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by Marcin Kolasa

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Abstract

This paper uses the EAGLE, a multi-country dynamic general equilibrium model, to illustrate dynamic adjustments in a small open economy undergoing real convergence. We consider the effects of productivity catch-up and misperceptions about future productivity developments. Our 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 overly optimistic expectations about productivity shifts can generate sizable boom-bust cycles and so be 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, while the opposite usually holds true for scenarios based on nontradable sector developments.

Keywords: Real convergence; Boom-bust cycles; Dynamic general equilibrium models.
JEL Classification: D58; E32; F41.

Non-technical summary

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

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., 2010), to analyze possible dynamic adjustments in a relatively small open economy undergoing real convergence processes. We focus our calibration around the Spanish economy. Using the four-country setup of EAGLE, we link it not only to the rest of the euro area, but also to the US and the rest of the world. The choice of Spain is motivated by the fact that this country's productivity relatively to the rest of the euro area has been far from stable over the last decades, with rapid catching-up in the 1970s and most of 1980s followed by years of marked divergence. At the same time, it has to be stressed that singling out Spain serves only illustrative purposes and our main goal is certainly not to describe actual past developments in this country. Instead, the analysis offered in this paper is aimed to be more general, relevant for any small (current or prospective) member of a monetary union, and the euro area in particular.

Apart from highlighting the real convergence mechanics in a fully-fledged multi-country dynamic general equilibrium 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. Several papers have incorporated confusion about the nature (e.g. persistence) of productivity shocks into micro-founded macroeconomic models (Schmitt-Grohe and Uribe, 2008; Fujiwara et al., 2008; Christiano et al., 2008). However, these studies are based on closed-economy setups, so they neglect channels arising from international linkages, which may be particularly important for relatively open current and prospective euro area members. 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 the dynamic responses to all these scenarios are shaped by a monetary policy regime. More specifically, we compare our baseline results to a fully floating exchange rate regime. 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 their contribution are short-run adjustments to a relatively standard set of transitory shocks rather than to long-run processes or misperceptions discussed in this paper.

Our main 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. It follows that they can be easily misinterpreted as manifestations of growing imbalances requiring policy intervention, while, at least from the model perspective, 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 relevant in accounting for cyclical deviations from a sustainable real convergence path. A comparison across alternative monetary regimes reveals that a flexible exchange rate helps to smooth real convergence processes and misperceptions associated with tradable sector productivity. This effect is particularly strong for inflation, non-negligible but substantially weaker for output, consumption and investment, while the current account position is hardly affected. In contrast, the free float usually generates more volatility in scenarios based on nontradable sector productivity developments.

1 Introduction

The world history is full of episodes of long- and medium-term shifts in countries' income per capita positions. This is also true for a relatively homogeneous and developed club of EU economies. Even within the euro area, as suggested by substantial diversity in past growth performance and still persisting differences in per capita output across its member states, the currently observed and possible future macroeconomic 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 designed to analyze only the 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 the selected long-run characteristics of the 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 at 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., 2010), to analyze possible dynamic adjustments in a relatively small open economy undergoing real convergence processes. We focus our calibration around the Spanish economy. Using the four-country setup of EAGLE, we link it not only to the rest of the euro area, but also to the US and the rest of the world. It has to be stressed that singling out Spain serves only illustrative purposes and our main goal is certainly not to describe actual past developments in this country. Instead, the analysis offered in this paper is aimed to be more general, relevant for any small (current or prospective) member of a monetary union, and the euro area in particular.

We define real convergence as productivity catch-up. While there is probably no need to argue that this kind of long- and medium-term processes is highly relevant for a number of small economies, including current and definitely 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, Spain's productivity relative to the rest of the euro area has been far from stable over the last thirty-five years. Two distinct periods stand out. During the first one, spanning over the 1970s and most of the 1980s, rapid and sustained catching-up brought the 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 the previously accumulated gains have been reversed. Interestingly, fluctuations in the productivity gap calculated for the nontradable industries contributed substantially less to the medium and long-term shifts in Spain's position relative to the rest of the euro area.

This simple illustration clearly suggests that long- and medium-term processes can play an important

[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.

role in accounting for asymmetric developments within the common currency area. Therefore, examining how a catching-up (or falling behind) economy might respond to such scenarios seems to be highly relevant for understanding the nature and sustainability of the observed divergences within the euro area.[2] Needless to say, this kind of developments will become even more relevant with the euro being adopted by the relatively poor EU member states from the ex-communist block.

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. (2008) 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 are particularly important for relatively open current and prospective euro area members. Also, the 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 the dynamic responses to all these scenarios are shaped by a monetary policy regime. More specifically, we compare our baseline results to a fully floating exchange rate regime. 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 their contribution are short-run adjustments to a relatively standard set of transitory shocks rather than to long-run processes or misperceptions discussed in this paper.

Our main 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. It follows that they can be easily misinterpreted as manifestations of growing imbalances requiring policy intervention, while, at least from the model perspective, 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 relevant in accounting for cyclical deviations from a sustainable real convergence path. A comparison across alternative monetary regimes reveals that a flexible exchange rate helps to smooth real convergence processes and misperceptions associated with tradable sector productivity. This effect is particularly strong for inflation, non-negligible but

[2]Clearly, productivity developments are not the only plausible sources of real convergence or divergence within the euro area. For instance, Gomes et al. (2008) 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 of interdependencies is however beyond the scope of this study.

substantially weaker for output, consumption and investment, while the current account position is hardly affected. In contrast, the free float usually generates more volatility in scenarios based on nontradable sector productivity developments.

The rest of this paper 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 in each of our scenarios. Section seven concludes.

2 Bird's-eye view at EAGLE

The 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.[3] Below, we provide only a brief overview of the main features of EAGLE, referring the reader to the source documents for details.

Except for the monetary policy regimes and some parameter values, each region covered in EAGLE is modelled in a symmetric fashion. The 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 other households 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 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 the 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 nontradables with a bundle of home-made tradables 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 goods and makes transfer payments to households. Transfers and lump-sum taxes are not evenly distributed across the two types

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

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 a 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, allowing for some interest rate smoothing.

