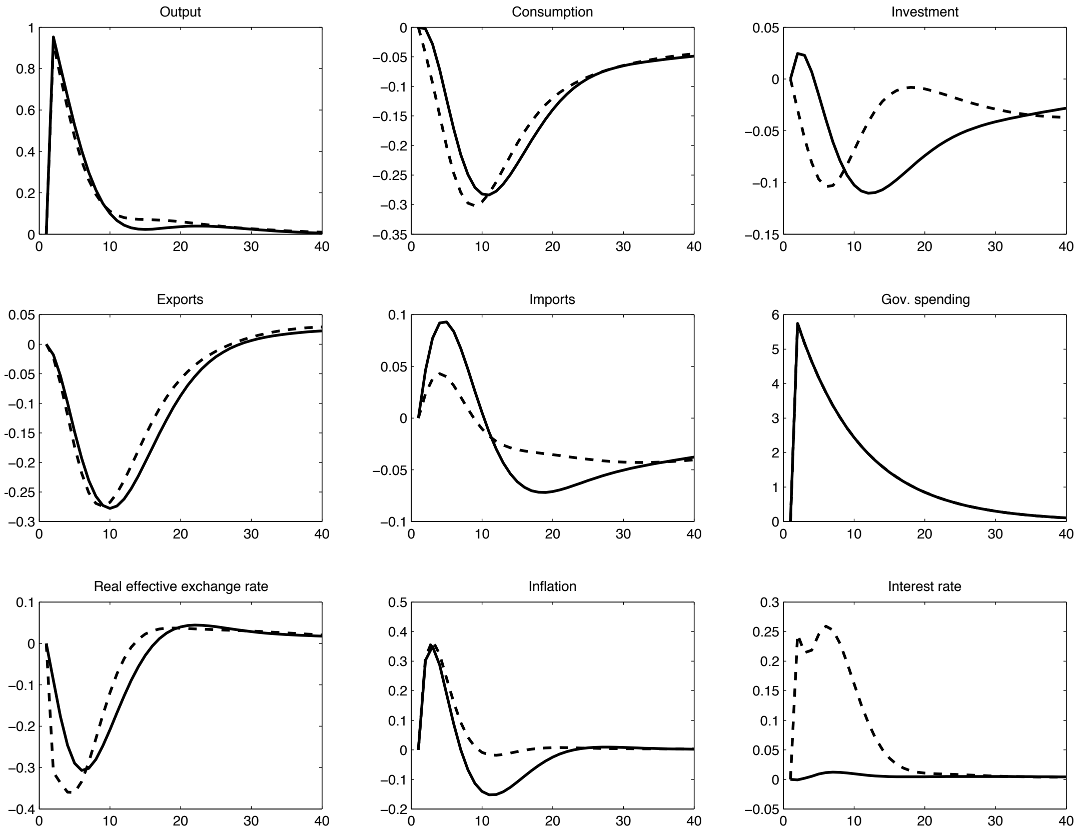
Note: Solid line - peg, dashed line - independent monetary policy. Both responses for Poland. All values in per cent deviations from steady state except inflation and interest rate, which are given in annualised percentage point deviations.

Figure 4: Impulse responses to a risk premium shock



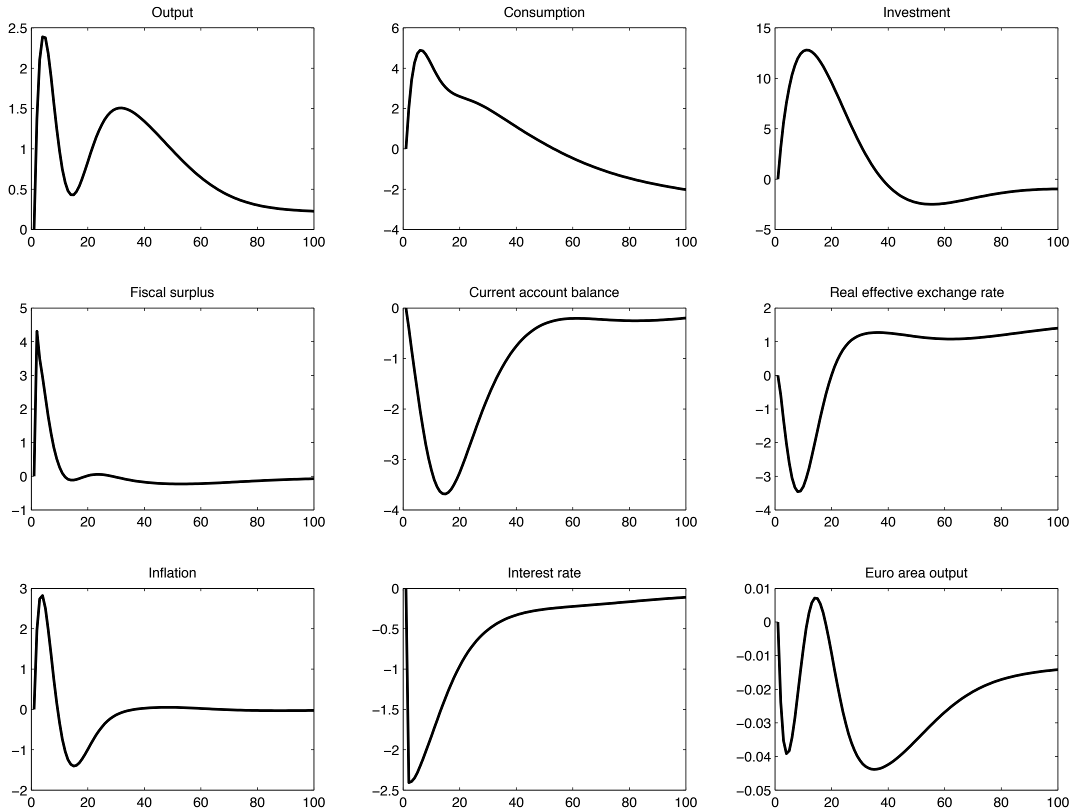
Note: Solid line - peg, dashed line - independent monetary policy. Both responses for Poland. All values in per cent deviations from steady state except inflation and interest rate, which are given in annualised percentage point deviations.

