# Real convergence and its illusions: illustrative scenarios from the EAGLE model*

Marcin Kolasa†

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**Abstract**

This paper uses the EAGLE model to illustrate possible dynamic adjustments in a relatively small euro area economy undergoing real convergence. We consider the effects of productivity catch-up, shifts in exports demand as well as misperceptions about future productivity developments. Our tentative results indicate that even if real convergence takes the form of a gradual process, the dynamic responses of key macrovariables can be far from smooth. We also find that misperceptions about permanent shifts in productivity can generate sizable boom-bust cycles and so can be potentially relevant in accounting for cyclical deviations from a sustainable real convergence path. Our comparisons across alternative monetary regimes reveal that a flexible exchange rate helps to smooth real convergence processes and misperceptions associated with tradable sector productivity, as well as shifts in demand for exports, while the opposite usually holds true for scenarios based on nontradable sector productivity developments.

## 1 Introduction

The world history is full of episodes of long- and medium-term shifts in countries' relative income per capita or external positions. This is also true for a more homogeneous and developed club of EU countries. Even within the euro area, as suggested by substantial diversity of past economic performance and still persisting differences in per capita output across its member states, the observed asymmetries cannot be attributed only to cyclical factors.

In recent years, an increasing number of cross-country studies have been based on micro-founded multi-country dynamic stochastic general equilibrium (DSGE) models, incorporating nominal and real rigidities sufficient to yield a reasonable empirical fit. While the early attempts usually used models

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†National Bank of Poland, Economic Institute, ul. Swietokrzyska 11/21, 00-919 Warsaw; Warsaw School of Economics, Department of Applied and Theoretical Economics, Al. Niepodleglosci 162, 02-554 Warsaw; e-mail: Marcin.Kolasa@mail.nbp.pl

designed to analyze only cyclical properties of the data,[1] recent advances in constructing large and relatively comprehensive DSGE models have made it possible to construct more sophisticated scenarios, including changes in parameters affecting selected long-run characteristics of modelled economies. Two important projects in this area are the Global Economic Model (GEM) maintained at the IMF (see Laxton and Pesenti, 2003) and the New Area-Wide Model (NAWM) constructed in the ECB (see Coenen et al., 2008a). These models and their offspring have been used in a variety of applications, including scenarios of global current account rebalancing (Faruqee et al., 2005), labour tax reforms (Coenen et al., 2008a), fiscal consolidation (Coenen et al., 2008b), structural reforms (Everaert and Schule, 2006) or globalization (Jacquinot and Straub, 2008).

In this paper, we use the EAGLE model, recently developed by the staff from the ECB, the Bank of Italy and the Bank of Portugal in the context of the ESCB working group (see Gomes et al., 2008a), to illustrate possible dynamic adjustments in a relatively small euro area economy undergoing real convergence processes. While our analysis is aimed to be quite general and relevant for any representative small euro area member (current or prospective), we focus our calibration of the model around the Spanish economy. Using the four-country setup of EAGLE, we link Spain not only to the rest of the euro area, but also to the US and the rest of the world.

We define real convergence as productivity catch-up and a shift in foreign tastes towards a converging country's exports. While there is probably no need to argue that this kind of long- and medium-term processes are highly relevant for some current and definitely to most of prospective euro area members, we briefly illustrate our case by referring to the past Spanish experience.

As can be seen from Figure 1, over the last thirty-five years Spain's productivity relative to the rest of the euro area has been far from stable. Two distinct periods seem to stand out. During the first one, spanning over the 1970s and most part of the 1980s, rapid and sustained catching-up brought Spanish tradable sector productivity to the average level observed in the rest of the club. Around early 1990s, however, real divergence set off and by now most of these gains have been reversed. Interestingly, fluctuations in the productivity gap calculated for nontradable industries contributed substantially less to the medium and long-term shifts in Spain's position relative to the rest of the euro area. Turning to Figure 2, it is apparent that recent decades have seen impressive growth in Spanish exports, outpacing by far the overall pace of increasing world trade flows related to globalization. While there are probably many reasons for this exceptional performance of Spain's export sector, a shift in world preferences might be one of them.[2]

These two simple illustrations clearly suggests that long- and medium-term processes can play a potentially important role in accounting for asymmetric developments within the euro area. Therefore, examining how the economy might respond to real convergence scenarios seems to be highly relevant for understanding the nature and sustainability of divergences within the monetary union.[3]

[1]For instance, building on a closed-economy setup of Smets and Wouters (2003), de Walque et al. (2005) estimate a two-country model linking the euro area and the US.

[2]As suggested by Lipschitz et al. (2002), this kind of shift may be even more relevant for the prospective euro area members from central and eastern Europe, experiencing a growing market penetration and product reputation in world markets.

[3]Clearly, productivity developments and shifts in export demand are not the only plausible sources of real convergence or divergence within the euro area. For instance, using the EAGLE model, Gomes et al. (2008b) demonstrate that structural reforms increasing competition on labour and product markets may also lead to sizable changes in output per capita across countries. It is worth noting that although productivity and the intensity of competition are assumed to be independent exogenous parameters in the EAGLE model, they may be interrelated in reality. Analyzing these kinds

Apart from highlighting the real convergence mechanics in a fully-fledged multi-country DSGE setup, we also demonstrate how misperceptions about productivity shifts may contribute to significant fluctuations in macroeconomic variables. We do so by considering situations in which the economic agents in our analyzed economy treat a temporary shift in productivity as a permanent one or are faced with optimistic but false news about future productivity developments. As pointed out by Collard et al. (2008), the idea of incorporating confusion about the nature (e.g. persistence) of productivity shocks into micro-founded macroeconomic models can be traced back to the seminal contribution by Kydland and Prescott (1982). At least since the work by Orphanides (2003) it is well known that this kind of misperceptions may be quite substantial and affect the efficient policy conduct even in relatively developed economies. The importance of true news shocks to aggregate fluctuations has been recently established by Schmitt-Grohe and Uribe (2008) or Fujiwara et al. (2008), while Christiano et al. (2007) consider a false news shock and demonstrate how it may generate boom-bust cycles. These papers, however, are based on closed-economy models, so they neglect channels arising from international linkages, which may be particularly important for relatively open economies of the euro area. Also, most of earlier contributions consider fluctuations in productivity (expected or unexpected) that are only transitory in nature. We argue that in the case of a catching-up economy, confusing temporary and permanent shocks or illusions about future permanent productivity improvements might be a more relevant description of reality.

Finally, we show how all the dynamic responses we analyze are shaped by the monetary regime adopted by the country affected. More specifically, we compare our baseline results to two hypothetical alternatives: a fully floating exchange rate regime and a peg to the euro. In this respect, our paper is related to a recent work by Karam et al. (2008), who use the GEM to assess the costs and benefits of adopting the euro by a small emerging economy. However, the focus of this contribution are short-run adjustments to a relatively standard set of shocks rather than to long-run processes or misperceptions as in our case.

Our results indicate that even if real convergence takes the form of a gradual process, the dynamic responses of key macrovariables may be far from smooth. If follows that they can be easily misinterpreted as manifestations of growing imbalances requiring policy intervention, while in fact they are just optimal responses of the private sector, given the monetary and fiscal feedback rules. We also find that misperceptions about permanent shifts in productivity can generate sizable boom-bust cycles and so can be potentially relevant in accounting for cyclical deviations from a sustainable real convergence path. Our comparisons across alternative monetary regimes reveal that a flexible exchange rate helps to smooth real convergence processes and misperceptions associated with tradable sector productivity, as well as shifts in demand for exports. The opposite usually holds true for scenarios based on nontradable sector productivity developments.

The rest of this draft is organized as follows. Section two provides a brief overview of the EAGLE model. Its parameterization and calibration is discussed in section three. Section four defines and presents the real convergence scenarios. An illustration of possible misperceptions along the convergence path is presented in section five. Section six discusses the role of monetary regimes for the dynamic responses under each of our scenarios. Section seven concludes.

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of interdependencies is however beyond the scope of this study.

## 2 Bird's-eye view at EAGLE

EAGLE ("Euro Area and GLobal Economy" model) is a relatively large and comprehensive DSGE model, designed to cover four regions of the world economy, two of which constitute a monetary union. The model structure builds largely on the NAWM, extending it in several dimensions.[4] Below, we provide only a brief overview of the main features of EAGLE, referring the reader to the source documents for details.

Except for monetary policy regimes and some parameter values, each region covered in EAGLE is modelled in a symmetric fashion. The modelled economic areas are linked with each other by bilateral trade relations and international financial markets, assumed to be incomplete and so allowing for only imperfect risk sharing across countries.

Each region is populated by two types of households, differing in their ability to participate in asset markets. One group of households can transfer its wealth intertemporally by holding money, trading bonds and accumulating physical capital, while the only asset held by the rest is money. There is monopolistic competition on the labour market, so each household acts as a wage setter for its differentiated labour service supplied to firms. Wage rigidities are modelled using the staggered contract setup as in Calvo (1983), augmented with an indexation scheme to past and steady-state consumer price inflation for those who cannot reoptimize.

There are two types of intermediate goods: nontradables and domestic tradables. Each is produced by a continuum of monopolistically competitive firms, using as inputs labour and capital services (allowing for time-varying capacity utilization) supplied by households. Firms set prices of their differentiated output according to a Calvo-type scheme with indexation. Tradable intermediate goods are subject to international trade, with export prices denominated in the importing country's currency.

Different varieties of domestic and imported goods are aggregated by perfectly competitive final goods firms, operating at a country level. Aggregation of imports into a homogeneous import good is subject to adjustment costs whenever the country trade structure changes. The final consumption good is produced by combining nontradable goods with a bundle of home-made tradable and imported goods. The final investment good is defined in a similar manner, while the final government good has only nontradable content.

The fiscal authority levies both proportional and lump-sum taxes and earns seignorage on outstanding money holdings. On the expenditure side, the government purchases final good and makes transfer payments to households. Transfers and lump-sum taxes are not evenly distributed across the two types of households, with those having full access to asset markets receiving less and paying more in per-capita terms. The fiscal debt is held in form of government bonds and its long-term target level is achieved by smooth adjustment in lump-sum taxes.

There are three monetary authorities in the model, one defined for the common currency area and two for the remaining regions. All follow a Taylor-type interest rate feedback rule, specified in terms of deviations of consumer price inflation and output from their target (steady-state) levels and allowing for some interest rate smoothing.

[4] See Jacquinot and Straub (2008) for an intermediate stage between NAWM and EAGLE.

## 3 Parameterization and calibration

We make one departure from the original EAGLE specification described in Gomes et al. (2008a). Rather than assuming that the costs of varying capacity utilization have to be covered by a current flow of final investment goods, we follow Greenwood et al. (1988) and have these costs take the form of an increase in capital depreciation. This apparently innocuous respecification of the model, together with assuming higher than in its original version costs of changing capacity utilization, turns out to be very important for obtaining a more realistic short-run response of investment to a productivity shock.[5]

The original version of EAGLE is calibrated to represent the following regions of the world economy: Germany, the rest of the euro area, the United States and the rest of the world. Given the main focus of our analysis, which is a relatively small and converging economy, we recalibrate the euro area block in EAGLE to single out Spain rather than Germany. It has to be stressed that this choice does not mean that we aim at fitting exactly the model to the Spanish data (and their cyclical components in particular). We want rather our analysis to be more general and relevant for any present or prospective euro area member with a real convergence potential. Therefore, we keep many of the model parameters symmetric across the four regions, even though making them heterogeneous could increase the overall fit of the model.

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.[6] 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 parameterization of NAWM or GEM, as well as estimated small scale DSGE models for the euro area and the United States (e.g. Smets and Wouters, 2003; Christiano et al., 2005; de Walque et al., 2005). The calibrated parameters for our four regional blocks are reported in Tables 1 through 9. Below we provide a brief discussion on our main choices and data sources.

### 3.1 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 1990-2004 and comes from the national accounts statistics collected in the World Development Indicators database.

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 (2001-2005). Since the model structure does not account for imported intermediate inputs in exports, we correct total imports of each region for the import content of exports, assumed at roughly 45%, consistently with

[5]See Altig et al. (2005) for a detailed discussion on the relation between costs of varying capacity utilization and a dynamic response of investment to a neutral technology shock.