3 Parameterization and calibration

We make one departure from the original EAGLE specification described in Gomes et al. (2010). 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 specify these costs in the form of an increase in capital depreciation. Using this apparently innocuous respecification of the model, we can allow for some (though limited if compared to the parameterization of the NAWM) variation in capacity utilization and still obtain a realistic short-run response of investment to productivity shocks.[4]

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 its 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 standard stages. First, we pin down a subset of parameters governing some key steady-state ratios, using their approximate empirical counterparts.[5] 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 the NAWM or the 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 of 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

[4] 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.

[5] 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.

shares of private consumption, public consumption and gross capital formation. The data used are the long-run averages and come 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. 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 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.[6]

The quasi-share[7] 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 using the EU-KLEMS database.

3.2 Other parameters

While parameterizing 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.

The 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 product markets.

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

[6] 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.

[7] Whenever we talk about quasi-shares, we mean the share parameters in the constant elasticity of substitution (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.

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 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 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

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 the 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 convergence 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, 2010).

More specifically, we consider a scenario in which a small member of a currency union embarks on the following productivity catching-up path:

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

where $A_{T,t}$ and $A^*_{T,t}$ are the tradable sector total factor productivity (TFP) levels in the converging economy and the (more developed) rest of the monetary union, respectively, and α is the parameter controlling the speed of convergence. Equation (1) can be seen as the law of motion for the productivity gap, defined as the percentage difference between the current and target TFP, with the latter assumed equal to that prevailing in more advanced economies. 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 our workhorse model to vary along and in line with the productivity convergence path. Given the structure of EAGLE, 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 the current and target TFP in the tradable sector to 11%, which is roughly consistent with Spain's labour productivity gap vis-a-vis the rest of the euro area of 17% observed in 2005 (see Figure 1).[8] 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.[9] 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,[10] 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, the 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 the domestically consumed tradable basket. In line

[8] 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.

[9] By construction, the long-run effects of all our convergence scenarios are identical across the anticipated and unanticipated variants.

[10] We discuss the consequences of relaxing this assumption in section 4.2.

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 decrease in total hours worked.[12] Given the low size of the converging economy, international spillovers related to this scenario are very limited. Output in the rest of the euro area basically does not move, 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 the main macrovariables are plotted in Figure 2. 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 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 has been completed. Since a mounting foreign debt needs to be serviced, deterioration in 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 the first years after the shock push inflation up. Since our economy is only a small part of the monetary union, nominal interest rates remain virtually unchanged and the rise in inflation is quite substantial. Its deviation from the area-wide 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 common currency 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 at 4%, which corresponds to a half of Spain's 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 is set to 0.05.

The long-run effects are presented in the second column of Table 10. They confirm the previous

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

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

observation that a sector specific productivity shock affects output in both sectors in the same direction. 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 the tradable sector productivity scenario 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 of the 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 in the nontradable goods sector are illustrated in Figure 3. 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 more than 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. Indeed, as can be seen from the 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 very different to the anticipated case.

4.2 Real convergence and shifts in international investment positions

Our 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.[15] A non-zero steady-state net

[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.

[15] 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

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 the 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 exogenous productivity driving the relevant 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.

This intuition is confirmed by our simulations.[16] 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 the tradable sector productivity convergence scenario. It has to be noted, however, that the differences are rather moderate, not exceeding 0.1 pp. for output. As regards the dynamic responses, the long-run reduction in wealth effects turns out to be more than offset in the short-run by a decrease in the costs of financing the current account deficit. As a result, consumption and investment (and, though to a lesser degree, output) go up by more than in the 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 short-run (i.e. one-year after) response of consumption is now larger by 0.4 pp., while that of investment by 1.1 pp.

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 depreciation. Given the assumption underlying the simulations presented in this section, as nominal GDP per hours worked remains unchanged, so does the target net foreign assets position.

5 Misperceptions along the convergence path

We have seen in the previous section that even smooth processes, like gradual productivity catching-up, do not necessarily result in smooth dynamic responses of the main macrovariables. Therefore, without knowing the underlying forces, such developments could be easily misinterpreted as manifestations of growing imbalances, requiring policy intervention to avoid huge boom-bust swings, while in fact they are just optimal (at least from the model perspective) responses of the private sector, given the monetary and fiscal policy feedback rules.[17]

is well known, there are various 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, this additional variant can be viewed as just a sensitivity check for one of the simplifying assumptions underlying the scenarios presented before.

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

[17] 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) was tailored to the specific convergence scenario. This kind of considerations is left for future research.

On the other hand, real convergence processes are obviously far more complicated than suggested by the stylized scenarios set up above. In particular, their driving forces are to a large extent neither smooth nor deterministic. 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 generate sizable boom-bust cycles.

We consider two misperceptions scenarios. The first is based on confusing a temporary productivity shift with a permanent one. The second scenario concerns 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 scenario is illustrated in Figure 4 (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.

Figure 5 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 pressures translate into higher inflation and the exchange rate appreciates. Once the expectations turn 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

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 a converging economy as a part of a common currency area. In this section we show how the responses to our stylized scenarios change if we consider an alternative regime, in which our catching-up economy follows a fully independent monetary policy, with a freely floating exchange rate. The parameterization of the interest rate feedback rule is the same as for the other three regions of the world economy.

In this alternative variant, 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 caveat in mind.

The dynamic responses of a set of key macrovariables to the five scenarios considered in section four and five are plotted in figures 6 to 9, which correspond to figures 2 to 5 described before.[18] The solid lines replicate the monetary union case (our baseline), while the dashed lines illustrate the dynamic responses under a flexible exchange rate regime.

We start from our two real convergence scenarios, focusing first on their baseline (anticipated) variants. In the tradable sector productivity catching-up scenario, if the exchange rate is allowed to float, it appreciates significantly on impact. The dynamic responses of output, consumption and investment are smoother than it was the case in the monetary union setup. The initial deterioration in the current account balance is also slightly more moderate, but then hardly distinguishable from the union case. Most importantly, a relatively sharp appreciation of the nominal exchange rate virtually 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.[19]

To a large extent, an opposite picture emerges in the case of productivity catch-up in the nontradable 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.

