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What drives the German current account?

And how does it affect other EU member states? (*)

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Abstract

We estimate a three-country model using 1995-2013 data for Germany, the Rest of the Euro Area (REA) and the Rest of the World (ROW) to analyze the determinants of Germany's current account surplus after the launch of the Euro. The most important factors driving the German surplus were positive shocks to the German saving rate and to ROW demand for German exports, as well as German labour market reforms and other positive German aggregate supply shocks. The convergence of REA interest rates to German rates due to the creation of the Euro only had a modest effect on the German current account and on German real activity. The key shocks that drove the rise in the German current account tended to worsen the REA trade balance, but had a weak effect on REA real activity. Our analysis suggests these driving factors are likely to be slowly eroded, leading to a very gradual reduction of the German current account surplus. An expansion in German government consumption and investment would raise German GDP and reduce the current account surplus, but the effects on the surplus are likely to be weak.

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1. Introduction

Germany experienced a spectacular current account (CA) reversal, after the launch of the Euro (1999). In the 1990s, the German current account was in deficit, but close to balance—however, in the early 2000s, the current account shifted to steadily increasing surpluses, vis-à-vis both the rest of the Euro Area (REA) and the rest of the world (ROW).[1] During the financial crisis, German capital flows to the REA fell abruptly, but the overall German current account surplus bounced back rapidly and reached record levels--185 bill. EUR in 2012, i.e. 7% of German GDP--due inter alia to a rise in the surplus vis-à-vis Asia. As a result, Germany has become one of the major surplus countries in the world.

These developments are currently at the heart of heated debates about the role of the German surplus and of intra-Euro Area external imbalances for the crisis and the slow recovery in Europe (see Lane (2012), Chen, Milesi-Ferretti and Tressel (2012) and Hobza and Zeugner (2013) for discussions of intra-EA imbalances). On October 30, 2013, the U.S. Treasury sharply criticized Germany's external surplus: 'Germany's anemic pace of domestic demand growth and dependence on exports have hampered rebalancing at a time when many other euro-area countries have been under severe pressure to curb demand and compress imports in order to promote adjustment. The net result has been a deflationary bias for the euro area, as well as for the world economy' (U.S. Treasury (2013), p.3). In the Treasury's view: 'To ease the adjustment process within the euro area, countries with large and persistent surpluses need to take action to boost domestic demand growth and shrink their surpluses' (p.25). The German Government swiftly rejected the US criticism. The German Economics Ministry stated that 'The Trade surpluses reflect the strong competitiveness of the German economy and the international demand for quality products from Germany' (Wall Street Journal, October 31, 2013); the German Finance Ministry argued that the German current account surplus was 'no cause for concern, neither for Germany, nor for the Eurozone, or the global economy,' and that 'On the contrary, the innovative German economy contributes significantly to global growth through exports and the import of components for finished products' (Financial Times, October 31, 2013).

The IMF has likewise repeatedly expressed concerns about the German external surplus, and argued that 'stronger and more balanced growth in Germany is critical to a lasting recovery in the euro area and global rebalancing' (IMF Executive Board, August 6, 2013a). By contrast to the U.S. Treasury, the IMF's policy advice centers on structural reforms in the German economy, such as measures to increase the productivity of the service sector and labour force participation. The European Commission too advocates supply side policies for Germany that 'strengthen domestic sources of potential growth against the background of unfavourable demographic prospects' (European Commission, Alert Mechanism Report 2014, November 2013). In November 2013, the persistent German current account surplus triggered an 'In-Depth Review' by the EU Commission, under the Commission's 'Macroeconomic Imbalances Procedure'. The result of the review were published in March 2014 and concluded that the German surplus constitutes an 'imbalance' (see Box on the Macroeconomic Imbalances Procedure below).[2]

The goal of this paper is to shed light on these policy issues, using a state-of-the-art macroeconomic model. Economic theory suggests that a country's current account reflects domestic and foreign macroeconomic and financial shocks, and the structural features of the domestic and foreign economies. An understanding of those shocks and structural properties

[1] Throughout this paper, the term 'Euro Area' (EA) refers to the 17 countries that were members of the Euro Area in 2013. REA is an aggregate of the EA less Germany.

[2] The German external surplus has also widely been discussed in the media. Prominent critics of the surplus include Krugman (2013) and Wolf (2013).

is thus crucial for positive and normative evaluations of the current account, and for policy advice (Obstfeld and Rogoff (1996), Obstfeld (2012), Kollmann (1998, 2001, 2004)). This underscores the importance of analyzing the current account using a structural model that captures the relevant shocks, and their transmission to the macroeconomy.