[6]More precisely, some of the key steady-state ratios give us restrictions on the parameter space rather than fixing them unambiguously. Whenever relevant, these restrictions are observed in the second stage of calibration.

estimates using input-output tables for the euro area countries (see e.g. Bowles and Maurin, 2008). The structure of bilateral trade flows, including their final use breakdown (consumption or investment), relies on flows of goods extracted from the CHELEM database and averaged over the years 2001-2005.[7]

The quasi-share[8] of nontradables in the consumption and investment basket is set to 70% and 40%, respectively, which together with the assumption on fully nontradable content of government expenditures implies the share of tradable output in GDP of about 30%. This number is roughly consistent with the values implied by the share of agriculture, mining and manufacturing in total market economy, calculated for Spain, the euro area and the United States for the period 1990-2004 using the EU-KLEMS database.

## 3.2 Other parameters

While parametrizing the production technology, we make the usual assumption that the nontradable sector is more labour intensive than the tradable sector. We also take into account that investment rates in Spain and the rest of the world are on average higher than in the euro area or in the US. In line with these observations, we set the capital share in nontradable (tradable) production at 0.35 (0.4) for the former two regions and at 0.3 (0.35) for the latter.

Price and wage mark-ups for Spain and the euro area are taken from Everaert and Schule (2006), while those for the United States and the rest of the world come from Faruqee et al. (2005). These estimates imply lower competition in the euro area region than in the rest of the global economy, both on the labour and the product market.

For the euro area and the United States, the share of households with limited access to asset markets is assumed to be 25%, in line with the estimates reported in Coenen and Straub (2005). For the remaining two regions, this share is twice as high, which is aimed at capturing their lower financial development.

The tax structure for Spain, the rest of the euro area and the United States is taken directly from Coenen et al. (2008a). 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.

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 NAWM.

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, while that governing substitutability across imports from different countries is assumed to be equal to 1.3.

The Calvo probabilities on the labour and domestic product markets are set to 0.75, implying an average time between wage and price reoptimization of four quarters. The degree of stickiness in the

[7] We are aware of the fact that the trade matrices for goods and services may exhibit quite different patterns. Unfortunately, there is no bilateral trade data for services available for the regions included in our model.

[8] Whenever we talk about quasi-shares, we mean the share parameters in CES aggregators. The quasi-shares coincide in the steady-state equilibrium with "true" nominal shares as long as all relevant relative prices are equal to one.

firms' export pricing decisions is assumed to be substantially lower (0.3). Indexation parameters are set to 0.5 on the product market and 0.75 on the labour market.

The choices of adjustment cost parameters are taken directly from earlier versions of the NAWM. As discussed before, an important exception is the cost of varying capacity utlization, which we assume to be relatively high.

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. 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 the output gap is calibrated at 2 and 0.25, respectively, while the weight on the lagged interest rate is set to 0.9.

# 4 Real convergence scenarios

As discussed above, we focus on two aspects of real convergence: productivity catching-up and shifts in demand for exports. In this section, we first define our baseline scenarios and express them in terms of model variables, parameters and assumptions. We next use the EAGLE model to inspect the response of main macroeconomic aggregates to each scenario.

While constructing our illustrative scenarios, we abstract away from any particular forces driving the real convergence processes, i.e. they are treated as purely exogenous, consistently with the logic of the model. We develop two alternative variants. In the first one, which is our baseline, we assume that once convergence kicks off, its whole future path is fully anticipated by all economic agents populating our model world. In the second variant, we take the opposite stance on agents' ability to anticipate future shifts in productivity or foreign preferences, i.e. we let them be taken by surprise each period, so that the whole process can be seen as a series of permanent but unanticipated shocks.

Admittedly, our illustrations of real convergence are very stylized and the reality is far more complicated. Still, we believe that considering and comparing across them provides a useful departure point for a theoretical analysis of cross-country heterogeneity resulting from dynamic structural asymmetries. A further discussion of possible disturbances along these deterministic and potentially smooth scenarios is postponed to the next section.

## 4.1 Productivity catching-up

We base our main catching-up scenario on the sector producing tradable goods. This is motivated by the common description of productivity convergence in the growth literature, based on the diffusion of technological advances between R&D intensive industries, usually open to international trade. Such an assumption also squares well with productivity developments in Spain discussed in the introduction and also general real convergence patterns observed in the EU new member states (see e.g. Bijsterbosch and Kolasa, 2009).

More specifically, we consider a scenario in which Spain embarks on the following productivity catching-up path:

$$\left(\frac{A_{T,t}}{A^*_{T,t}} - 1\right) = (1-\alpha)\left(\frac{A_{T,t-1}}{A^*_{T,t-1}} - 1\right) \tag{1}$$

where $A_{T,t}$ and $A^*_{T,t}$ are the tradable sector total factor productivity (TFP) levels in Spain and the rest of the euro area, respectively, and $\alpha$ is the parameter controlling for the speed of convergence. Equation (1) can be seen as the law of motion for the productivity gap, defined as the percentage difference between current and target TFP, with the latter assumed equal to the rest of the euro area level. A useful feature of this specification is that it implies a declining profile for the speed at which the technological gap is reduced, consistently with a standard description of such processes (see e.g. Barro and Sala-i-Martin, 1997).

Importantly, we implement this scenario by allowing the steady-state of the model to vary along and in line with the productivity convergence path. Given the structure of our workhorse model, we find this formulation more realistic than the natural alternative, which is making the steady-state jump immediately to its terminal level (i.e. to which the dynamic model solution converges only after the catching-up process is completed). The main reason for it is because in EAGLE (as well as in the NAWM) many fiscal policy variables (e.g. government expenditures, lump sum transfers and taxes) are tied to steady-state nominal output. Hence, making the steady-state instantaneously reach its terminal level would mean an abrupt increase in some state budget components, which seems neither realistic nor desired given our focus on developments purely related to real convergence.

While calibrating the catching-up scenario, we set the initial difference between current and target TFP in Spain's tradable sector to 11%, which is roughly consistent with the labour productivity gap vis-a-vis the rest of the euro area of 17% observed in 2005 (see Figure 1).[9] The speed of convergence is calibrated at 0.05, implying that half of the gap between the current and target TFP level is eliminated after about 14 quarters, while after 11 years the gap is reduced to just 1%.

The long-run (i.e. after the catch-up and all short-term adjustments have been completed) impact of this scenario is presented in the first column of Table 10.[10] We can see that higher tradable sector productivity leads to higher steady-state output not only in this sector, but also in the nontradable sector, though naturally to a much lesser extent. Given higher tradable content, investment expands by more than consumption. Higher productivity boosts international trade, with exports gaining in real terms more than four times as much as imports. Since both the original and the new steady-state feature a zero nominal trade balance, this expansion in export volume has to be offset by a depreciation of the terms of trade, i.e. an increase in import prices relative to export prices. Similarly, a new equilibrium on the domestic market requires an increase in the internal real exchange rate, defined as the price of nontradables relative to the price of domestically consumed tradable basket. In line with the Harrod-Balassa-Samuelson (HBS) effect,[11] the consumer-price-based external real exchange rate appreciates. Due to a positive wealth effect, labour supply declines, leading to a slight

[9] This is just a stylized and mechanical approximation, calculated by simply correcting the labour productivity gap for factor elasticities of output. Since such a calibration of the TFP gap neglects a number of intratemporal mechanisms present in the model (e.g. intersectoral reallocations, changes in relative prices, consumption-leasure choice, international spillovers), driving it to zero does not result in exact equalization of labour productivity across Spain and the euro area in our model simulations presented below.

[10] By construction, the long-run effects of all our convergence scenarios are identical across the two variants considered.

[11] See Harrod (1933), Balassa (1964) and Samuelson (1964).

decrease in total hours worked.[12] Given the low size of the Spanish economy, international spillovers related to its productivity convergence are very limited. Output in the rest of the euro area basically does not move at all, while consumption increases by a notch, following a favourable change in this region's terms of trade. Spillovers to the US and the rest of the world (not reported) are virtually zero.

The dynamic responses of Spain's macrovariables to our productivity convergence scenario are plotted in Figure 3. Focusing first on our baseline variant (fully anticipated convergence - solid lines), we first note that the responses in general do not evolve as smoothly as the underlying productivity path described by equation (1). In particular, investment shoots up and then is increasing at a somewhat slower rate. The initial reaction of private consumption relative to its target level is very similar, but then it decelerates very significantly and approaches its steady-state at a very low pace. Compared to domestic demand components, the expansion in total output is relatively moderate and smooth, so the trade balance deteriorates. The size of the deficit may be considered as not very high (0.4% of output at the trough), but it is sustained for an extended period of time, turning positive only after eight years, which is when about two-thirds of the convergence process have been completed. Since a mounting foreign debt needs to be serviced, a deterioration of the current account is deeper and its negative balance lasts even longer. Interest paid on net foreign liabilities, which at a trough reach nearly 10% of nominal GDP, is the main factor behind deceleration in consumption discussed above. Increased demand pressures during first years after the shock push inflation up. Since Spain is only a small part of the euro area economy, nominal interest rates remain virtually unchanged and the rise in inflation is quite substantial. Its deviation from the ECB target falls below 0.2 percentage points only after four years and stays above 0.1 for about a decade. An increased inflation rate relative to the rest of the euro area can be seen as a manifestation of the HBS effect and results in a strong appreciation of the real exchange rate.

Turning to our second variant of convergence (unanticipated catching-up - dashed lines), it is apparent that it yields far smoother dynamic responses than our baseline. This is particularly true for consumption, which, absent strong wealth effects related to expectations about future income increases, now evolves much more gradually. Consistently with a subdued initial expansion in domestic demand components, the current account deteriorates less, while the peak response of inflation is halved and postponed by two years compared to the baseline variant.

We have argued that productivity convergence based on the tradable sector provides a more realistic description of a typical catching-up process. Still, at least for comparison, it might be useful to see how the response of key macroaggregates would change if our lagging economy embarked on a convergence path based on productivity gains in the nontradable sector.

The scenario is implemented in a similar fashion as the previous one, so the catching-up trajectory evolves in an analogous way as represented by equation (1). We calibrate the initial difference between the current and target nontradable sector TFP level in Spain at 4%, which corresponds to a half of the labour productivity gap vis-a-vis the rest of the euro area observed in 2005 (equal to about 13%, see Figure 1). As before, the speed of convergence parameter is set to 0.05.

The long-run effects are presented in the second column of Table 10. They confirm the previous observation that a sector specific productivity shock affects output in both sectors in the same direction.

[12]This would not be the case if we assumed a unit intertemporal elasticity of substitution.

Looking at domestic demand components, one can see that a shift in nontradable sector productivity raises consumption more than investment. This is the opposite to what we observed in the case of a tradable productivity shock and results from differences in the tradable-nontradable composition across these two final goods. One can also note a much smaller than before effect on foreign trade volumes, even if one takes into account that the magnitude of shocks are not the same. The long-run response of the internal and external real exchange rates are just the HBS effect in reverse. A limited expansion of exports over imports implies only a moderate depreciation in terms of trade, which makes the magnitude of spillovers to Spain's trading partners virtually equal to zero. As before, the wealth effect decreases the labour supply.

The dynamic responses to the convergence scenario limited to the nontradable goods sector are illustrated in Figure 4. Starting with our baseline variant, the most striking difference compared to the tradable sector scenario is the initial decrease in investment, which is reversed only in the sixth year after the shock. This fall is driven by the expected further rise in productivity (given its gradual rather than instantaneous shift) and the corresponding postponement of investment.[13] A similar mechanism is also at work if productivity convergence is based on the tradable sector. In that case, however, it is offset by the expected appreciation of the real exchange rate, which encourages taking loans abroad. The opposite holds true if real convergence relies on nontradable sector productivity gains, as in this case the real exchange rate depreciates. As can be seen from the dynamic response of the current account, it actually improves and goes negative only after seven years. The same considerations also explain why consumption does not increase as fast as in our previous scenario, but moves more smoothly towards its target level.[14] Consistently with the HBS effect in reverse, productivity gains in the nontradable sector lead to a fall in inflation, which does not die out completely for an extended period of time.

When the nontradable sector productivity catching-up is unanticipated, there is no reason to postpone investment, so its initial response is positive and the current account deteriorates. As in our previous scenario, decreased wealth effects lead to a slower increase in consumption. The peak response of inflation is postponed by about a year, but its size is not much different to the anticipated case.