The unanticipated variants of the two real convergence scenarios lead to qualitatively similar conclusions about the role of the monetary regime. The dynamic responses to the tradable sector productivity catching-up and the foreign demand shift are smoother if the exchange rate is allowed to float, while the opposite holds true for the catching-up scenario in the nontradable sector.

Turning to the misperceptions about tradable sector productivity, one can note that a flexible ex-

[18] Changing a monetary regime has no impact on the model's steady-state equilibrium.

[19] 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.

change rate tends to somewhat mitigate the boom-bust pattern in the response of output and private 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 under a free float than in the common currency case.

7 Conclusion

In this paper we have used EAGLE, a multi-country DSGE model recently developed for the ESCB, to analyze dynamic adjustments in a relatively small economy undergoing real convergence processes within a monetary union. We considered a set of scenarios related to productivity catch-up and misperceptions about productivity developments.

Our 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. Moreover, misperceptions about productivity shifts can be an important source of cyclical deviations from a sustainable real convergence path. We find that if these processes are related to tradable sector developments or shifts in foreign preferences, keeping the monetary autonomy helps to reduce the volatility of key macrovariables, especially of inflation, but also (though to lesser extent) of output, consumption and investment. In contrast, being a part of a monetary union seems to smooth developments originating from the nontradable sector.

As we have stressed, even though our quantitative results rely on a model that is calibrated with a focus on the Spanish economy, our findings are aimed 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 some of them have been experiencing significant boom-bust cycles. These countries are also expected to join the euro area, and this will probably happen long before real convergence processes become relatively less relevant for the 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 sticking to their current currencies.

One can think about a number of potentially attractive avenues for further research on topics discussed in this paper. First and foremost, one has to bear in mind that our analysis is based on a calibrated model. Given the large size of EAGLE and short time series available for countries where real convergence processes are particularly relevant, having an estimated version of this model will not be feasible in the near future. Therefore, 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

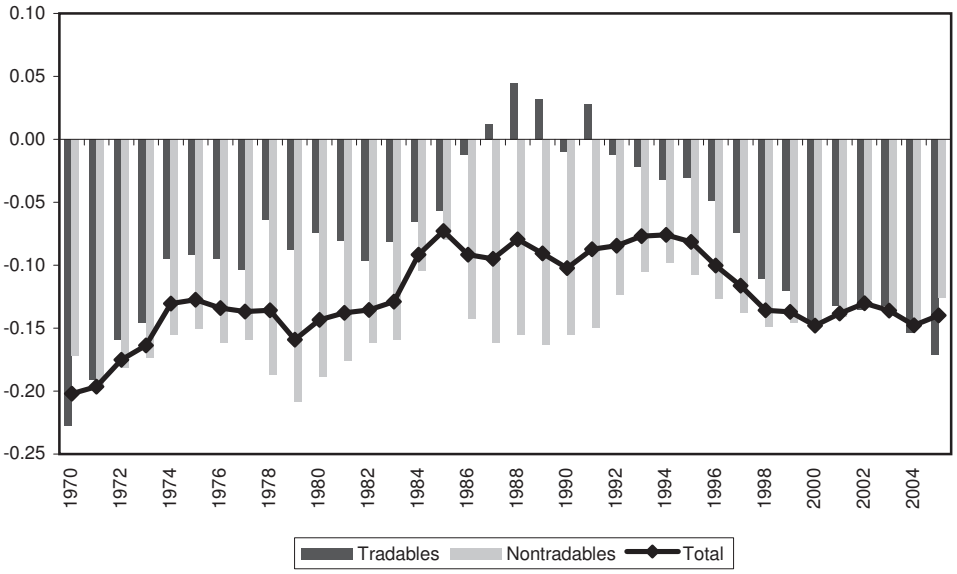
	Spain	REA	USA	RW
Capacity utilization cost (second derivative)	0.05	0.05	0.05	0.05
Investment adjustment cost (second derivative)	3.0	3.0	3.0	3.0
Import adjustment cost for consumption goods (second derivative)	5.0	5.0	5.0	5.0
Import adjustment cost for investment goods (second derivative)	2.0	2.0	2.0	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
Output	5.6	3.0
Tradable	11.2	1.5
Nontradable	2.5	3.8
Consumption	3.6	3.1
Investment	6.5	1.8
Exports	8.2	1.2
Imports	1.9	0.3
Terms of trade	6.2	0.9
Real exchange rate	-3.6	3.9
Internal exchange rate	8.3	-4.7
Hours worked	-1.2	-1.0
Real wage rate	4.9	4.1
REA Output	0.0	0.0
REA Consumption	0.1	0.0