Figure 5: Impulse responses to a government expenditure shock



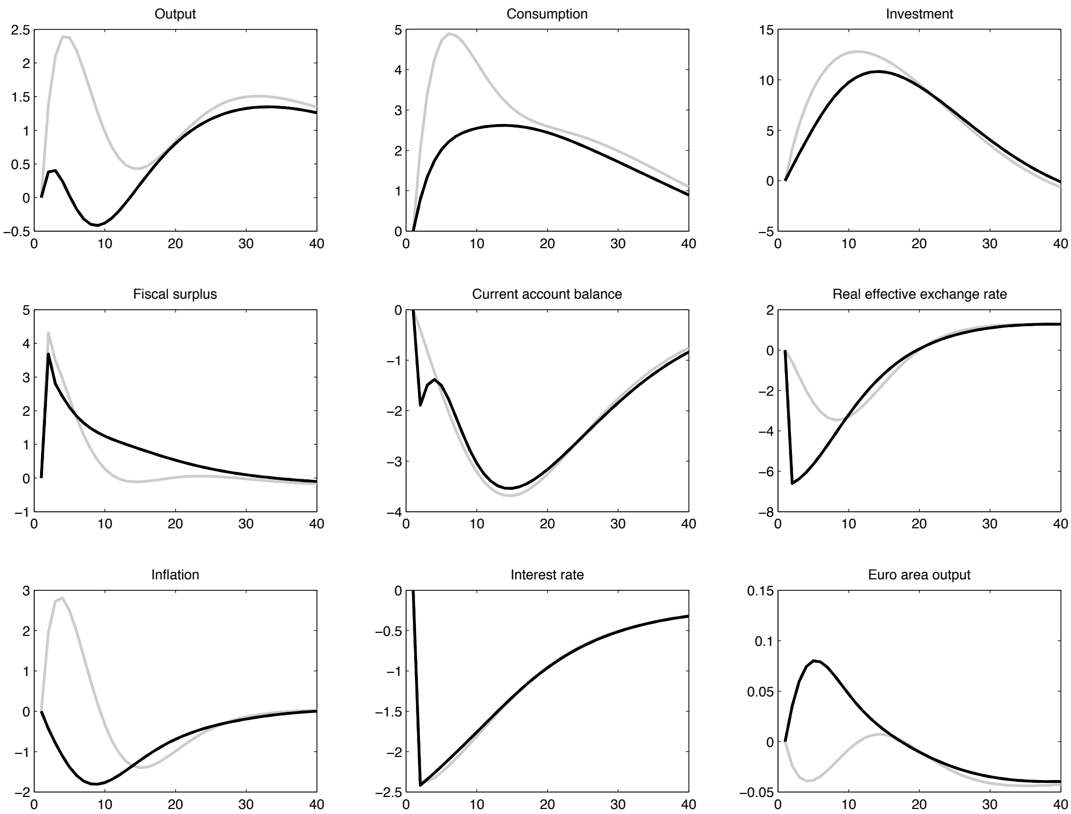
Note: Solid line - peg, dashed line - independent monetary policy. Both responses for Poland. All values in per cent deviations from steady state except inflation and interest rate, which are given in annualised percentage point deviations.