This paper therefore studies the German current account using an *estimated* Dynamic Stochastic General Equilibrium (DSGE) model with three countries: Germany, the REA and the ROW. The model is estimated using quarterly data for the period 1995q1-2013q2. The model assumes a rich set of demand and supply shocks in goods, labour and asset markets, and it allows for nominal and real rigidities, and financial frictions. [3]

Several hypotheses about the causes of Germany's external surplus have been debated in the policy and academic literature. Those causes have mostly been discussed separately, although in reality these drivers can operate jointly. Our estimated model allows us to recover the shocks that drive the German external balance—and, hence, we can determine what shocks mattered most, and when. The model also allows us to assess what policy measures might best be suited for changing the German external surplus.

We devote particular attention to the following potential causes of the German external surplus: (i) In the run-up to the Euro (1995-1998), REA interest rates converged to German rates, an indication that the Euro led to greater financial integration in Europe; it has frequently been argued (e.g., Sinn (2010) and Hale and Obstfeld (2013)) that greater financial integration triggered capital flows from Germany to the REA. (ii) A second widely discussed factor was the strong growth in emerging economies during the past two decades--German exports may have benefited particularly from the rising demand for investment goods by emerging economies, given German's specialization in the production of those goods; strong growth in emerging economies may have also have added to *intra*-EA imbalances by increasing competition for exports from the EMU periphery (e.g., Chen et al. (2012)). (iii) The growth of outsourcing by German firms to low wage countries (notably in Eastern Europe), and the German labour market liberalization during the period 2002-2005, have often been viewed as factors that raised German labour supply, and restrained German wage growth, thereby boosting German competitiveness (e.g., Dustmann et al. (2014)). (iv) Finally, it has been argued that depressed German domestic demand (as pointed out above), and thus a high saving rate, are key drivers of the German surplus; high saving may partly reflect German households' concerns about rapid population ageing, following pension reforms (2001-2004) that markedly lowered state-funded pensions, and created tax incentives for private retirement saving (Deutsche Bundesbank (2011), Huefner and Koske (2010)). Fiscal consolidation in Germany after the financial crisis may also have contributed to weak domestic demand (Lagarde (2012), IMF (2013b), in 't Veld (2013)).

Our empirical results suggest that all of these factors played a role in driving the German external surplus, but that their quantitative importance and timing differed markedly. Mono-causal explanations of the German surplus are, thus, insufficient: the surplus reflects a *succession* of distinct shocks.

According to the estimated model, greater financial integration (narrowing of the REA-German interest rate spread) had a positive effect on aggregate demand in the REA, which boosted REA and German GDP and raised the German current account. However, quantitatively, these effects are rather modest, and they operated mainly during the late 1990s and early 2000s; thus, REA-German interest rate convergence cannot explain the persistence of the rise of the German external surplus. We find that strong ROW growth contributed positively to German and REA GDP and net export—the effect of ROW growth was stronger

[3]Earlier applications of similar models can be found in in't Veld, Raciborski, Ratto and Roeger (2011), Kollmann, Roeger and in't Veld (2013) and Kollmann, Ratto, Roeger and in't Veld (2013).

than that of interest rate convergence, and it mainly affected the German external balance between the early 2000s and the global recession. German labour market reforms had a marked effect on German GDP and the German current account, after 2007; these reforms also had a positive, but much weaker, effect on REA GDP (due to stronger German demand for REA exports), and a weak negative effect on REA net exports. According to our estimates, positive shocks to German private saving strongly depressed aggregate demand in Germany after the mid-2000s and lowered German GDP, while raising the German current account; these shocks also stimulated aggregate demand in the REA (due to a fall in interest rates).

All in all, the key shocks that drove German real activity and the German current account only had a minor effect on real activity and inflation in the REA. In other terms, real activity in the REA was largely driven by domestic factors rather than by German economic conditions. The key supply and demand shocks that kept the German surplus at a high level likewise only had a weak effect on inflation in the REA. The model also allows us to make predictions about the future path of the German external balance. The rise in the interest rate spread between the REA and Germany since the sovereign debt crisis, and pressure toward labour market reform in the REA suggest a gradual reduction of the German current account surplus. Also the effects of labour market reforms enacted in Germany during the early 2000s are likely to be gradually eroded by higher German real wage growth, signs of which are already becoming visible (e.g. the new German Federal Government elected in the Fall of 2013 plans to introduce a minimum wage law). The German fiscal stance is also likely to become less restrictive, allowing a reversal of the trend decline in public investment. And given low interest rates in Germany, residential investment is also likely to pick up.