## 4.2 Shifts in export demand

Another real convergence scenario we consider is an exogenous shift in the rest of the world tastes towards goods produced in Spain. It is defined as an increase in quasi-shares of goods imported from Spain in other countries' consumption and investment baskets. This shift takes place at the expense of the quasi-shares of domestically produced goods in Spain's trading partners final baskets, leaving the quasi-shares of imports from third countries unchanged. In other words, we consider a reduction in home bias outside Spain, which is fully directed at Spanish exports. We implement the shock in a uniform fashion: the quasi-shares of goods imported from Spain are assumed to shift in the same

[13] See Jacquinot and Straub (2008) for a similar interpretation of this result.

[14] Another (though far less important) reason for a different response of domestic demand to gradual productivity gains in the tradable vs. nontradable sector is higher price flexibility of the former. This results from our calibration, which assumes that prices of exported goods are reoptimized more frequently than prices of goods sold domestically. See Gali (1999) for an exposition of the relation between price stickiness and a dynamic response of hours worked (which can be extended to factor inputs in general) to a permanent productivity shock.

proportion across all trading partners and both types of final baskets with non-zero tradable content (i.e. consumption and investment). See the appendix for details.

Foreign preferences is arguably only one among many factors affecting international trade flows and it is beyond the scope of this paper to carefully examine the relative importance of any of them for Spain. Therefore, we just set the size of our shock to 50%, without attempting to argue that this magnitude relates to any probable future developments. We only note that the resulting increase in the share of Spain's exports in world GDP (by about 40%) is rather moderate if compared to evolution of this ratio observed over the last decades (see Figure 2).

As before, we assume that the shift in foreign tastes does not occur within one period, but rather evolves gradually in line with equation (1). We think it reasonable to claim that preferences tend to change more slowly than technologies, and so set the speed of convergence parameter to 0.02, which is lower than used in the productivity convergence scenarios. This parameter value means that half of the shock is realized after about 9 years, compared to 14 quarters implied by the previously used calibration of 0.05.

The long-run effects of the scenario are presented in the last column of Table 10. The main channel through which the shock affects the Spanish economy is a change in the terms of trade. They appreciate substantially since increased demand for Spain's exports pushes up prices of exports relative to those of imports. This creates a wealth effect, leading to higher consumption and lower labour supply. An increase in domestic demand is mainly satisfied from imports, which become much cheaper relative to domestically produced tradable goods. In fact, there is even some crowding out of domestic goods from Spain's tradable basket, so that domestic tradable production actually falls and is shifted towards nontradables.[15] Cheap imports also imply an increase in the internal exchange rate and appreciation of the external real exchange rate. As before, this makes real investment rise by more than consumption. Higher investment makes it possible to increase total output despite unchanged technology and a fall in labour input. An appreciation of the terms of trade at home means a symmetric depreciation abroad. This negative wealth effect, given a relatively large size of the shock, leads to a nonnegligible fall in consumption in the rest of the euro area.

The dynamic responses to the export demand shock are illustrated in Figure 5. As can be seen, despite a gradual evolution of the shock, the response of many macroaggregates in our baseline variant is far from smooth. In particular, output and investment overshoot their new steady-state values. The response of consumption exhibits a similar pattern to that observed in our baseline convergence scenario: it reaches more than half of its terminal value within a year, but then decelerates very significantly. An expansion in domestic demand is much larger than that of output, so the trade (and current account) balance deteriorates, leading to a relatively fast decumulation of net foreign assets. This has a negative effect on consumption in a way discussed before. The terms of trade index appreciates rather sharply, which helps to shift domestic demand towards imports during the initial boom. Increased demand pressures translate into higher inflation, which starts to fall rapidly in the second year after the shock, but then remains significantly above the target for an extended period of time.

[15] This result hinges on a relatively low elasticity of substitution between tradable and nontradable goods, calibrated at 0.5 (see Table 4). If it is closer to one (at least 0.75), the long-run response of both tradable and nontradable output is positive.

In the unanticipated variant, the main macroaggregates evolve more smoothly. Interestingly, the current account improves in the short run, which clearly indicates that its deterioration in our baseline variant was entirely driven by wealth effects and expectations about the exchange rate appreciations. The response of inflation is now much more moderate, with its peak occurring one and a half years later than in the fully anticipated case.

### 4.3 Real convergence and shifts in international investment positions

Both of our two variants of real convergence scenarios assume that they do not lead to permanent changes in international investment positions, i.e. each country's net foreign assets to GDP ratios eventually go back to their initial steady-state levels. Now we analyze how our results change if this restriction is relaxed.

More specifically, we assume that a 1 per cent increase in a converging economy's steady-state GDP per hours worked (in PPP terms) is associated with a deterioration in its steady-state international investment position (relative to annual GDP) by 0.4 percentage points.[16] A non-zero steady-state net foreign asset position is technically implemented as in Faruqee et al. (2005) and Coenen et al. (2008b), i.e. by making financial intermediation costs dependent on the deviation of actual net holdings of foreign assets from their desired (target) level (rather than from zero). The new target net foreign assets position is allowed to approach its terminal level in a gradual way, in line with equation (1), with the speed of convergence identical to that assumed for the relevant exogenous parameters (productivity or quasi-shares) in the underlying scenario.

In the long run, a negative target international investment position generates additional expenditures for domestic households in form of interest paid on foreign debt. Therefore, introducing this additional channel can reduce the wealth effects associated with real convergence. In the short run, however, a decrease in the desired net foreign assets position makes running the current account deficit less costly, which facilitates a sharper response of domestic demand components to favourable shifts in productivity or foreign preferences.

This intuition is confirmed by our simulations.[17] Indeed, allowing for permanent changes in net foreign assets holdings results in a smaller long-run response of consumption and hours worked (but a larger response of output) in those of our convergence scenarios that lead to an increase in Spain's dollar-denominated output per hour worked.[18] It has to be noted, however, that the differences are rather moderate, never exceeding 0.3 for output. As regards the dynamic responses to our scenarios, the long-run reduction in wealth effects turns out to be more than offset in the short-run by a decrease

[16]This is a very rough and only illustrative calibration, based on the observed relation between the initial output per capita gap (around 60% if estimated in 1960 for Spain and in 1995 for the EU new member states) and the sustainable external debt target (estimated at 53-65% of GDP for the relevant group of countries; see Bulíř and Šmídková, 2005). As it is well known, there are different patterns of real convergence with respect to changes in international investment positions. For instance, China's catching-up is accompanied by accumulation and not decumulation of net foreign assets. Therefore, our third variant can be viewed as just a sensitivity check for one of the simplifying assumptions made in the first variant.

[17]The results are available from the author upon request.

[18]This applies for two of our three convergence scenarios: tradable sector productivity catching-up and an increase in export demand. As regards the scenario based on nontradable sector productivity developments, its results do not differ from those presented before. This is because the observed increase in Spain's (real) labour productivity is offset by the real exchange rate depreciacion. As nominal GDP per hours worked remains unchanged, so does the target net foreign assets position.

in costs of financing a current account deficit. As a result, consumption and investment (and, though to a lesser degree, output) go up by more than in our baseline variant, the current account deterioration is deeper and initial inflation pressures are higher. Contrary to the long-run effects, the short-run impact of allowing the target net foreign position to change are more pronounced. For instance, the peak response of consumption in the export demand shift scenario is now larger by 1.4 percentage points, while that of investment by 4.4 percentage points.

# 5 Misperceptions along the convergence path

We have seen in the previous section that even smooth processes, like gradual productivity catching-up or shifts in external tastes, do not necessarily result in smooth dynamic responses of the main macrovariables. Therefore, without knowing the underlying forces, these developments can be easily misinterpreted as manifestations of growing imbalances, requiring policy intervention to avoid huge boom-bust swings, while in fact they are just optimal responses of the private sector, given the monetary and fiscal feedback rules.[19]

On the other hand, the real convergence processes are far more complicated than suggested by the stylized scenarios set up above. Obviously, they are to a large extent neither smooth nor deterministic. In particular, transitory productivity shocks coexist with permanent shifts and it may be difficult to distinguish between them straight after they hit the economy. In this section we demonstrate how such misperceptions can lead to boom-bust cycles in the economy.

We consider two misperceptions scenarios, one based on confusing a temporary productivity shift with a permanent one, the other describing optimistic expectations about future productivity, which however fail to materialize.

We define the first misperception scenario as a temporary shift in tradable sector productivity, which rises by 1% and comes back to its original level after two years. However, once the shock hits, it is perceived as permanent and only after it unwinds do the agents realize its true nature.

The dynamic response of selected variables to such a confusion scenario is illustrated in Figure 6 (solid line), along with the response to a truly permanent productivity shift (dashed line). If agents are faced with a shock that is perceived as permanent, the economic activity increases, with output and investment even overshooting the new steady-state. The current account deteriorates, the real exchange rate appreciates and inflation rises. Once it becomes clear that the shock is only temporary, the optimal plans of economic agents have to be substantially revised. Consequently, output and domestic demand contract sharply, falling below their initial levels within a year. A nearly instantaneous improvement in the current account balance resembles a "sudden stop". Inflation falls sharply and quickly turns into deflation. As a result, the real exchange rate depreciates.

In the second misperception scenario, the economic agents receive news, according to which tradable sector productivity is going to increase permanently in one year by 1%. After a year, however, this news turns out to be false.

[19] It has to be noted that the policy rules assumed in the model are rather mechanical and uncontingent on the underlying shocks. Therefore, the dynamic responses of macroaggregates could be different if the policy (and the fiscal policy in particular, given Spain being only a small member of the monetary union) was tailored to the specific convergence scenario. This kind of considerations is left for future research.

Figure 7 depicts the dynamic response to this false news shock (solid line), together with a hypothetical situation in which the news would be true (dashed line). In qualitative terms, this scenario turns out to result in similar responses as the previous one. On impact, consumption and investment start to rise. Output goes up as well, but not enough to satisfy the domestic demand, so the current account turns negative. Increased demand pressure translates into higher inflation and the exchange rate appreciates. Once the news turns out to be an illusion, the economic activity contracts, inflation goes down and turns into deflation, and the exchange rate depreciates. There is also some improvement in the current account balance, but it takes about another three and a half years before it comes back to zero.

Finally, we briefly describe the results for an analogous pair of misperception scenarios based on productivity developments in the nontradable sector (not illustrated in figures). Confusing a transitory shock with a permanent one turns out to lead to qualitatively similar dynamic responses of the key real variables as it was the case with the shock originating from the tradable sector, except that the correction following the turning point (i.e. when agents realize that they have been wrong) is more gradual. Naturally, the response of inflation and the real exchange rate are of the opposite sign to what we have seen before and also come back to their initial levels at a somewhat faster pace. Similar observations can be made in the case of the false news shock, except that it fails to generate a boom-bust cycle in investment. This is related to the initially negative response of investment following expectations of future productivity improvements in the nontradable sector, the mechanics of which we have discussed before.

# 6 The role of alternative monetary regimes

In all scenarios described so far we have used our baseline parameterization of EAGLE, which models the Spanish economy as a part of the euro area. In this section we show how the responses to our stylized scenarios change if we consider two alternative regimes. In the first one, Spain is following a fully independent monetary policy, with a freely floating exchange rate. The parameterization of the interest rate feedback rule is then the same as for the other three regions of the world economy. The second variant is a fixed (pegged) exchange rate regime, which is technically implemented by augmenting the Spanish monetary policy rule with an additional term, defined as an increase in the bilateral nominal exchange rate versus the euro and multiplied by a coefficient sufficiently high to ensure that this exchange rate is effectively fixed.[20]

In both of these alternative variants, all structural parameters of the model are the same as in the baseline monetary union case. In other words, our exercise just compares the impact of monetary regimes across otherwise identical economies. Although in general DSGE models are considered to be much more immune to the Lucas critique than less micro-founded approaches, one cannot completely rule out that some of the parameters describing the optimization problems of economic agents are in fact endogenous to the monetary regime. All our subsequent results should be interpreted with this

[20]It has to be noted that the fixed exchange rate regime, aimed to mimic the ERM2-like mechanism, is not isomorphic to the common currency area in the EAGLE world. This is because in the former case the economic conditions in Spain are not taken directly into account by the monetary policy feedback rule of the euro area. Indeed, these two regimes become indistinguishable as the size of the Spanish economy approaches zero.

caveat in mind.