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

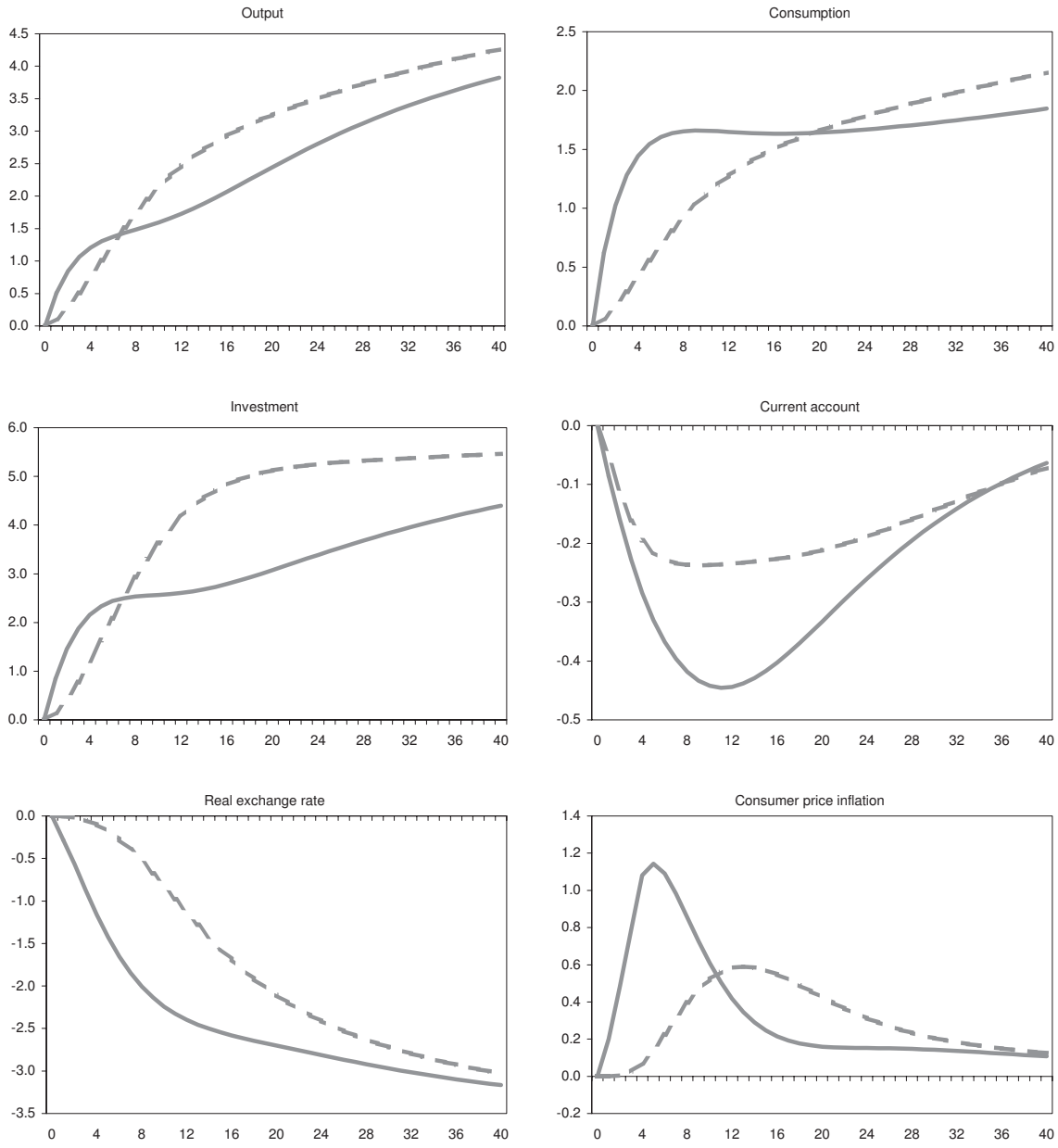
Figure 1. Productivity gap in Spain vis-á-vis the euro area



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).

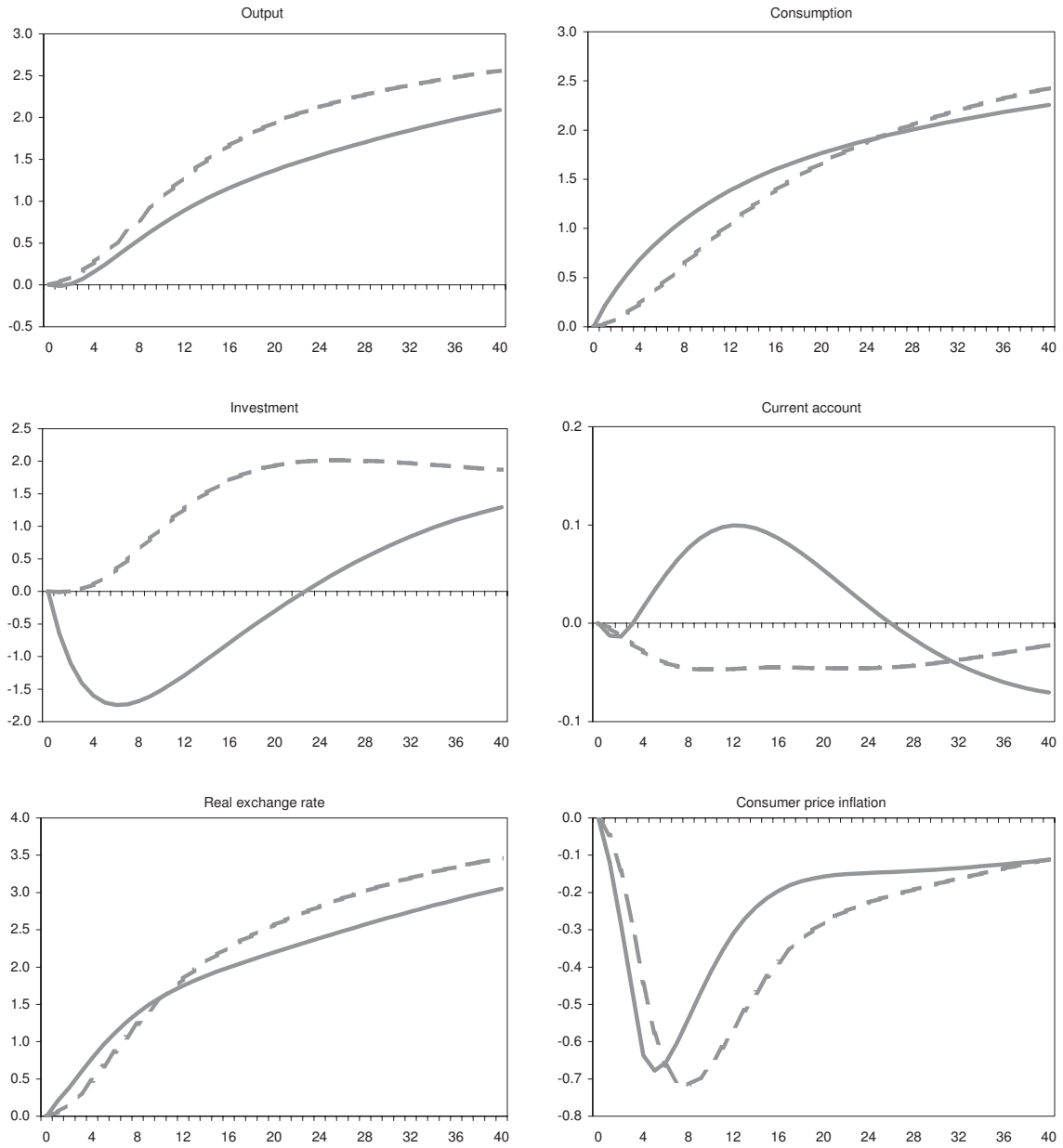
Source: Own calculations based on data from EU-KLEMS.