What light do these results shed on the policy debate about the German surplus? Our findings are consistent with the view that adverse shocks to domestic demand were key drivers of the surplus, especially after the mid-2000s. Our analysis also supports the official German view that strong external demand and German competitiveness gains (wage moderation and technological improvements) were important sources of the German external surplus. However, strong external demand and German competitiveness gains explain, at most 1/3 to 1/2 of the surplus; strong external demand mattered mainly before the financial crisis, while wage restraint induced by labour market reforms contributed to the German surplus after the mid-2000s. The relative role of these factors has thus varied greatly across time. Positive shocks to the German saving rate have been especially important since the mid-2000s.

The view that German labour market reforms represented 'wage dumping' at the expense of foreign economies (e.g., Flassbeck (2012)) is not consistent with our estimation results, due to the very modest effects of the reforms on real activity in the rest of the Euro Area.

Our analysis suggests that structural reforms to raise productivity and labour supply in the rest of the Euro Area would benefit the REA economies, and also lower the German external surplus. Boosting German government consumption would only have a modest stimulative effect on German GDP, on the German current account, and on REA GDP. Increases in German government *investment* would boost German output much more, but would lead to an even more modest fall in the current account. Measures that raise German wages would lower German GDP and the German current account. Additional structural reforms to boost German aggregate supply would tend to further raise the German external surplus, in the short and medium term--which contrasts with the often-held view that such measures would *lower* the German surplus (see above).

The present paper is related to a vast empirical and theoretical literature that has studied 'sudden stops,' i.e. episodes in which large and persistent current account *deficits*

suddenly come to an end, due to a drop in foreign capital *inflows* (e.g. Milesi-Ferretti and Razin (1998), Adalet and Eichengreen (2007), Mendoza (2010), Fornaro (2013)). By contrast, the paper here analyzes a rapid and persistent current account 'surge' that follows a prolonged period of current account balance.

In terms of related academic literature, it can be noted that several papers have analyzed the dynamics of the current account using two-country DSGE models (e.g., Kollmann (1998), Erceg et al. (2006)); by contrast to the paper here, that literature has typically used calibrated (not estimated) models, and it has abstracted from housing markets and the key financial frictions considered in the present model. Jacob and Peersman (2013) study the determinants of the US current account deficit, using an estimated two-country model; that model too abstracts from housing and financial frictions. The paper here also differs from these studies, by considering a three-country set-up. A key advantage of that set-up is that a German trade surplus does not necessarily lead to a trade deficit of the same size in other EA countries (as would be the case in a standard two-country model). Empirically, the REA trade balance is not a perfect mirror image of the German TB. Also, the REA is a less important trading partner for Germany than the ROW; the share of exports to the REA in German exports fell from 46% in 1995 to 36% in 2012, while the share of the EA in German imports fell from 47% to 37%.

Section 2 describes Germany's external balance and macroeconomic conditions in Germany, the REA and the ROW, during the period 1991-2012. Section 3 provides a brief overview of our model. Section 4 presents the model estimates. Section 5 concludes.

Box on Macroeconomic Imbalances Procedure:

Drawing lessons from the financial and economic crisis, the European Commission has strengthened macroeconomic surveillance by introducing the Macroeconomic Imbalances Procedure (MIP) in 2011. The aim of the MIP is to identify potential risks to macroeconomic stability at an early stage and to ensure that Member States adopt appropriate policy responses to prevent harmful imbalances and correct those that have already built up.

EU Regulation No 1176/2011 characterizes a macroeconomic imbalance as "any trend giving rise to macroeconomic developments which are adversely affecting, or have the potential adversely to affect, the proper functioning of the economy of a Member State or of the Economic and Monetary Union, or of the Union as a whole." Excessive imbalances are defined as "severe imbalances that jeopardize or risk jeopardizing the proper functioning" of EMU.

The MIP adopts a graduated approach. The first step is a screening for potential imbalances against a scoreboard of eleven indicators, comprising the current account balance, the net international investment position, the real effective exchange rate, nominal unit labour costs, the export market share, the unemployment rate, house price developments, private sector credit, private sector debt, government debt, and financial sector liabilities. The MIP scoreboard establishes threshold values for each indicator. The result of the screening by the European Commission is published in the annual Alert Mechanism Report (AMR). The violation of one or several threshold values provides an early warning and indicates the need for further analysis by the European Commission in the form of an In-Depth Review (IDR). On the basis of the IDR, the Commission determines whether imbalances, and excessive imbalances, exist.