The dynamic responses of a set of key macrovariables to the five scenarios considered before are plotted in figures 8 to 12, which correspond to figures 3 to 7 described before.[21] The solid lines replicate the monetary union (our baseline), the dashed lines illustrate the dynamic responses under a flexible exchange rate regime and the dotted lines show the peg case. As indicated before, given the relatively small size of the Spanish economy, pegging to the euro yields the results similar to the monetary union case, so we focus most of our discussion on comparisons across the latter and the flexible exchange rate regime.

Starting from our main productivity catching-up scenario, i.e. based on anticipated productivity convergence in the tradable goods sector, we first note that if the exchange rate is allowed to float, it appreciates significantly on impact. The dynamic responses of output, consumption and investment are much smoother than it was the case in the monetary union setup. The initial deterioration in the current account balance is also slightly more moderate. A relatively sharp appreciation of the nominal exchange rate allows to eliminate the surge in inflation, but then it somewhat increases, exceeding the target by more than 0.2 percentage points for about a decade.[22]

To a large extent, an opposite picture emerges in the case of productivity catch-up in the non-tradable goods sector. In the free float regime, the exchange rate depreciates sharply. The short-run response of output and its expenditure components is less smooth and regular as in the monetary union case. The nominal exchange rate depreciation and higher demand pressures actually lead to an increase rather than a fall in inflation, which stays above the target for an extended period of time.

Moving to our last real convergence scenario, based on a gradual shift in export demand for Spanish products, we observe similar qualitative differences across the alternative monetary regimes as those observed in the case of tradable productivity catching-up. Under the free float, the exchange rate appreciates very sharply. Consumption and investment respond far more smoothly than in the monetary union case and output even somewhat declines in the short run. Lower demand pressures and the exchange rate appreciation more than eliminate the relatively large inflationary effect that could be observed in the common currency case.

Turning to the misperceptions about tradable sector productivity, one can note that a flexible exchange rate tends to somewhat mitigate the boom-bust pattern in the response of output and domestic demand components. This is also true for inflation, especially in the false news variant. The latter feature can also be observed for a pair of related scenarios based on nontradable productivity misperceptions (not illustrated in figures). On the contrary, variables describing the real economic activity display much more pronounced swings than in the common currency case.

[21] The alternative monetary regimes have no impact on the model's steady-state equilibrium.

[22] Clearly, the dynamic response of inflation is highly dependent on the assumed monetary policy feedback rule, the calibration of which relies on estimates obtained from models abstracting from real convergence processes. In reality, an autonomous central bank seeing inflation above the target for an extended period of time would probably follow a more restrictive line. This would make the differences across the monetary union and the flexible exchange rate regime even more pronounced. This remark also applies to other scenarios discussed in this section.

# 7 Conclusion

In this paper we have used EAGLE, the multi-country DSGE model recently developed at the ECB, to analyze dynamic adjustments in a relatively small economy undergoing real convergence processes within a monetary union. We consider a set of scenarios related to productivity catch-up, shifts in foreign tastes towards a country's exports and misperceptions about productivity developments.

Our tentative results indicate that even if real convergence takes the form of a set of gradual processes, the dynamic responses of key macrovariables can be far from smooth. Moreover, misperceptions about productivity shifts can be an important source of cyclical deviations from a sustainable real convergence path. If this kind of processes are related to tradable sector developments or shifts in foreign preferences, keeping the monetary autonomy helps to reduce the volatility of key macrovariables, while being a part of a monetary union seems to smooth shocks originating from the nontradable sector.

While our quantitative results rely on a model that is calibrated with a focus on the Spanish economy, our findings are also likely to be relevant for other countries, particularly for the EU new member states from central and eastern Europe. All of them are relatively small economies, undergoing real convergence processes and experiencing significant boom-bust cycles. These countries are also expected to become members of the euro within a decade, and so in all likelihood long before real convergence processes become relatively less relevant for their policy makers. Given the main patterns of real convergence observed in the new member states, i.e. rapid gains in tradable sector productivity and strong export performance, our results suggest that entering the euro area (or the ERM2 system) may be followed by an increase in volatility at an aggregate level, posing a challenge for policy makers. Of course, being a member of the euro area is much more than just sharing a common currency, so our results should not be interpreted as a suggestion that central and eastern European countries would be better off keeping out of the EMU.

One can think about a number of potentially attractive avenues for further research on topics analyzed in this paper. First and foremost, one has to bear in mind that our analysis is based on a calibrated rather than estimated model. Given the large size of EAGLE and short time series available for countries where real convergence processes might be particularly relevant, having an estimated version of this model will not be feasible in the near future. While some preliminary robustness checks indicate that our main results are not very sensitive in qualitative terms to varying the key model parameters within reasonable bounds, it might be still useful to investigate this issue in more detail, including a recalibration of the model to represent another current or prospective euro area member.

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# Tables and figures

Table 1. Steady state ratios (%)

| | Spain | REA | USA | RW |
|---|---|---|---|---|
| GDP share in world GDP | 2.1 | 20.9 | 28.2 | 48.7 |
| Consumption share in GDP | 58.4 | 58.3 | 66.9 | 58.4 |
| Government expenditures share in GDP | 17.3 | 20.8 | 15.0 | 16.5 |
| Investment share in GDP | 24.3 | 20.9 | 18.1 | 25.1 |
| Imported consumption goods share in GDP | 9.9 | 7.3 | 4.8 | 4.0 |
| Imported investment goods share in GDP | 6.6 | 4.9 | 3.3 | 4.7 |
| Net exports share in GDP | 0.0 | 0.0 | 0.0 | 0.0 |

Table 2. Trade matrix - consumption goods imports (%)

| to - from | Spain | REA | USA | RW |
|---|---|---|---|---|
| Spain | . | 55.6 | 1.9 | 42.5 |
| REA | 12.3 | . | 4.8 | 82.9 |
| USA | 0.6 | 13.3 | . | 86.1 |
| RW | 4.8 | 52.1 | 43.1 | . |

Table 3. Trade matrix - investment goods imports (%)

| to - from | Spain | REA | USA | RW |
|---|---|---|---|---|
| Spain | . | 60.6 | 4.4 | 35.0 |
| REA | 5.1 | . | 13.6 | 81.3 |
| USA | 0.6 | 15.6 | . | 83.8 |
| RW | 1.9 | 37.6 | 60.5 | . |

Table 4. Final goods technology

| | Spain | REA | USA | RW |
|---|---|---|---|---|
| Quasi-share of nontradables in final consumption goods (%) | 70.0 | 70.0 | 70.0 | 70.0 |
| Quasi-share of nontradables in final investment goods (%) | 40.0 | 40.0 | 40.0 | 40.0 |
| Quasi-share of imports in tradable consumption goods (%) | 62.1 | 47.7 | 24.6 | 25.2 |
| Quasi-share of imports in tradable investment goods (%) | 45.9 | 43.3 | 30.4 | 33.5 |
| Elasticity of substitution between tradable and nontradable goods | 0.5 | 0.5 | 0.5 | 0.5 |
| Elasticity of substitution between domestic goods and imports | 2.0 | 2.0 | 2.0 | 2.0 |
| Elasticity of substitution between imported goods | 1.3 | 1.3 | 1.3 | 1.3 |

Table 5. Intermediate goods technology

| | Spain | REA | USA | RW |
|---|---|---|---|---|
| Capital share in nontradable production | 0.35 | 0.30 | 0.30 | 0.35 |
| Capital share in tradable production | 0.40 | 0.35 | 0.35 | 0.40 |
| Elasticity of substitution between intermediate nontradable varieties | 3.5 | 3.5 | 4.6 | 4.6 |
| Elasticity of substitution between intermediate tradable varieties | 5.8 | 5.8 | 7.7 | 7.7 |
| Calvo probability for goods sold domestically | 0.75 | 0.75 | 0.75 | 0.75 |
| Calvo probability for exported goods | 0.30 | 0.30 | 0.30 | 0.30 |
| Price indexation | 0.50 | 0.50 | 0.50 | 0.50 |

Table 6. Households

| | Spain | REA | USA | RW |
|---|---|---|---|---|
| Share of households with limited access to capital markets | 0.50 | 0.25 | 0.25 | 0.50 |
| Inverse of the intertemporal elasticity of substitution | 2.0 | 2.0 | 2.0 | 2.0 |
| Habit persistence | 0.7 | 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 7. Fiscal authorities

| | Spain | REA | USA | 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 (%) | 16.0 | 18.5 | 7.7 | 7.7 |
| Personal income tax rate (%) | 9.7 | 12.5 | 15.4 | 15.4 |
| Social security contribution tax paid by employees (%) | 4.9 | 12.5 | 7.1 | 7.1 |
| Social security contribution tax paid by employers (%) | 23.4 | 21.7 | 7.1 | 7.1 |

Table 8. Monetary authorities

| | Spain | REA | USA | RW |
|---|---|---|---|---|
| Interest rate smoothing | 0.9 | 0.9 | 0.9 | 0.9 |
| Long-run response of interest rates to inflation | 2.0 | 2.0 | 2.0 | 2.0 |
| Long-run response of interest rates to output gap | 0.25 | 0.25 | 0.25 | 0.25 |

Table 9. Adjustment costs

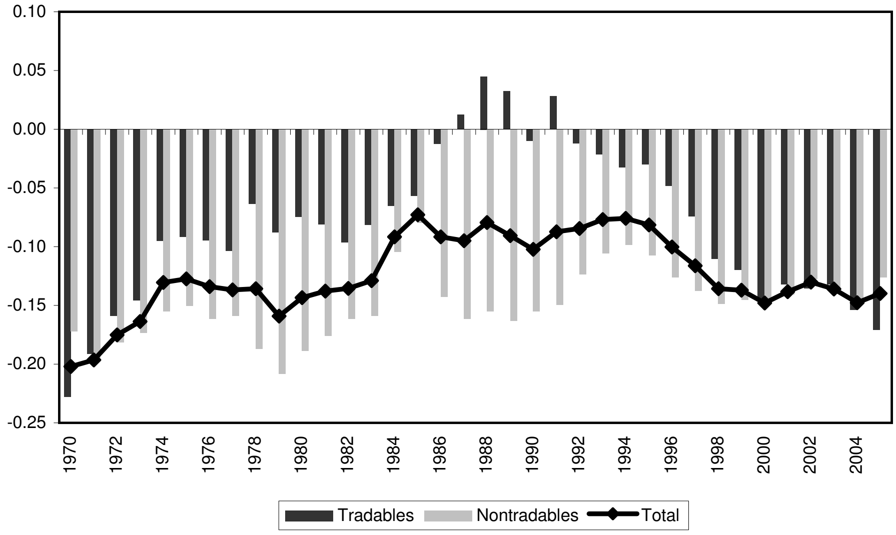
| | Spain | REA | USA | RW |
|---|---|---|---|---|
| Capacity utilization cost (second derivative) | 0.05 | 0.05 | 0.05 | 0.05 |
| Investment adjustment cost (second derivative) | 3.0 | 3.0 | 3.0 | 3.0 |
| Import adjustment cost for consumption goods (second derivative) | 5.0 | 5.0 | 5.0 | 5.0 |
| Import adjustment cost for investment goods (second derivative) | 2.0 | 2.0 | 2.0 | 2.0 |
| International transaction cost (first derivative in steady state) | 0.01 | 0.01 | . | 0.01 |

Table 10. Long-run impact of real convergence scenarios

| | Productivity shock in tradables | Productivity shock in nontradables | Foreign demand shock |
|---|---|---|---|
| Output | 5.6 | 3.0 | 1.5 |
| Tradable | 11.2 | 1.5 | -2.4 |
| Nontradable | 2.5 | 3.8 | 3.7 |
| | | | |
| Consumption | 3.6 | 3.1 | 6.5 |
| Investment | 6.5 | 1.8 | 9.4 |
| Exports | 8.2 | 1.2 | 7.7 |
| Imports | 1.9 | 0.3 | 38.2 |
| | | | |
| Terms of trade | 6.2 | 0.9 | -22.1 |
| Real exchange rate | -3.6 | 3.9 | -18.8 |
| Internal exchange rate | 8.3 | -4.7 | 18.5 |
| | | | |
| Hours worked | -1.2 | -1.0 | -2.1 |
| Real wage rate | 4.9 | 4.1 | 8.7 |
| | | | |
| REA Output | 0.0 | 0.0 | 0.0 |
| REA Consumption | 0.1 | 0.0 | -0.4 |

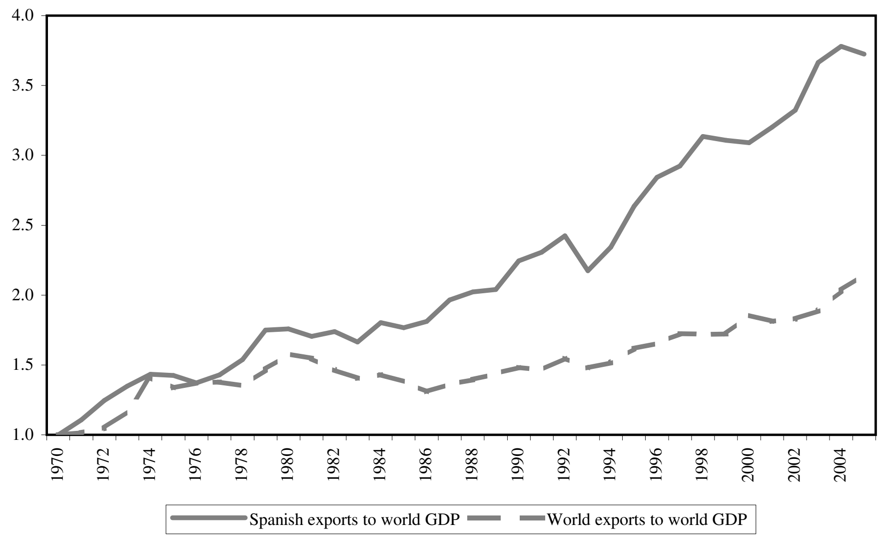
Notes: All variables reported as percentage deviations from their initial steady-state levels.