Figure 2. Dynamic responses to productivity convergence in the tradable sector



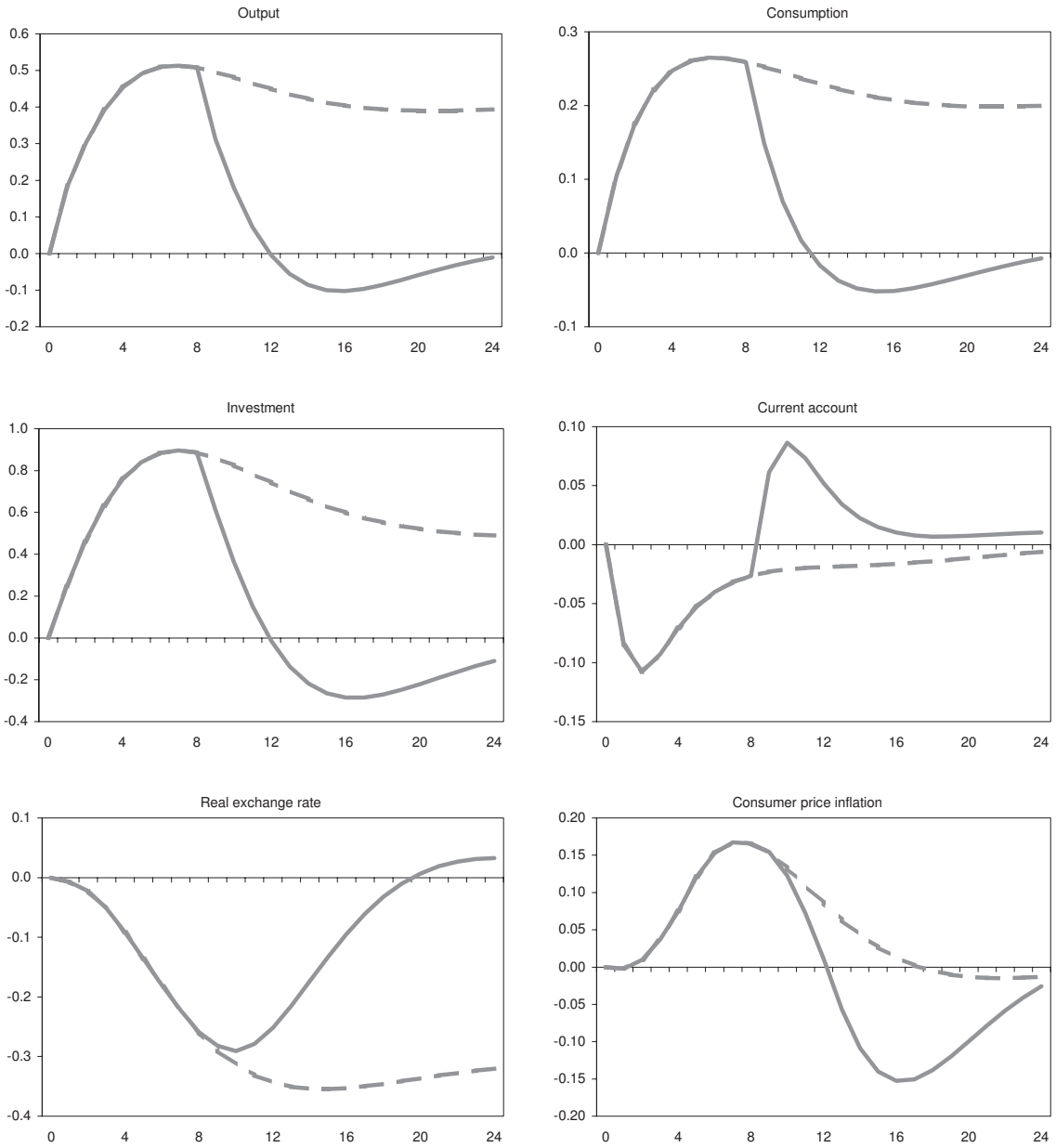
Notes: The solid (dashed) lines present the dynamic response to the fully anticipated (unanticipated) real convergence scenario. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point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

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



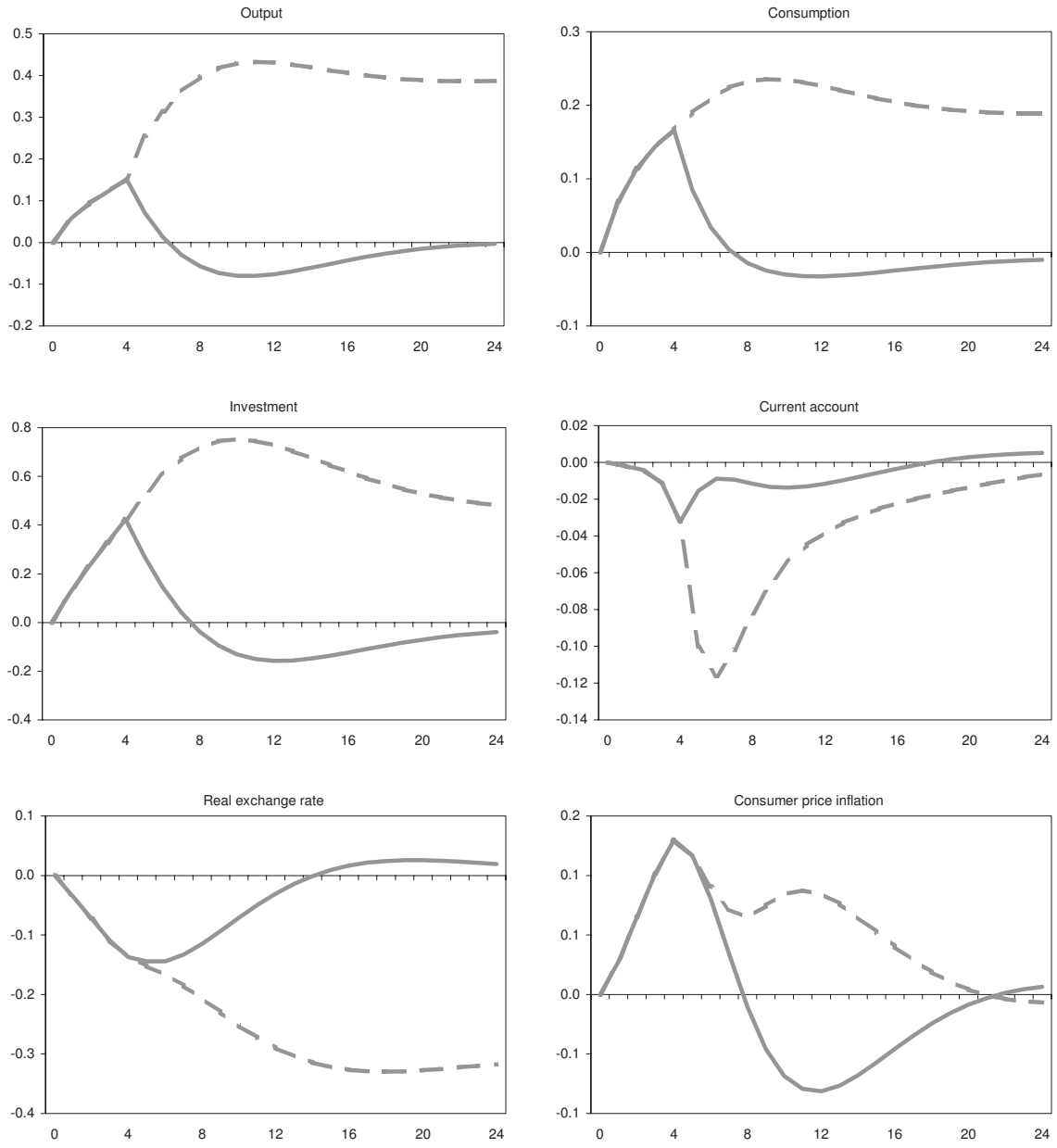
Notes: The solid (dashed) lines present the dynamic response to the fully anticipated (unanticipated) real convergence scenario. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate, reported as percentage point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