Figure 6: Credibility shift scenario (baseline)



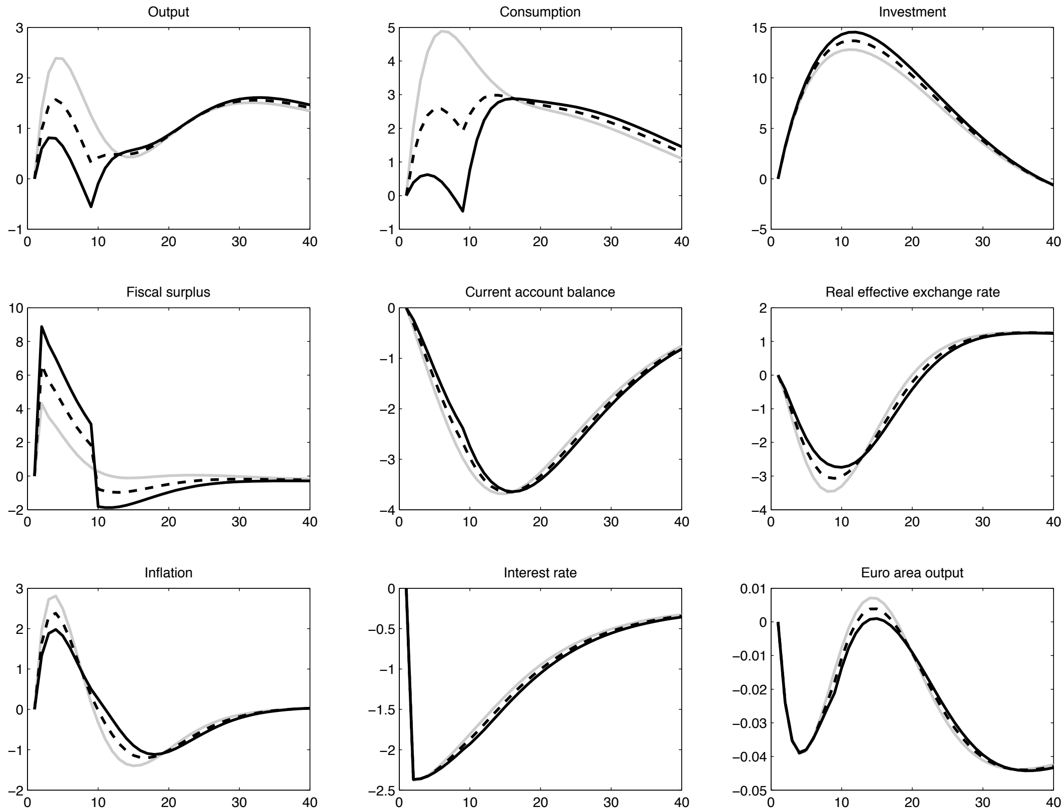
Note: The fiscal surplus and current account balance are expressed relative to nominal output. Inflation and the nominal interest rate are annualised. All variables are reported as per cent or percentage point deviations from their initial steady state values.

Figure 7: Credibility shift scenario with exchange rate revaluation



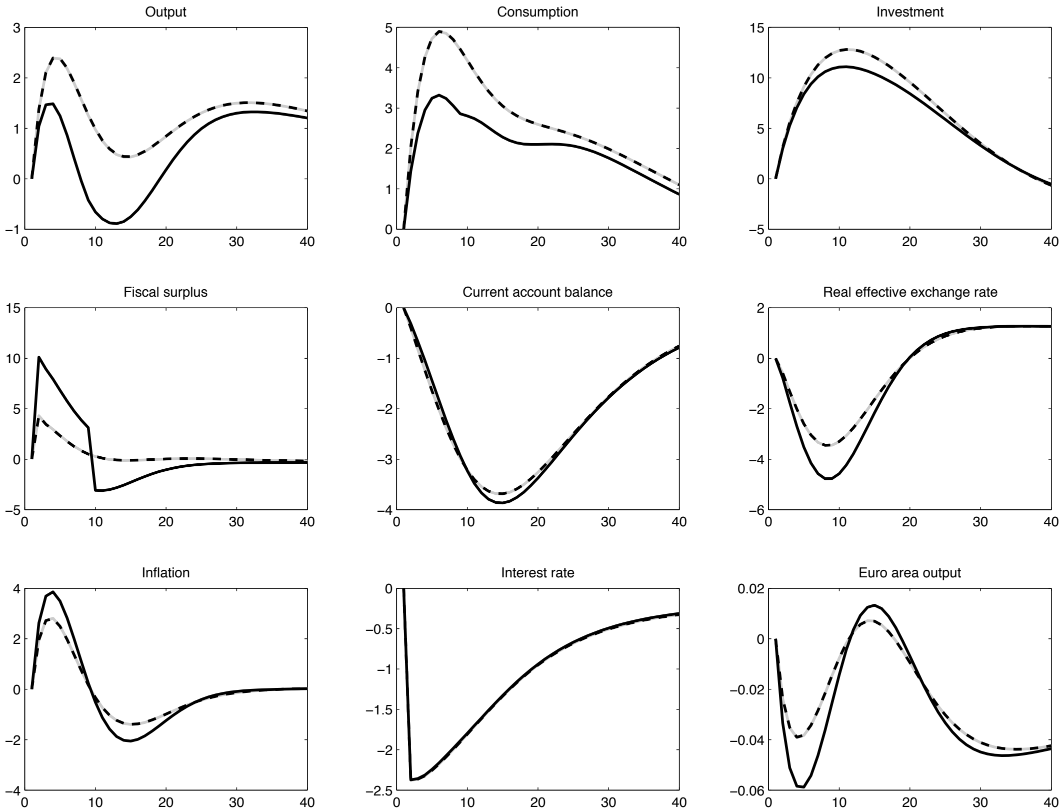
Note: Grey line - baseline scenario, black line - baseline with exchange rate revaluation by 7%. The fiscal surplus and current account balance are expressed relative to nominal output. Inflation and the nominal interest rate are annualised. All variables are reported as per cent or percentage point deviations from their initial steady state values.