Figure 1. Productivity gap in Spain vis-á-vis the euro area



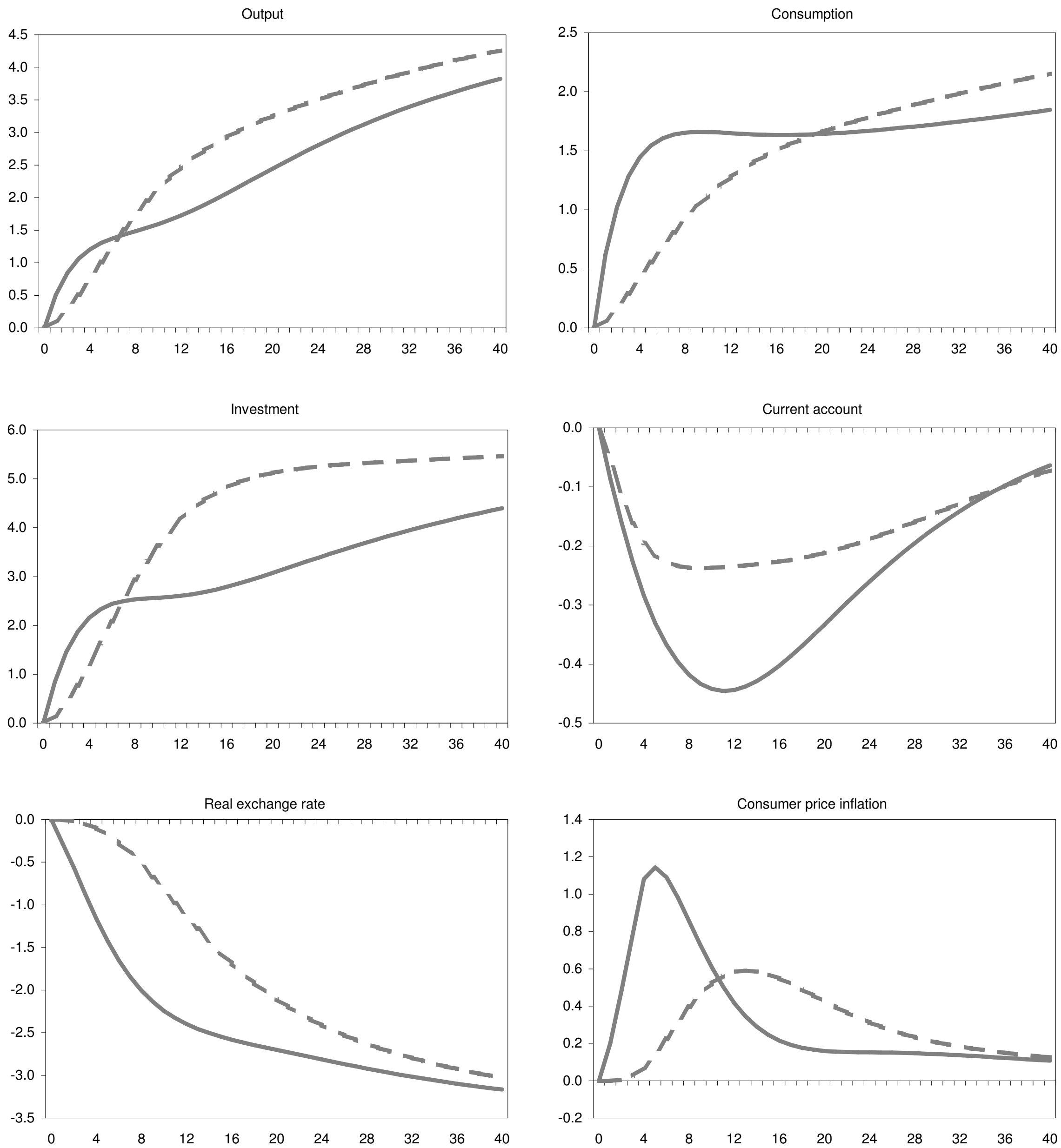

Notes: The productivity gap is defined as the percentage difference between gross value added per hours worked in Spain and that in the rest of the euro area. Aggregation and comparison is based on industry specific purchasing power parities. The tradable sector comprises the following industries: agriculture (NACE A and B), mining and quarrying (C) and manufacturing (D). The nontradable sector covers the rest of the market economy, i.e. it excludes real estate activities (NACE 70) as well as community and social services (L to O).
Source: Own calculations based on data from EU-KLEMS.

Figure 2. Share of Spanish and world exports in world GDP



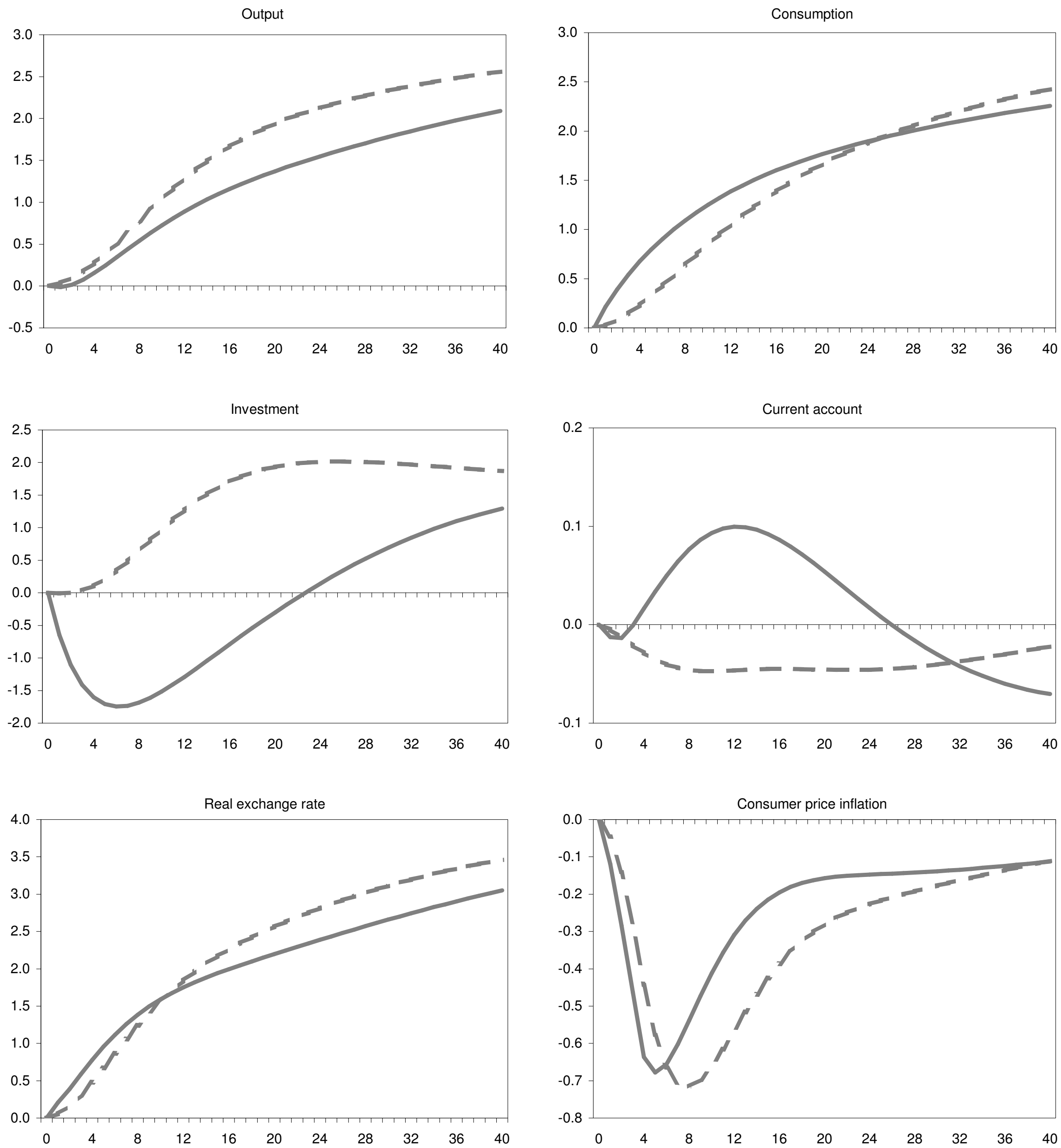

Notes: Both series are normalized to one in 1970.
Source: Own calculations based on data from World Development Indicators.