If the European Commission concludes that excessive imbalances exist in a Member State, it may, in a third step, recommend to the European Council that the Member State concerned draw up a corrective action plan. After adoption of the recommendation by the Council, the European Commission and the European Council monitor its implementation. Repeated failure to take action can, in a fourth step, lead to financial sanctions: the European Commission can propose to the European Council to levy a fine for not taking action. The European Council decides by reverse qualified majority vote, i.e. sanctions are approved unless overturned by a qualified majority of Member States.

The scoreboard-based AMR of November 2013 concluded that IDRs were warranted for 16 Member States, including Germany. The IDR for Germany has been motivated in particular by the breach of the current account threshold. The latter issues an alert whenever the three-year average of the current account balance as a percentage of GDP exceeds 6% or falls below -4%.

The current account indicator has upper and lower bounds because both large surpluses and large deficits can be the result of inefficiencies and adversely affect the proper functioning of monetary union. The threshold values establish tighter limits on the deficit side. This derives from the view that current account deficits pose greater risk for macroeconomic stability than current account surpluses. In particular, large and growing deficits are associated with risks of sudden stops and financial contagion (European Commission (2012b)).

The European Commission published its IDR on Germany on March 5, 2014. It concluded that Germany is experiencing macroeconomic imbalances, which require monitoring and policy action. According to the IDR, the large and persistent external surplus "stems primarily from a lack of domestic demand, which in turn poses risks to the growth potential of the German economy." (European Commission (2014), p.107). The European Commission argues it would therefore be important to identify and implement measures that help strengthen demand and the economy's growth potential. The report discusses measures to address the backlog in public investment, to further reduce disincentives to work, to improve the business environment in order to support private investment, and to ensure that the banking sector has sufficient loss absorption capacity to withstand economic and financial shocks. The IDR did not include an explicit quantitative discussion of spillovers.

The Commission will put forward country specific recommendations to deal with the imbalance by early June 2014, for consideration by the European Council.

2. Macroeconomic conditions and the German external account, 1991-2012

Germany's current account balance (CA) and trade balance (TB) in the period 1991-2012 are plotted in Figure 1.a. The dynamics of the CA is closely linked to that of the TB (i.e. to net exports). After close-to-balance positions in the 1990s, the TB and the CA have been in persistent surplus since the early 2000s. The German TB and CA surpluses peaked at about 7% of GDP in 2007, receded to about 5%-6% in the global recession of 2008-9, and reached 6%-7% of GDP in 2012; these persistent surpluses have led to a substantial positive international investment position, that amounted to 35% of German GDP in 2011 (Figure 1.b). The balance on incomes and transfers shows a persistent increase (from about -2% to +1% of GDP) starting in 2003, but the overwhelming part of the rise in the German current account since the early 2000s is linked to the rise in net exports.[4]

Saving, investment and the German external balance

The current account equals the difference between gross national saving (*S*) and gross national investment (*I*): *CA=S-I*. Figure 1.c plots German saving and investment, in % of GDP (Y). (All ratios of variables to GDP discussed in the following paragraphs are ratios of *nominal* variables.) The German investment rate (I/Y) rate had a slight downward trend in the 1990s; it fell markedly during the early 2000s, and thereafter fluctuated without trend around a mean value that was about 4 ppt (percentage points) below the mean investment rate observed in the 1990s. The German saving rate (S/Y) closely tracked I/Y until the early 2000s, but rose markedly and persistently during the 2000s (by close to 4ppt between 2000 and 2012). This divergence between saving and investment rates accounts for the sharp and persistent rise of the German current account in the early 2000s. Figure 1.d shows that the persistent rise in the German current account is accounted for by a persistent rise in the *private* sector saving-investment gap. The German fiscal surplus (government S-I) fluctuated cyclically, but was essentially trendless (as a fraction of GDP), and thus did not contribute to the persistent rise in the German current account.

Figure 1.e shows the contributions of private consumption (C) and government consumption (G), and of investment (I) to German net exports: NX=(Y-C-G)-I. The (C+G)/Y ratio has, essentially, been trend-less throughout the sample period, but exhibited some marked transient changes (see Fig. 1.f).[5] Saving, S, equals Y-C-G plus net incomes and transfers from the rest of the world. The fact that S/Y rose after 2002, while (Y-C-G)/Y has been trendless is due to the persistent rise in the balance on income and transfers.