Figure 8: Credibility shift scenario with a 2-year VAT hike



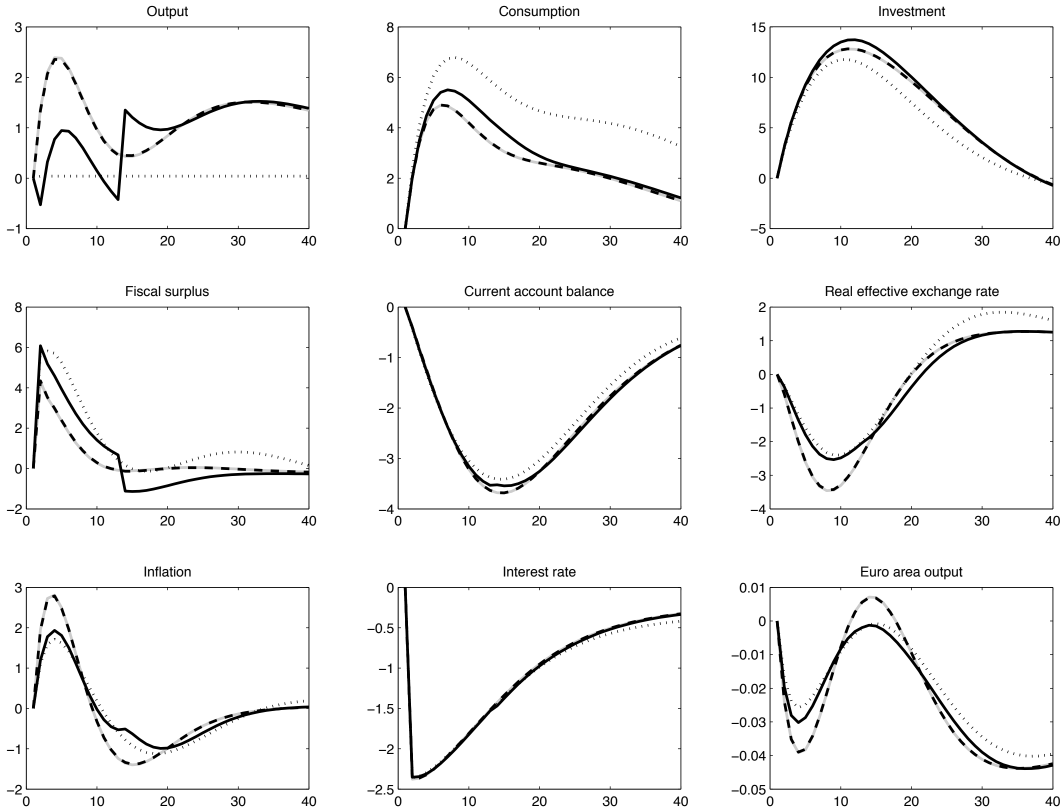
Note: Grey line - baseline scenario, black solid line - baseline with VAT rate hike by 9 pp for 2 years, black dashed line - baseline with VAT rate hike by 4.5 pp for 2 years. The fiscal surplus and current account balance are expressed relative to nominal output. Inflation and the nominal interest rate are annualised. All variables are reported as per cent or percentage point deviations from their initial steady state values.