Figure 3. Dynamic responses to productivity convergence in the tradable sector



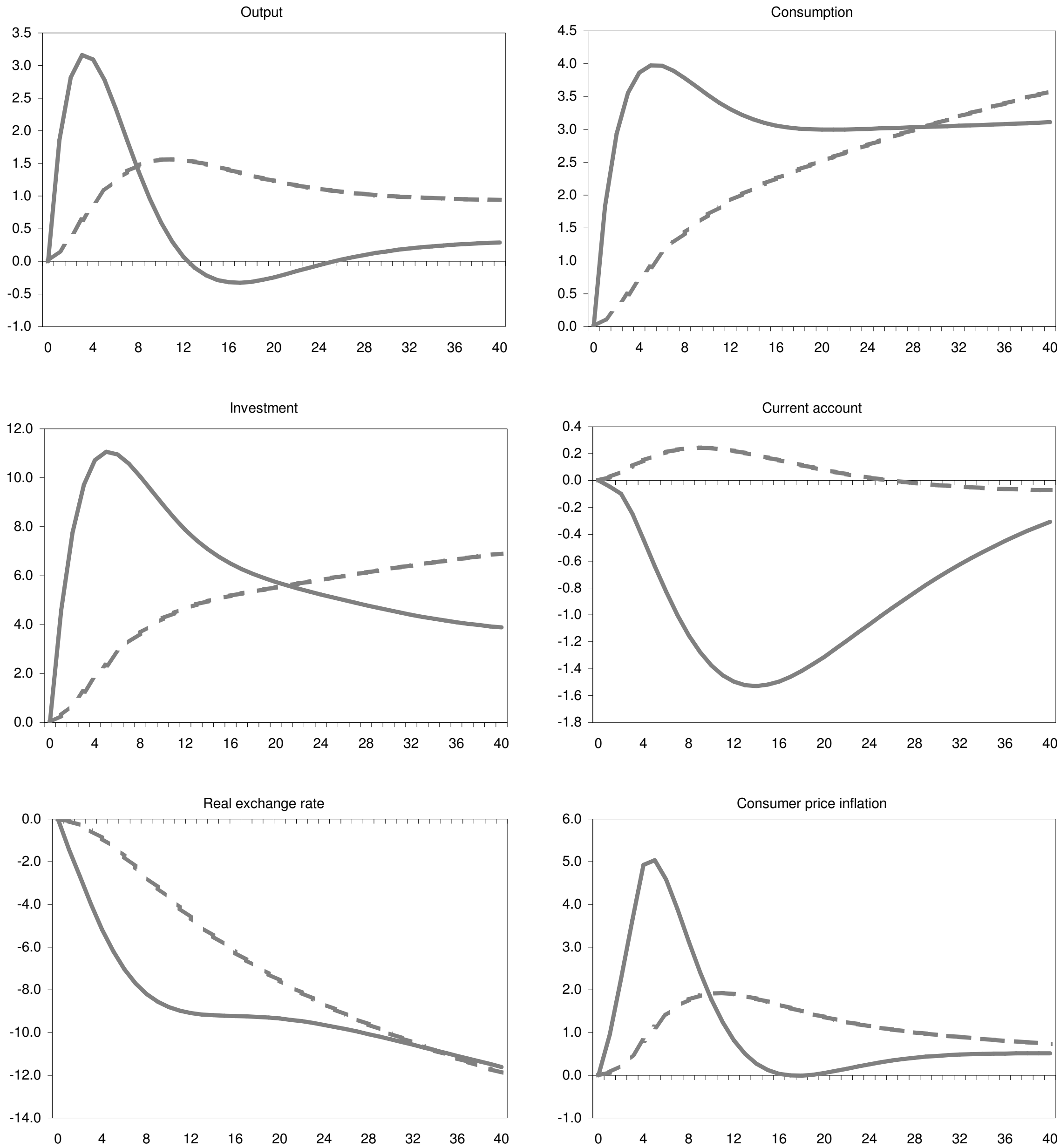

Notes: The solid (dashed) lines present the dynamic response to the fully anticipated (unanticipated) real convergence scenario. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 4. Dynamic responses to productivity convergence in the nontradable sector



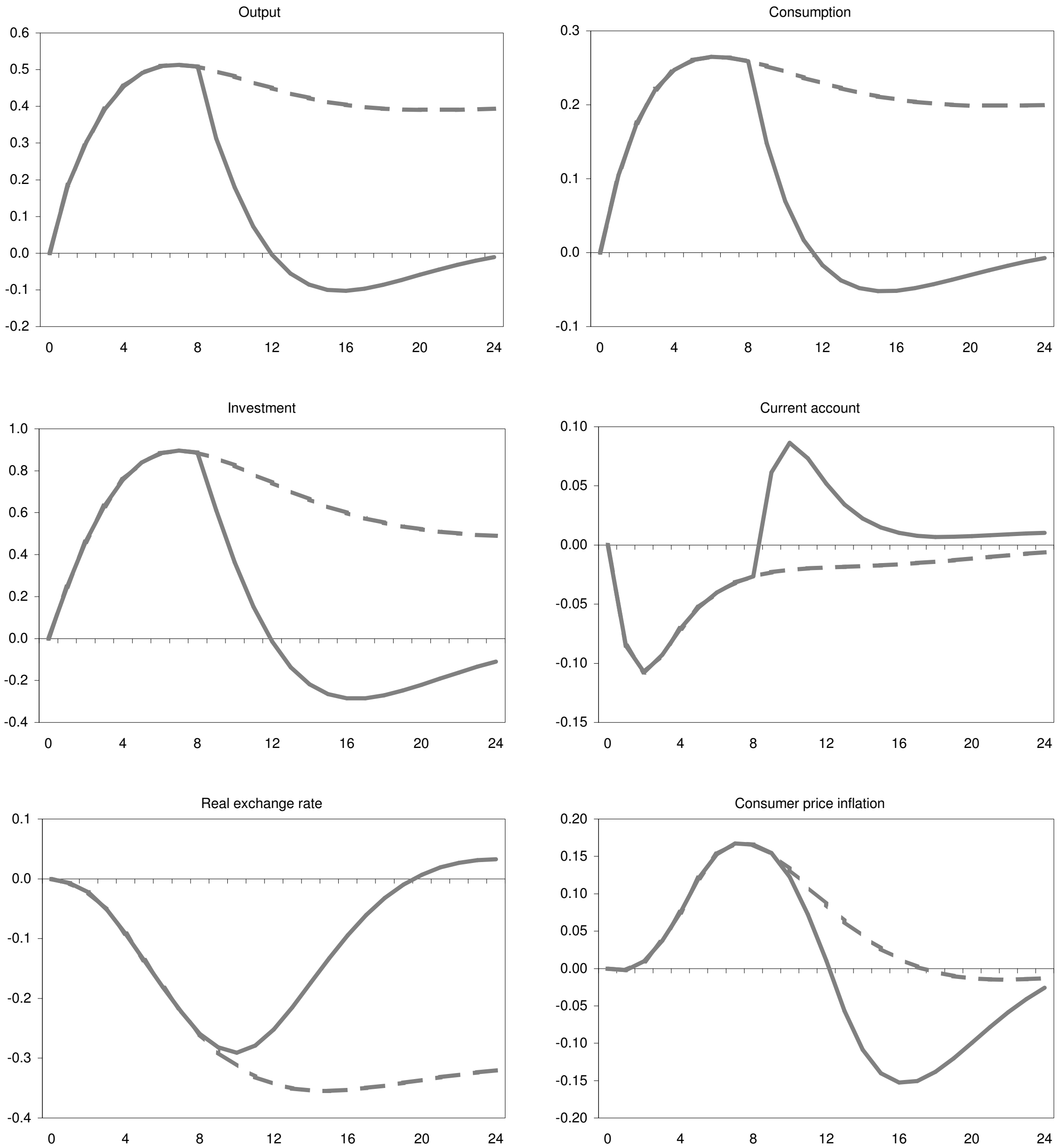

Notes: The solid (dashed) lines present the dynamic response to the fully anticipated (unanticipated) real convergence scenario. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 5. Dynamic responses to a gradual shift in exports demand



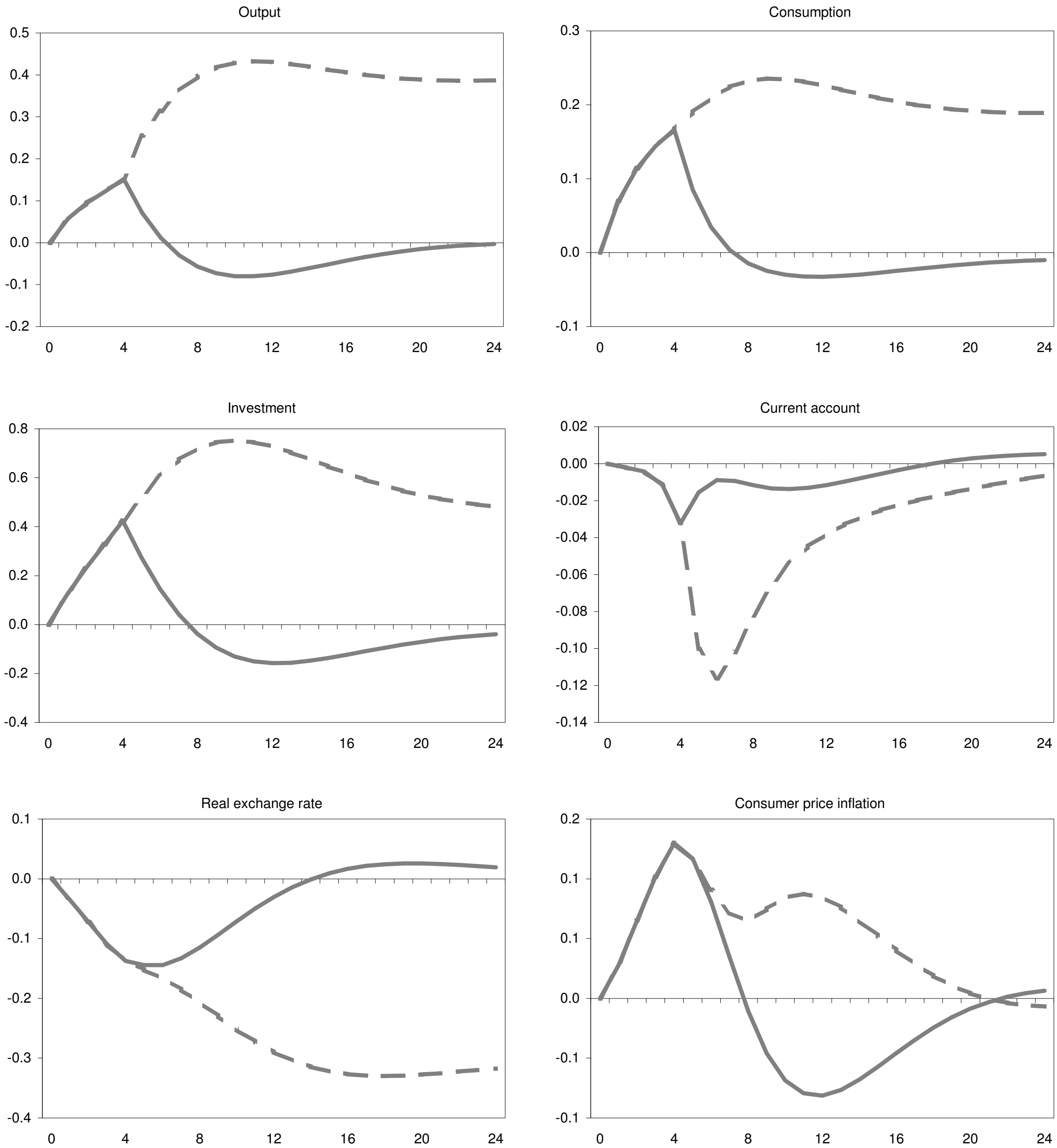

Notes: The solid (dashed) lines present the dynamic response to the fully anticipated (unanticipated) real convergence scenario. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 6. Transitory (but perceived as permanent) productivity shock in the tradable sector



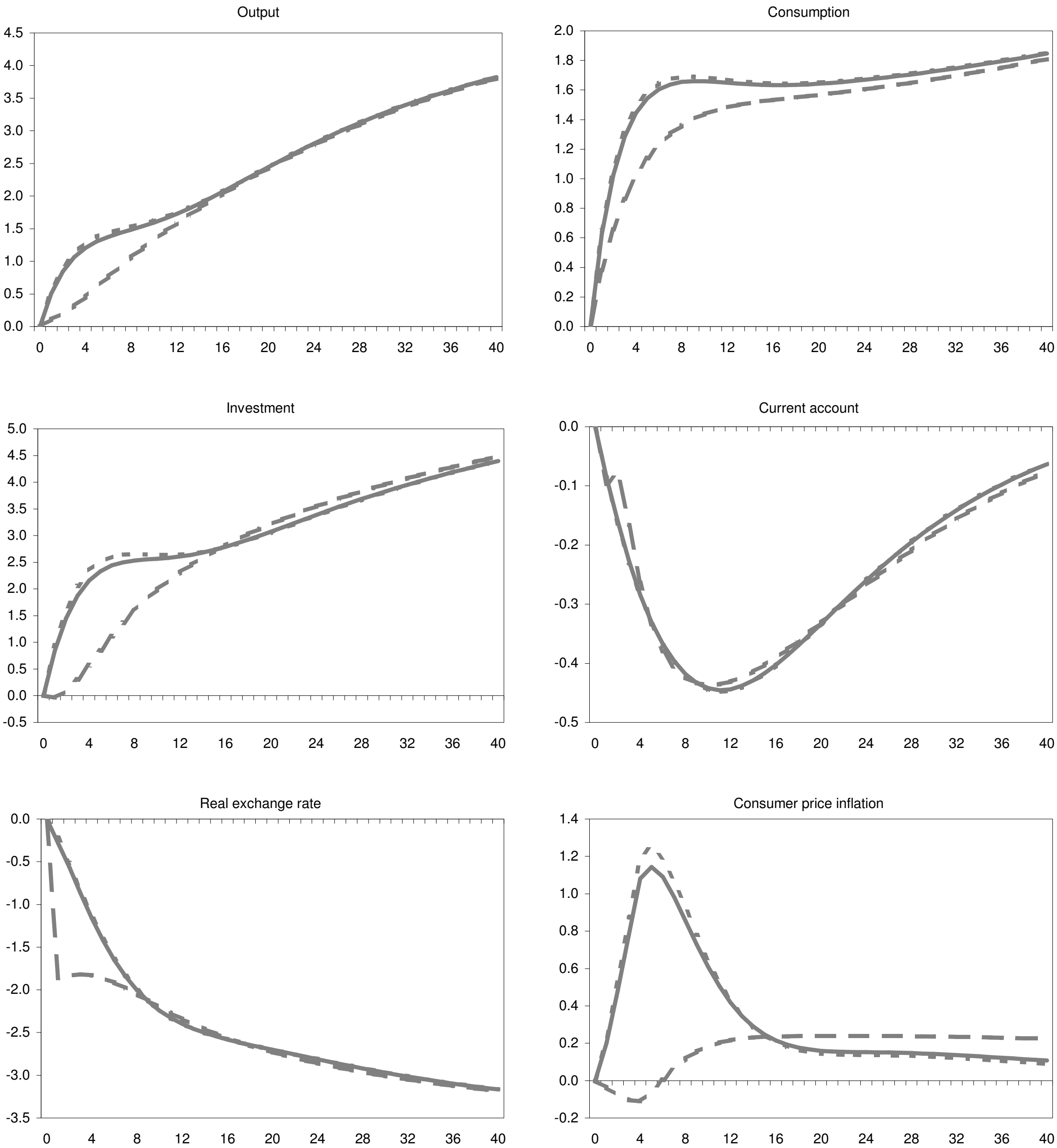

Notes: The solid lines present the dynamic response to the misperception scenario (i.e. confusing a transitory shock with a permanent one), while the dashed lines show how the economy would evolve if the shock was indeed permanent. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 7. Expected (but failing to materialize) productivity shock in the tradable sector