Figure 1.g plots ratios of German exports and imports (of goods and services) to GDP. Both ratios have steadily trended upward, doubling during the past two decades. The two ratios have mostly moved in tandem—except in the period 2001-03, when the imports/GDP ratio fell, while the exports/GDP ratio continued to grow.

Figure 1.h plots German net exports to the REA, total REA net imports, overall German net exports, and Euro Area (EA) net exports (these variables are reported in % of EA GDP). German net exports are highly positively correlated with REA net imports. However, the REA trade balance is not a perfect mirror image of the German TB. E.g., the German trade balance surplus remained sizable after the financial crisis, while REA net imports fell

[4] The rise in the German net incomes and transfers balance is solely driven by the rise in net financial income that resulted from the rise in the German net international investment position. Net international transfers are very stable across time, and represent about -1.4% of German GDP throughout the sample period. The net income balance was slightly negative during the second half of the 1990s. Thereafter, net income rose steadily, due to the rise in the German net international investment positions, and reached 2.4% of German GDP in 2012. Net *financial* income accounts for the lion share of net income (net employee income is negligible).

[5] Saving, S, equals Y-C-G plus net transfers and incomes from the rest of the world. The fact that S/Y rose after 2002, while (Y-C-G)/Y has been trendless is due to the persistent rise in the balance on income and transfers.

sharply. The rise in German net exports to the REA only accounts for about one half of the deterioration of the overall REA trade balance between the 1990s and 2008. The EA as a whole ran a trade balance surplus throughout the sample period. During the sample period, the share of the (fast-growing) ROW in total German foreign trade has risen steadily. The share of exports to the REA in German exports fell from 46% in 1995 to 36% in 2012, while the share of the EA in German imports fell from 47% to 37%.

Real activity in Germany and in German export markets

Figures 2.a plots volume series of GDP, private consumption, government purchases and investment for Germany (compared to the base year 1995). German private consumption growth in real terms has been lower than real GDP growth since the mid-2000. (The stability of the ratio of nominal consumption to nominal GDP documented above reflects a gradual rise in the ratio of the German CPI to the German GDP deflator.) More strikingly, however, real investment demand has almost had a flat trend between 1995 and 2012, experiencing mainly temporary ups and downs.

Figure 2.b plots year-on-year (YoY) growth rates of real GDP in Germany, the REA and the ROW. (ROW output is aggregate real GDP in 40 industrialized and emerging economies, including EU members who are not EA members; see Appendix.) Output growth fluctuations have been highly synchronized across these countries/regions. However, German real GDP grew noticeably less than REA and ROW GDP during 1995-2005. The gap in growth rates was especially sizable in 2002-2005. During that period Germany was sometimes referred to as the 'laggard of Europe' (Sinn, 2003). Since 2006, German GDP has grown faster than REA GDP, except during the Great Recession of 2009. ROW growth has markedly exceeded REA growth since the early 2000s.

REA-German interest rate convergence

The creation of the Euro eliminated exchange rate risk, and reduced financial transaction costs across member countries. The date of the launch of the Euro (1.1.1999) was announced by the European Council in December 1995. Until 1995, the short term nominal interest on government debt was markedly higher in the REA than in Germany; see Figure 3.a (mean REA-German interest rate spread: 2.3% p.a. in 1991-1995). The German nominal interest rate had a flat trend between 1995 and 1999, while the REA nominal rate fell rapidly, and thus converged to the German rate. The REA-German nominal interest rate spread was (essentially) zero when the Euro was launched in 1999. Between 1999 and the financial crisis, the interest rate spread remained very small; a positive spread emerged again after the eruption of the sovereign debt crises in some REA countries (2010).

Exchange rates and inflation

Due to strong domestic demand (fuelled i.a. by expansionary fiscal policy) the Deutsche Mark (DM) appreciated against REA currencies between German Reunification (1990) and 1995. The DM then depreciated against the REA until the launch of the Euro, but that depreciation only *partly* undid the strong post-Reunification appreciation (see Figure 3.c).