Figure 4. Transitory (but perceived as permanent) productivity shock in the tradable sector



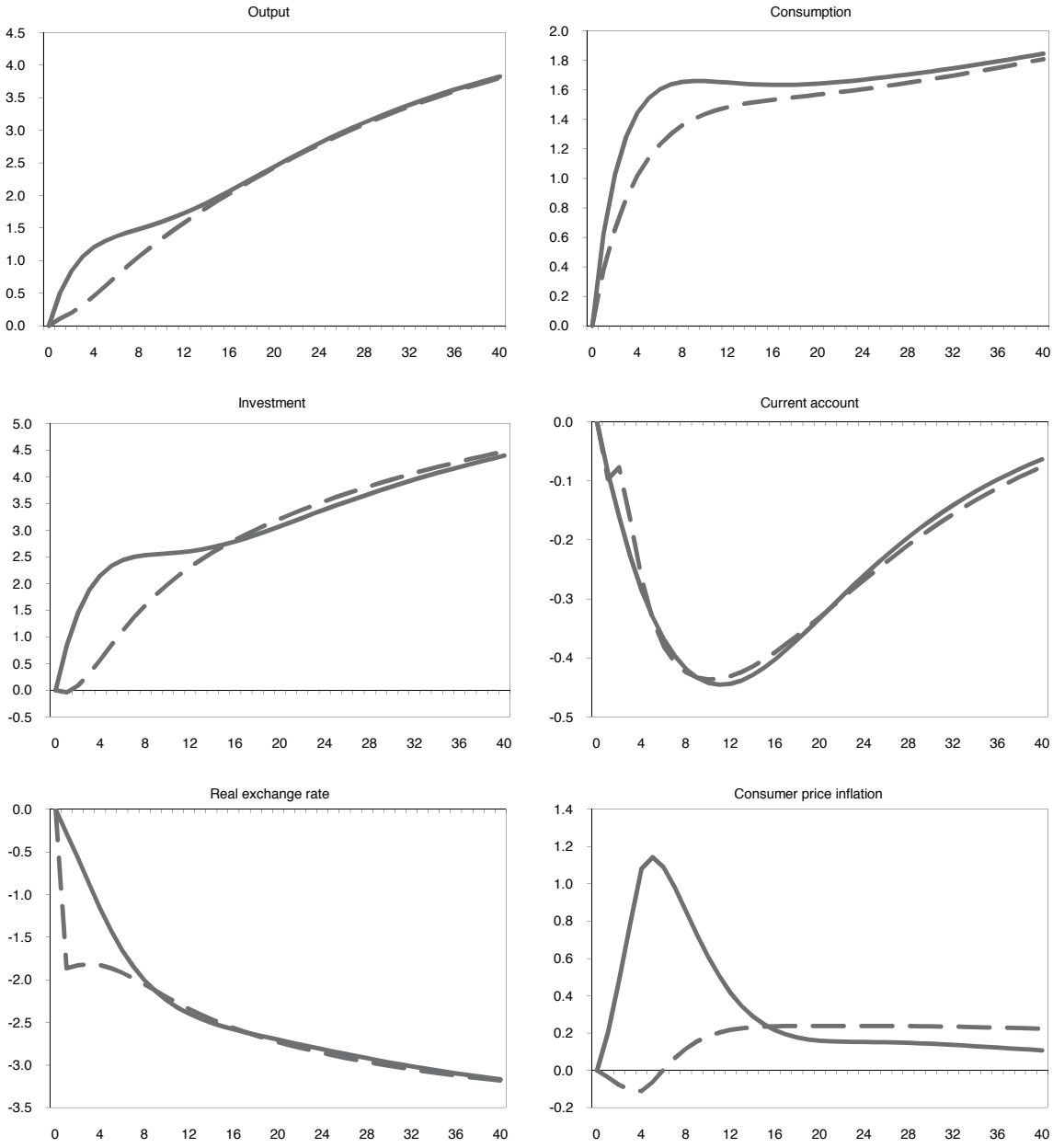
Notes: The solid lines present the dynamic response to the misperception scenario (i.e. confusing a transitory shock with a permanent one), while the dashed lines show how the economy would evolve if the shock was indeed permanent. The current account balance is expressed relative to nominal GDP and, 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 5. Expected (but failing to materialize) productivity shock in the tradable sector