Figure 9: Credibility shift scenario with a 2-year PIT hike



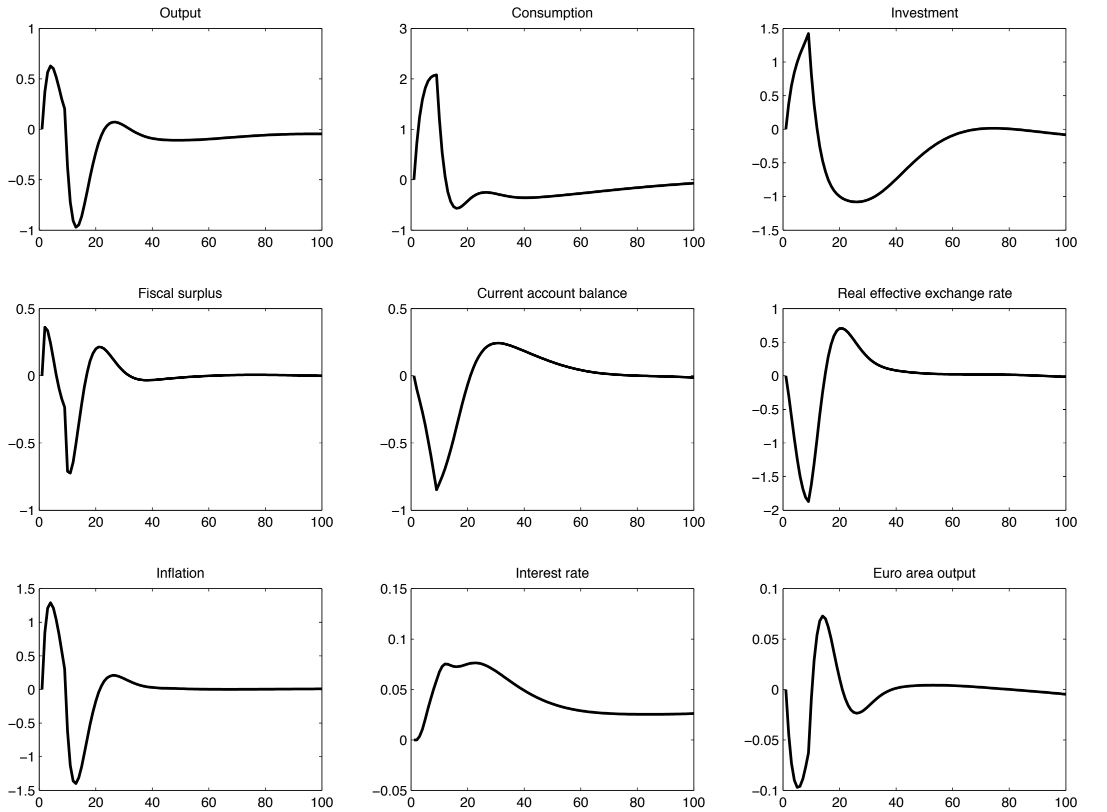
Note: Grey line - baseline scenario, black solid line - baseline with PIT rate hike by 12 pp for 2 years, black dashed line - baseline with PIT rate reduction by 0.08 pp for 2 years. The fiscal surplus and current account balance are expressed relative to nominal output. Inflation and the nominal interest rate are annualised. All variables are reported as per cent or percentage point deviations from their initial steady state values.

Figure 10: Credibility shift scenario with government spending cuts



Note: Grey line - baseline scenario, black solid line - baseline with fiscal contraction by 2% of GDP for 3 years, black dashed line - baseline with fiscal contraction by 0.04% of GDP for 3 years, black dotted line - baseline with government spending adjustments that fully stabilize output. The fiscal surplus and current account balance are expressed relative to nominal output. Inflation and the nominal interest rate are annualised. All variables are reported as per cent or percentage point deviations from their initial steady state values.

Figure 11: Overly optimistic expectations scenario



Note: The fiscal surplus and current account balance are expressed relative to nominal output. Inflation and the nominal interest rate are annualised. All variables are reported as per cent or percentage point deviations from their initial steady state values.

Appendix: Derivation of the import content of exports

This appendix documents the extension of EAGLE for a non-zero import content of exports. The derivation draws from Coenen and Vetlov (2009). A new type of good - export good - is introduced, which is used as input in the production of consumption, investment and export goods in other countries. This derivation is to be read together with the original model description (Gomes et al., 2010).

In what follows, the following indexing will be applied. For exports and their prices, index $CO1, CO2$ denotes exports from country $CO1$ to country $CO2$. For imports and their prices, index $CO1, CO2$ denotes imports by country $CO1$ from country $CO2$. When no index is given, the home economy H is meant.

The export good

The export good is produced by an infinite number of monopolistically competitive firms h of measure s_H. The production process is completed in two stages. First, capital and labour are combined to produce a domestic tradable good. Next, this good is combined with an imported good, being itself an aggregate of export goods from all trading partners. The export good is priced to the export market subject to nominal price rigidities.