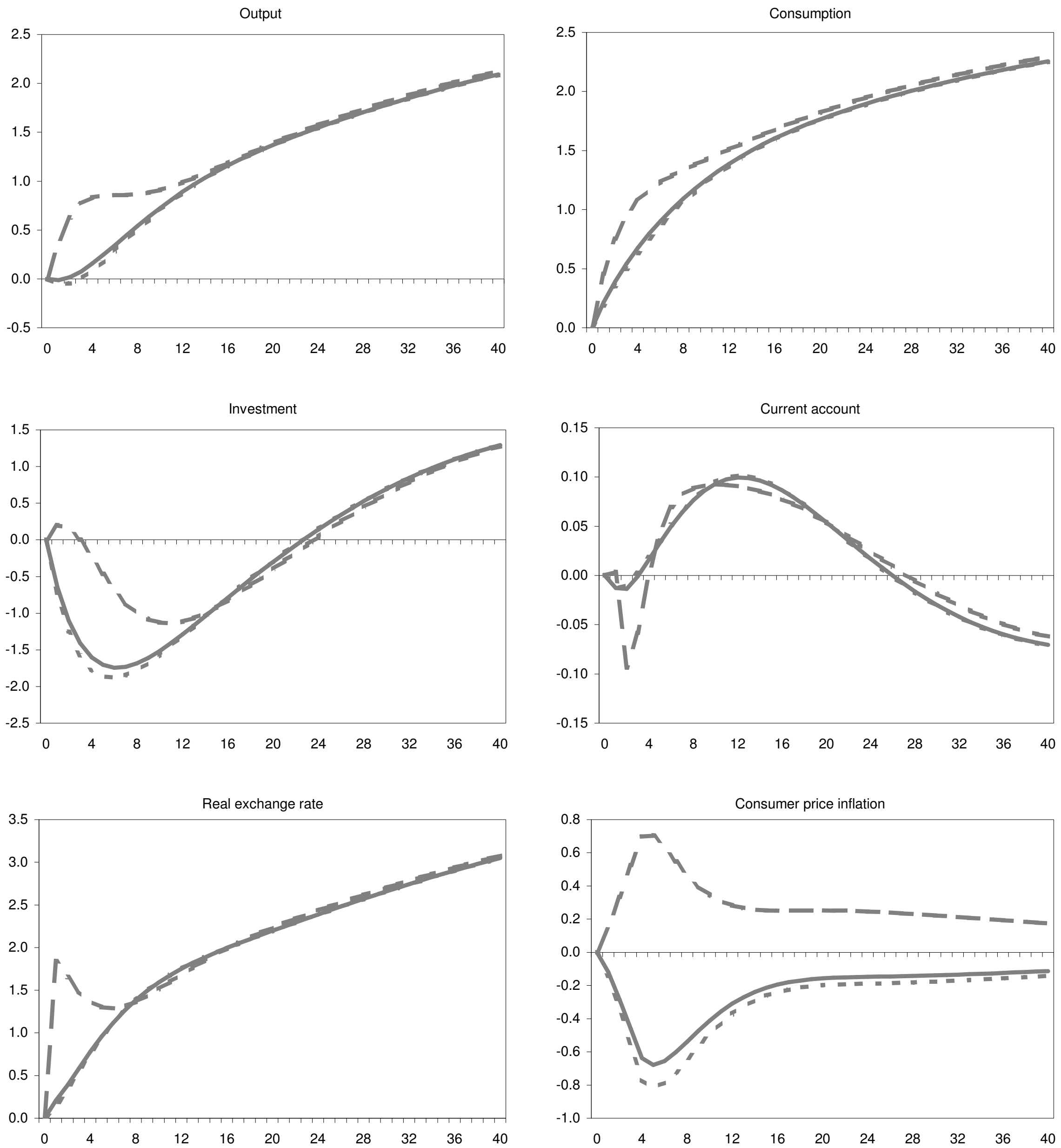

Notes: The solid lines present the dynamic response to the false news scenario, while the dashed lines show how the economy would evolve if the news was true. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 8. Dynamic responses to productivity convergence in the tradable sector: different regimes



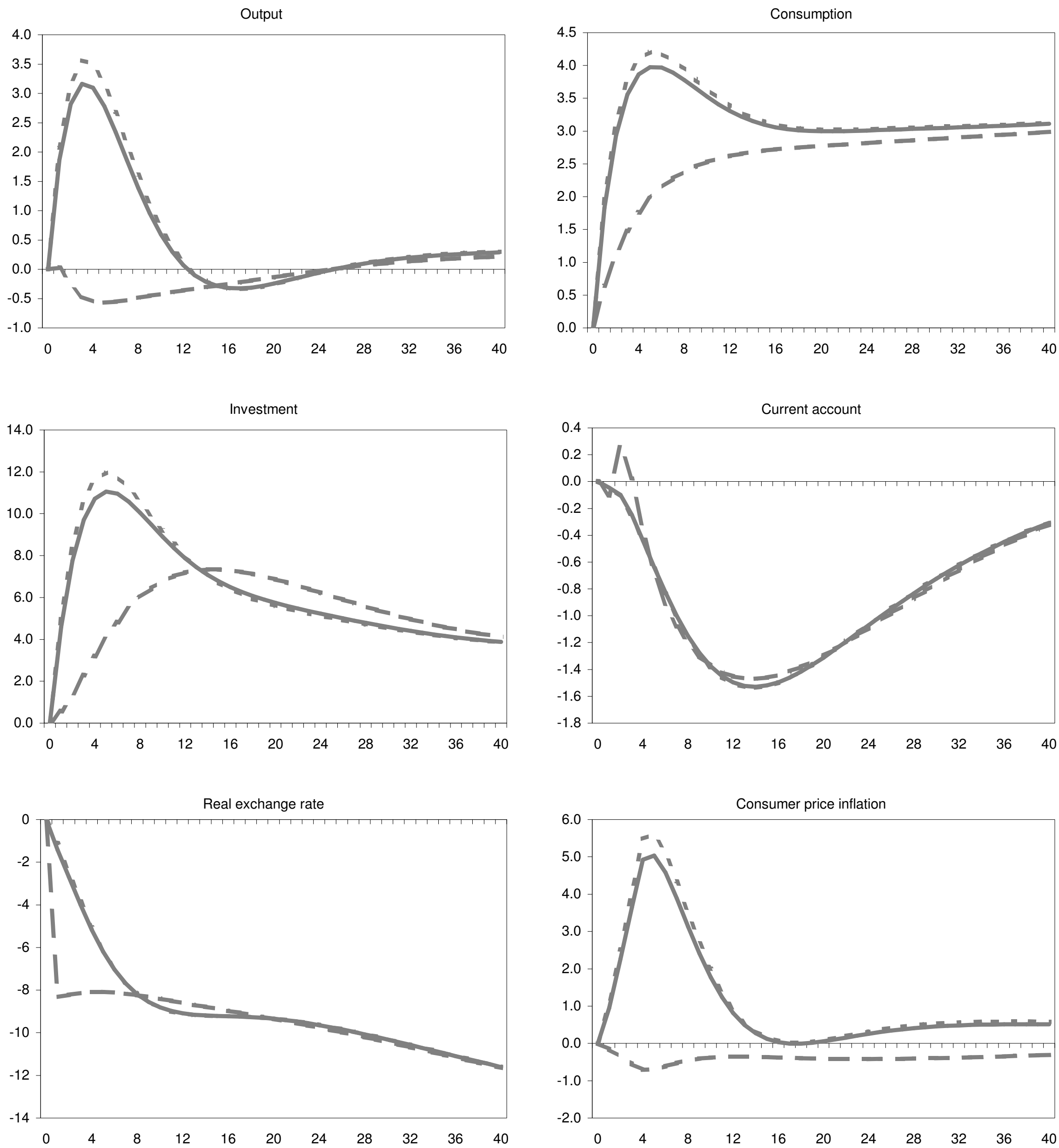

Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), the dashed lines show the flexible exchange rate regime, while the dotted lines correspond to the peg vis-a-vis the euro. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 9. Dynamic responses to productivity convergence in the nontradable sector: different regimes



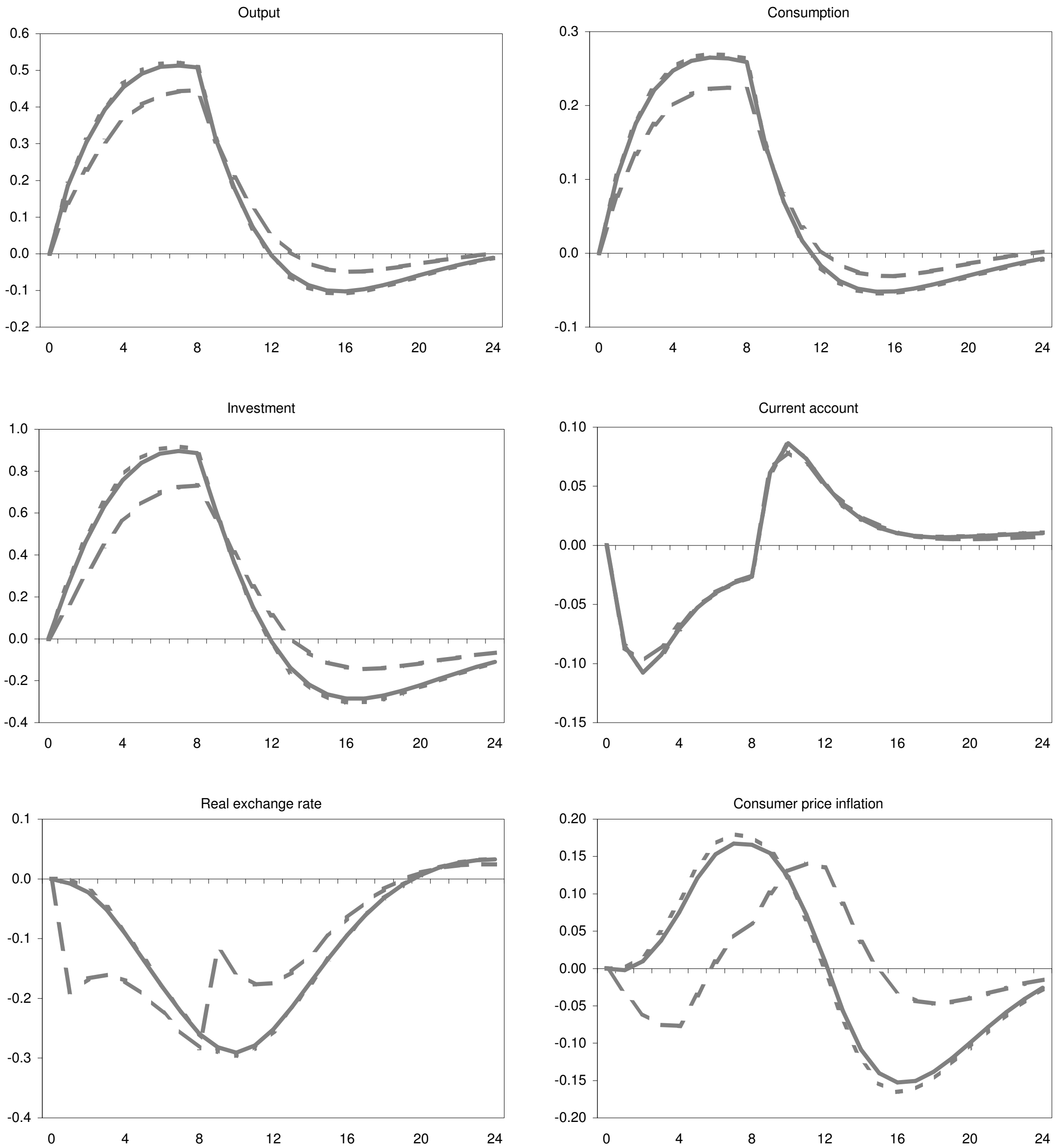

Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), the dashed lines show the flexible exchange rate regime, while the dotted lines correspond to the peg vis-a-vis the euro. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 10. Dynamic responses to a gradual shift in exports demand: different regimes