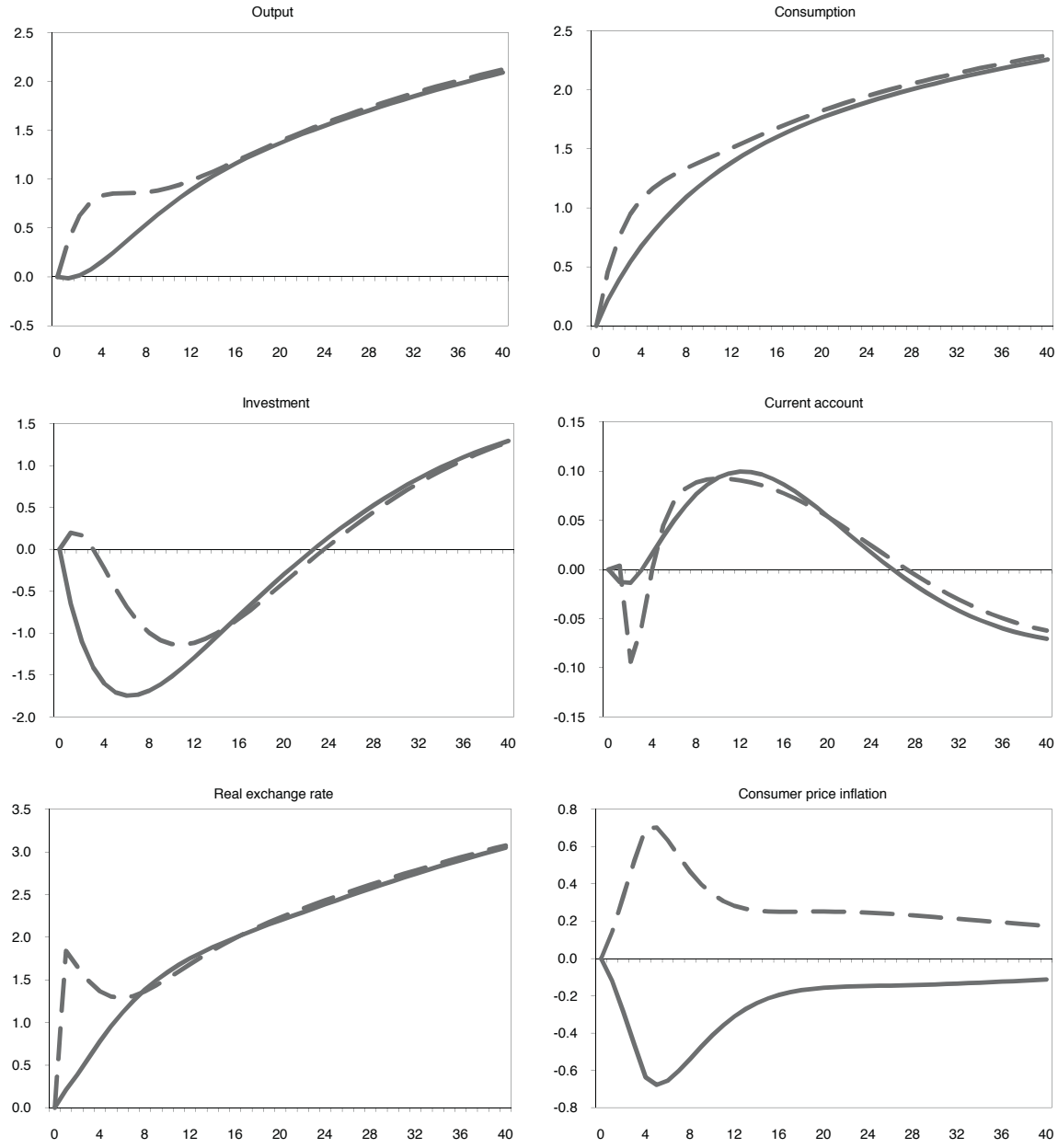
Notes: The solid lines present the dynamic response to the false news scenario, while the dashed lines show how the economy would evolve if the news was true. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term interest rate,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

Figure 6. Dynamic responses to productivity convergence in the tradable sector: different regimes



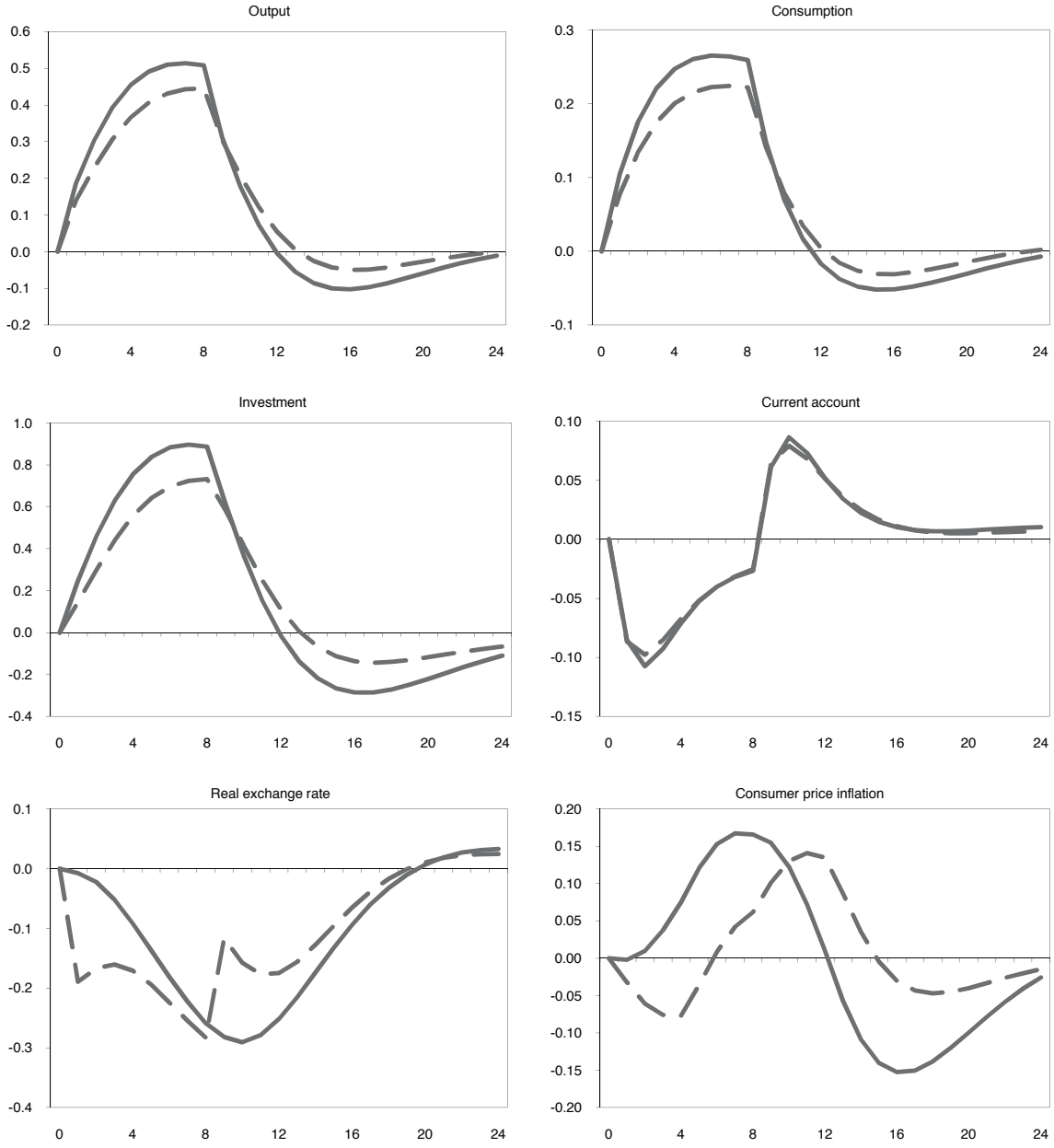
Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), while the dashed lines show the flexible exchange rate regime. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term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