Production of the export good

The export good $X_t(h)$ is produced by firm h from tradable home goods $HT^X(h)$ and (imported) export goods $IM_t^X(h)$:

$$X_t(h) = [(\nu_X)^{\frac{1}{\mu_X}} \, HT_t^X(h)^{\frac{\mu_X-1}{\mu_X}} + (1-\nu_X)^{\frac{1}{\mu_X}} IM_t^X(h)^{\frac{\mu_X-1}{\mu_X}}]^{\frac{\mu_X}{\mu_X-1}} \tag{1}$$

where μ_X is the intratemporal elasticity of substitution between domestic and imported goods and ν_X is the home bias parameter in the production of export goods ($1-\nu_X$ is the import content of exports).
The domestic input into the export good $HT_t^X(h)$ consists of intermediate tradable goods $Y_{T,t}^S(h)$, which are produced according to the following technology:

$$Y_{T,t}^S(h) = max\left\{z_T K_t^D(h)^{\alpha_T} N_t^D(h)^{1-\alpha_T} - \psi_T, 0\right\} \tag{2}$$

where $K_t^D(h)$ and $N_t^D(h)$ are inputs of capital and labour bundles, z_T is a productivity shock in the tradables sector and ψ_T represents a fixed production cost.
The basket $IM^X(h)$ is a CES composite of bilateral imports bought from all trading partners and is constructed as:

$$IM_t^X(h) = \left[\sum_{CO\neq H} (\nu_{IM^X}^{H,CO})^{\frac{1}{\mu_{IM^X}}} \left(IM_t^{X,H,CO}(h)\left(1-\Gamma_{IM^X}^{H,CO}(h)\right)\right)^{\frac{\mu_{IM^X}-1}{\mu_{IM^X}}}\right]^{\frac{\mu_{IM^X}}{\mu_{IM^X}-1}} \tag{3}$$

where $\nu_{IM^X}^{H,CO}$ denotes the share of IM_t^X imported from CO in total imports of IM_t^X by H. This yields the demand function for imports from country CO to H:

$$IM_t^{X,H,CO}(h) = \nu_{IM^X}^{H,CO}\left(\frac{P_{IM,t}^{H,CO}}{P_{IM^X,t}\Gamma_{IM^X}^{H,CO,\dagger}(h)}\right)^{-\mu_{IM^X}}\frac{IM^X(h)}{1-\Gamma_{IM^X}^{H,CO}(h)} \tag{4}$$

where $P_{IM,t}^{H,CO}$ is the price of the good imported by H from CO and

$$P_{IM^X,t} = \left[\sum_{CO\neq H/}\nu_{IM^X}^{H,CO}\left(\frac{P_{IM,t}^{H,CO}}{\Gamma_{IM^X}^{H,CO,\dagger}(h)}\right)^{1-\mu_{IM^X}}\right]^{\frac{1}{1-\mu_{IM^X}}} \tag{5}$$

is the aggregate price of imports of IM_t^X to H.

The variable $\Gamma_{IM^X}^{H,CO}$ is the adjustment costs on bilateral imports of export goods and is given by:

$$\Gamma_{IM^X}^{H,CO}(h) = \frac{\gamma_{IM^X}}{2}\left(\frac{IM_t^{X,H,CO}(h)/X_t(h)}{IM_{t-1}^{X,H,CO}/X_{t-1}}-1\right)^2 \tag{6}$$

and

$$\Gamma_{IM^X}^{H,CO,\dagger}(h) = 1-\Gamma_{IM^X}^{H,CO}(h)-\left(\Gamma_{IM^X}^{H,CO}(h)\right)' \tag{7}$$

where the last term is the derivative of $\Gamma_{IM^X}^{H,CO}(h)$ with respect to imports $IM_t^{X,H,CO}(h)$.

Cost minimisation

Following (1), the cost of producing export goods depends on the cost of home tradables and imports.

The marginal cost of producing home tradable goods can be derived by minimising the total input cost $R_t^K K_t^D(h) + (1+\tau_t^{W_f})W_t N_t^D(h)$ subject to the production function (2):

$$MC_{T,t} = \frac{(R_t^K)^{\alpha_T}((1+\tau_t^{W_f})W_t)^{1-\alpha_T}}{z_{T,t}(\alpha_T)^{\alpha_T}(1-\alpha_T)^{1-\alpha_T}} \tag{8}$$

where R_t^K is the rental cost of capital and $(1+\tau_t^{W_f})W_t$ is the wage augmented by the labour tax.

Derivation of the marginal cost of exported goods involves minimising the cost of inputs $MC_{T,t}HT_t^X(h) + P_{IM^X,t}IM_t^X(h)$ subject to (1). This yields the following demand functions for home tradable and imported goods:

$$HT_t^X(h) = \nu_X\left(\frac{MC_{T,t}}{MC_{X,t}}\right)^{-\mu_X} X_t(h) \tag{9}$$

and

$$IM_t^X(h) = (1-\nu_X)\left(\frac{P_{IM^X,t}}{MC_{X,t}}\right)^{-\mu_X} X_t(h) \tag{10}$$

Where $MC_{X,t}$ is the marginal cost of producing the export good:

$$MC_{X,t} = \left[\nu_X\left[MC_{T,t}\right]^{1-\mu_X} + (1-\nu_X)\left[P_{IM^X,t}\right]^{1-\mu_X}\right]^{\frac{1}{1-\mu_X}} \tag{11}$$

Pricing of the export good

Export good producers discriminate between export markets. Given marginal cost they set the price subject to the demand function[14] for exports to country CO. Price setting is subject to nominal rigidities of the Calvo type. Every period $1-\xi_X$ firms are allowed to change their price - for the export market CO they choose the price $\tilde{P}^{H,CO}_{HT^X,t}$. The rest updates their prices according to:

$$P^{H,CO}_{X,t}(h) = (\Pi^{H,CO}_{X,t-1})^{\chi_X}\bar{\Pi}^{1-\chi_X}P^{H,CO}_{X,t-1}(h) \tag{17}$$

where $\Pi^{H,CO}_{X,t-1}$ denotes the inflation rate in the export sector,$\bar{\Pi}$ is the inflation target of the central bank and χ_X is the indexation parameter.