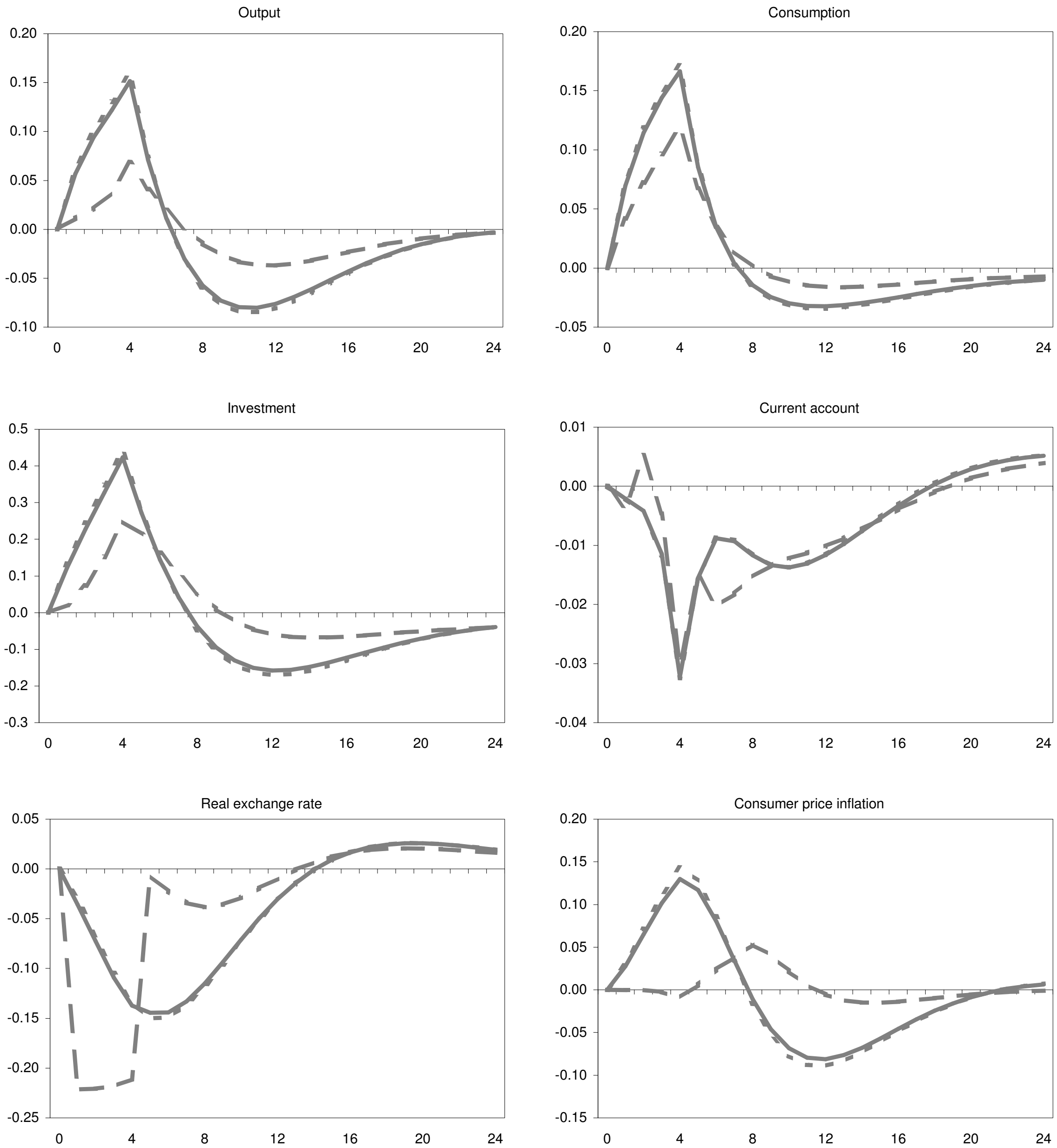

Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), the dashed lines show the flexible exchange rate regime, while the dotted lines correspond to the peg vis-a-vis the euro. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 11. Transitory (but perceived as permanent) productivity shock in the tradable sector: different regimes




Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), the dashed lines show the flexible exchange rate regime, while the dotted lines correspond to the peg vis-a-vis the euro. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

Figure 12. Expected (but failing to materialize) productivity shock in the tradable sector: different regimes




Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), the dashed lines show the flexible exchange rate regime, while the dotted lines correspond to the peg vis-a-vis the euro. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point deviations from their initial steady-state levels. All remaining variables are reported as percentage deviations.

# Appendix

In this section we present the structure of the final goods baskets in the EAGLE model and explain how we implement our foreign tastes shift described in section 4.2. We refer the reader to the original documentation of EAGLE (Gomes et al., 2008a) or a multi-country version of the NAWM (Jacquinot and Straub, 2008) for more details.

The final consumption ($C$) or investment ($I$) good of country $l$ is defined by the following CES aggregator:

$$Q_t^{i,l} = \left( \left(\upsilon^{i,l}\right)^{\frac{1}{\mu^{i,l}}} \left(TT_t^{i,l}\right)^{\frac{\mu^{i,l}-1}{\mu^{i,l}}} + \left(1-\upsilon^{i,l}\right)^{\frac{1}{\mu^{i,l}}} \left(NT_t^{i,l}\right)^{\frac{\mu^{i,l}-1}{\mu^{i,l}}} \right)^{\frac{\mu^{i,l}}{\mu^{i,l}-1}} \tag{A.1}$$

where, $i = \{C, I\}$, $TT_t^{i,l}$ and $NT_t^{i,l}$ denote tradable and nontradable components of the final good $Q_t^{i,l}$, $\mu^{i,l}$ is the intertemporal elasticity of substitution between these two components and $\upsilon^{i,l}$ denotes the quasi-share of tradable goods.

The tradable basket is in turn an aggregate of home-made tradable goods $HT_t^{i,l}$ and imports $IM_t^{i,l}$, according to the formula:

$$TT_t^{i,l} = \left( \left(\upsilon_T^{i,l}\right)^{\frac{1}{\mu_T^i}} \left(HT_t^{i,l}\right)^{\frac{\mu_T^i-1}{\mu_T^i}} + \left(1-\upsilon_T^{i,l}\right)^{\frac{1}{\mu_T^i}} \left(IM_t^{i,l}\right)^{\frac{\mu_T^i-1}{\mu_T^i}} \right)^{\frac{\mu_T^i}{\mu_T^i-1}} \tag{A.2}$$

where $\mu_T^{i,l}$ is the intertemporal elasticity of substitution between domestic and imported components and $\upsilon_T^{i,l}$ denotes the quasi-share of the former (and so can be interpreted as a home bias in production of the tradable basket $TT_t^{i,l}$).

Finally, the bundle of imported goods is defined as:

$$IM_t^{i,l} = \left( \sum_{j \neq l} \left(\upsilon_{M,j}^{i,l}\right)^{\frac{1}{\mu_M^{i,l}}} \left( \left(1-\Gamma_{M,j,t}^{i,l}\right) IM_{j,t}^{i,l} \right)^{\frac{\mu_M^{i,l}-1}{\mu_M^{i,l}}} \right)^{\frac{\mu_M^{i,l}}{\mu_M^{i,l}-1}} \tag{A.3}$$

where, $j$ indexes country $l$ trading partners, $\mu_M^{i,l}$ is the intertemporal elasticity of substitution between imports from different countries, $\upsilon_{M,j}^{i,l}$ denotes the quasi-share of country $j$ in country $l$ imports of type $i$ and $\Gamma_{M,j,t}^{i,l}$ is an import adjustment cost function (equal to zero in steady-state).

The quasi-share of country $j$ imports in the final good of type $i$ consumed or invested in country $l$ is then a product of $\upsilon^{i,l}$, $\left(1-\upsilon_T^{i,l}\right)$ and $\upsilon_{M,j}^{i,l}$. While implementing our scenario described in section 4.2, we increase this product by 50% whenever $j$ corresponds to Spain and keep it constant otherwise. This implies an appropriate change not only in relevant $\upsilon_{M,j}^{i,l}$'s but also in $\upsilon_T^{i,l}$'s for all Spain's trading partners. The resulting quasi-share parameters, together with their initial values, are reported in Table A.

For all parameters, the transition between the initial and target values of quasi-shares follows equation (1), with a common $\alpha$ equal to 0.02.

Table A. Calibration of quasi-shares parameters underlying the foreign tastes shift scenario

| | baseline | terminal | difference |
|---|---|---|---|
| $\upsilon_T^{C,REA}$ | 0.587 | 0.560 | -0.027 |
| $\upsilon_T^{C,US}$ | 0.795 | 0.794 | -0.001 |
| $\upsilon_T^{C,RW}$ | 0.685 | 0.678 | -0.007 |
| $\upsilon_{M,ES}^{C,REA}$ | 0.129 | 0.182 | 0.053 |
| $\upsilon_{M,US}^{C,REA}$ | 0.053 | 0.050 | -0.003 |
| $\upsilon_{M,RW}^{C,REA}$ | 0.818 | 0.768 | -0.050 |
| $\upsilon_{M,ES}^{C,US}$ | 0.007 | 0.010 | 0.003 |
| $\upsilon_{M,REA}^{C,US}$ | 0.146 | 0.145 | 0.000 |
| $\upsilon_{M,RW}^{C,US}$ | 0.848 | 0.845 | -0.003 |
| $\upsilon_{M,ES}^{C,RW}$ | 0.046 | 0.067 | 0.021 |
| $\upsilon_{M,REA}^{C,RW}$ | 0.519 | 0.507 | -0.012 |
| $\upsilon_{M,US}^{C,RW}$ | 0.436 | 0.426 | -0.010 |
| $\upsilon_T^{I,REA}$ | 0.640 | 0.631 | -0.010 |
| $\upsilon_T^{I,US}$ | 0.743 | 0.742 | -0.001 |
| $\upsilon_T^{I,RW}$ | 0.591 | 0.588 | -0.004 |
| $\upsilon_{M,ES}^{I,REA}$ | 0.053 | 0.077 | 0.024 |
| $\upsilon_{M,US}^{I,REA}$ | 0.151 | 0.147 | -0.004 |
| $\upsilon_{M,RW}^{I,REA}$ | 0.796 | 0.776 | -0.021 |
| $\upsilon_{M,ES}^{I,US}$ | 0.006 | 0.009 | 0.003 |
| $\upsilon_{M,REA}^{I,US}$ | 0.171 | 0.170 | -0.001 |
| $\upsilon_{M,RW}^{I,US}$ | 0.823 | 0.821 | -0.003 |
| $\upsilon_{M,ES}^{I,RW}$ | 0.018 | 0.027 | 0.009 |
| $\upsilon_{M,REA}^{I,RW}$ | 0.372 | 0.369 | -0.003 |
| $\upsilon_{M,US}^{I,RW}$ | 0.609 | 0.604 | -0.006 |