Figure 7. Dynamic responses to productivity convergence in the nontradable sector: different regimes



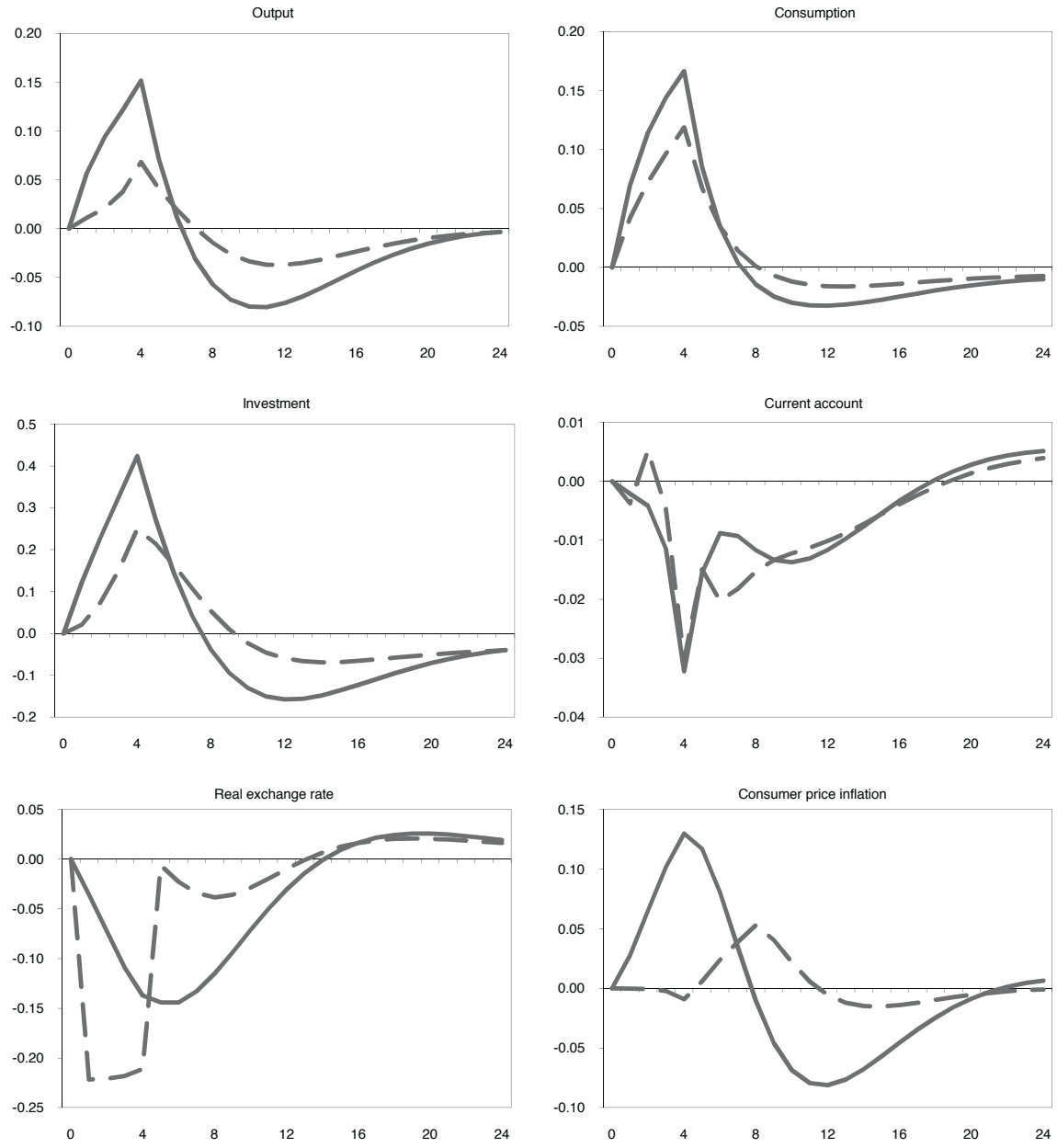
Notes: The solid lines illustrate the dynamic responses under the monetary union (our baseline specification), while the dashed lines show the flexible exchange rate regime. The current account balance is expressed relative to nominal GDP and, together with consumer price inflation and the short-term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

Figure 8. 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), while the dashed lines show the flexible exchange rate regime. 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. 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), while the dashed lines show the flexible exchange rate regime. 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.