Each firm that reoptimises its price at period t maximises the discounted sum of its expected nominal profits expressed in domestic currency:

$$E_t\left\{\sum_{k=0}^{\infty}\Lambda_{t,t+k}\sum_{CO\neq H}\left[(\xi_X)^k\left(S^{H,CO}_{t+k}P^{H,CO}_{X,t+k}(h)IM^{CO,H}_{t+k}(h) - MC_{X,t+k}(IM^{CO,H}_{t+k}(h)+\psi_T)\right)\right]\right\} \tag{18}$$

where $S^{H,CO}_t$ is the nominal exchange rate between countries H and CO. The first order condition for maximising profits is:

$$\begin{aligned} E_t\left\{\sum_{k=0}^{\infty}\Lambda_{t,t+k}(\xi_X)^k\prod_{s=1}^{k}(\Pi^{H,CO}_{X,t+s-1})^{\chi_X}\bar{\Pi}^{1-\chi_X}\tilde{P}^{H,CO}_{X,t}IM^{CO,H}_{t+k}(h)\right\} &= \\ \frac{\Theta_X}{\Theta_X-1}E_t\left\{\sum_{k=0}^{\infty}\Lambda_{t,t+k}(\xi_X)^k(S^{H,CO}_{t+k})^{-1}MC_{X,t+k}IM^{CO,H}_{t+k}(h)\right\} \end{aligned} \tag{19}$$

The resulting price index of export goods exported from country H to country CO is a geometric average of reoptimised and indexed prices and evolves according to:

[14]The basket $IM^{X,CO}_t(h)$ of imports to country CO from H (demanded by the foreign company h^{CO}) is constructed according to the following technology:

$$IM^{X,CO,H}_t(h^{CO}) = \left(\left(\frac{1}{s_H}\right)^{\frac{1}{\Theta_X}}\int_0^{s_H}\left(IM^{X,H,CO}_t(h,h^{CO})\right)^{\frac{\Theta_X-1}{\Theta_X}}dh\right)^{\frac{\Theta_X}{\Theta_X-1}} \tag{12}$$

where $IM^X_t(h,x)$ denotes the use of export goods produced by company h used by importer h^{CO}. Given the price of home tradable goods, minimisation of expenditure for the bundle $\int_0^{s_H}P_{X,t}(h)IM^X_t(h,h^{CO})dh$ results in the following demand function of importer h^{CO} for the product of producer h:

$$IM^{X,CO,H}_t(h,h^{CO}) = \frac{1}{s^H}\left(\frac{P^{H,CO}_{X,t}(h)}{P^{H,CO}_{X,t}}\right)^{-\Theta_X}IM^{X,CO,H}_t(h^{CO}) \tag{13}$$

where $P^{H,CO}_{X,t}$ is the price of the bundle of export goods:

$$P^{H,CO}_{X,t} = \left[\frac{1}{s^H}\int_0^{s^H}P^{H,CO}_{X,t}(h)^{1-\Theta_X}dh\right]^{\frac{1}{1-\Theta_X}} \tag{14}$$

Aggregating the demand function over importers yields demand for brand h:

$$IM^{X,CO,H}_t(h) = \left(\frac{P^{CO}_{X,t}(h)}{P^{H,CO}_{X,t}}\right)^{-\Theta_X}IM^{X,CO,H}_t \tag{15}$$

or equivalently:

$$X^{H,CO}_t(h) = \left(\frac{P^{CO}_{X,t}(h)}{P^{H,CO}_{X,t}}\right)^{-\Theta_X}X^{H,CO}_t \tag{16}$$

$$P_{X,t}^{H,CO} = \left[\xi_X \left((\Pi_{X,t-1}^{H,CO})^{\chi_X}\bar{\Pi}^{1-\chi_X} P_{HT^X,t-1}^{H,CO}\right)^{1-\Theta_X} + (1-\xi_X)\left(\tilde{P}_{X,t}^{H,CO}\right)^{1-\Theta_X}\right]^{\frac{1}{1-\Theta_X}} \tag{20}$$

Closing conditions

This section describes closing conditions that are changed as compared to EAGLE. For brevity, the reader is referred to Gomes et al. (2010) for definitions and derivations of several newly introduced variables.

Market clearing in the home tradable sector

Home tradables are used for production of consumption, investment and export goods:

$$Y_{T,t}(h) = HT_t^C(h) + HT_t^I(h) + \sum_{CO\neq H} HT_t^{X,H,CO}(h) \tag{21}$$

$$\begin{aligned}
Y_{T,t} &= \frac{1}{s_H}\int_0^{s_H} Y_{T,t}(h)dh = \frac{1}{s_H}\left[\int_0^{s_H} HT_t^C(h)dh + \int_0^{s_H} HT_t^I(h)dh + \sum_{CO\neq H}\int_0^{s_H} HT_t^{X,H,CO}(h)dh\right] \\
&= \frac{1}{s_H}\left[(HT^C + HT^I)\int_0^{s_H}\left(\frac{P_t(h)}{P_{HT,t}}\right)^{-\Theta_X} dh\right] \\
&\quad + \frac{1}{s_H}\left[\sum_{CO\neq H}\nu_X\left(\frac{MC_{T,t}}{MC_{X,t}}\right)^{-\mu_x} X^{X,H,CO}\int_0^{s_H}\left(\frac{P_X^{H,CO}(h)}{P_{X,t}}\right)^{-\Theta_X} dh\right] \\
&= s_{HT,t}(HT^C + HT^I) + \nu_X\left(\frac{MC_{T,t}}{MC_{X,t}}\right)^{-\mu_x}\sum_{CO\neq H} s_{X,t}^{H,CO} X^{H,CO}
\end{aligned} \tag{22}$$

where the derivation uses (9) and (16). Moreover, $s_{HT,t}$ is the measure of dispersion of prices of home tradables, $HT_t^C(h)$ and $HT_t^I(h)$ are home tradable goods used in the production of final consumptions and investment goods respectively, $P_t(h)$ is the price of the tradable good produced by firm h and sold on the domestic market and $P_{HT,t}$ is the aggregate price of these goods. Details on these variables can be found in Gomes et al. (2010). Finally,

$$\begin{aligned}
s_{X,t}^{H,CO} &= \int_0^{s_H}\left(\frac{P_X^{H,CO}(h)}{P_{X,t}}\right)^{-\Theta_X} dh \\
&= (1-\xi_X)\left(\frac{\tilde{P}_{HT^X,t}^{H,CO}}{P_{X,t}^{H,CO}}\right)^{-\Theta_X} + \xi_X\left(\frac{\Pi_{X,t}^{H,CO}}{(\Pi_{X,t-1}^{H,CO})^{\chi_X}\bar{\Pi}^{1-\chi_X}}\right)^{-\Theta_X} s_{X,t-1}^{H,CO}
\end{aligned} \tag{23}$$

is the measure of dispersion of prices charged for exports to market CO.

Aggregation in the import sector

Total imports consist of imports of consumption, investment and export goods:

$$IM_t^{H,CO} = \sum_{j=C,I,X} IM_t^{j,H,CO}\frac{1-\Gamma_{IM^j}^{H,CO}}{\Gamma_{IM^j}^{H,CO,\dagger}} \tag{24}$$

where $IM_t^{C,H,CO}$ and $IM_t^{I,H,CO}$ denote, respectively, imports of consumption and investment goods, and $\Gamma_{IM}^{H,CO}$ and $\Gamma_{IM}^{H,CO,\dagger}$ are variables related import adjustment costs. Again, these variables are precisely described in Gomes et al. (2010).

Exports from H to CO equal imports to CO from H:

$$s_H X_t^{H,CO} = \int_0^{s_{CO}} IM_t^{CO,H}(h^{CO})dh^{CO} = s_{CO} IM_t^{CO,H} \int_0^{s_{CO}} \left(\frac{P_{X,t}^{CO}(h^{CO})}{P_{X,t}^{H,CO}} \right)^{-\Theta_X} dh^{CO} \quad (25)$$

$$X_t^{H,CO} = \frac{s_{CO}}{s_H} s_{X,t}^{CO,H} IM_t^{CO,H} \quad (26)$$

Dividends in the tradable sector

Dividends in the tradable sector are given by:

$$\begin{aligned} D_{T,t} &\equiv \int_0^{s_H} D_{H,t}(h)dh + \int_0^{s_H} D_{X,t}(h)dh = \\ &= P_{HT,t}(HT_t^C + HT_t^I) + \sum_{H \neq CO} P_X^{H,CO}(IM_t^{C,CO,H} + IM_t^{I,CO,H} + IM_t^{X,CO,H}) \frac{s_{CO}}{s_H} \\ &\quad - R_t^K K_t^D + (1 + \tau_t^{W_f}) W_t N_t^D \end{aligned} \quad (27)$$

where $D_{H,t}(h)$ and $D_{X,t}(h)$ denote profits made by firm h by producing for the domestic and export market, respectively.