It has been argued that Germany entered EMU at an overvalued exchange rate--and that hence low wage and price growth was needed to re-establish German competitiveness (internal devaluation) after the launch of the Euro (e.g., Louanges (2005) and Carton and Hervé (2012)). The real exchange rate of Germany plotted in Figure 3.d is consistent with that view. The Deutsche Mark appreciated in real terms against both the REA and the ROW, after Reunification. Real appreciation peaked in 1995; the German real exchange rate against the REA was still above pre-unification levels when German-REA bilateral exchange rates were frozen at the beginning of 1999. After the launch of the Euro, German real depreciation vis-à-vis the REA has continued via lower German inflation (see Figure 3.b): the average

annual growth rate of the GDP deflator after 1999 was 0.75% in Germany, and 2.49% in the REA. The nominal (effective) exchange rates of Germany against the ROW depreciated much more strongly than the German-REA exchange rate, between 1995 and 2001; the German-ROW exchange rate then appreciated, by more than 70%, until 2008. Since the financial crisis, the external value of the Euro has fluctuated widely, around a slight downward trend (Fig. 3.d.). Due to nominal interest rate convergence, the lower German inflation implied that the German real interest rate was higher than the REA real interest during the first 10 years of the Euro. The financial crisis led to a rise in German inflation, and to a sharp reduction in REA inflation.

Labour market reforms

As a response to stagnant real activity in the early 2000s, the German government implemented a far-reaching labour market deregulation in 2003-05 ('Hartz' reforms) that included a reduction in unemployment benefits and measures such as a re-organization of labour placement and of job training schemes to improve job matching. Fig. 4.d plots the German average unemployment benefit ratio (ratio of unemployment benefit to wage rate). The benefit ratio fell permanently in 2004-05, from 62% to 53%. German labour market reforms arguably weakened the bargaining power of German trade unions. The fraction of wage earners who are union members fell steadily from 29% in 1995 to 18% in 2011 (OECD (2013)). It has been argued that the growth of outsourcing by German firms to low wage countries, notably in Eastern Europe, also reduced German trade union power (Dustmann et al. (2014)). These developments may have contributed to the very low growth of wages and of unit labour costs in Germany and thus to low German inflation (see below). These factors raised the competitiveness of German exporters, relative to the rest of the EA.

Wages and unit labour cost

Nominal wage growth has been markedly lower in Germany than in the aggregate EA during most of the Euro-era (see Fig. 4.a). Between 2002 and 2010, real wage growth has also been lower in Germany than in the EA. In fact, German real wage growth was *negative* during part of this period (Figure 4.b). As a result of these developments, the German labour share (share of wage income in GDP) fell steadily, from 57% in the early 1990s to 49% in 2008. Nominal unit labour cost (ULC, ratio of nominal compensation per employee to real GDP per person employed) was essentially flat between 1995 and 2007, or fell slightly, and only started to rise (by about +10%) after the financial crisis (Fig. 4.c). By contrast, nominal ULC rose steadily in the REA, between 1995 and 2008, but has been stable constant since then.

Demographics and pension reforms

One prominent candidate for explaining the German external surplus is population ageing. Empirical research by the IMF (2013b) provides evidence for a strong positive impact of projected ageing speed on the current account balance. Based on a sample of 49 countries (1986-2010), the IMF finds that a 1 percentage-point increase in the old-age dependency ratio (defined as the number of people aged 65 and above, relative to the working age population) relative to the country average increases the current account balance by 0.2 percentage points. In Germany, the dependency ratio increased by 10 percentage points between the mid-1990s and 2012 (Figure 5.a). Projections (German Council of Economic Advisors (2011)) point to an increase by around 20 percentage points within the next 20 years, due to the retirement of the post-war 'baby boom' cohorts. Importantly, the speed of population ageing is higher in Germany than in most other major economies. Higher future old-age dependency ratios imply lower future per-capita pension entitlements or higher future financing costs in a PAYG system, which both reduce future disposable income and provide an incentive to increase private savings.

In Germany, the pension replacement rate (ratio of the average pension to the average wage income per employee) has fallen by 13 ppt between the late 1990's and 2012 (Figure 5.b). Public pension reforms enacted in Germany between 2001 and 2004 stipulate a rise in mandatory public pension contributions and in the retirement age, as well as reduction of pension benefits (these changes are being phased-in gradually); in addition, the reforms have provided new tax incentives for private pension saving (Deutsche Bundesbank, 2011; Huefner and Koske, 2010).

3. Modeling the German current account: key relationships

This Section discusses the main relationships in our model that allow us assess the role of the key potential drivers of the German current account discussed in the previous Section. We solve the model by linearizing it around a deterministic steady state; the linearized model is estimated with Bayesian methods, using quarterly German, REA and ROW data for the period 1995q1-2013q2. We begin our estimation sample in 1995q1 in order to include the pre-Euro convergence of interest rates in our sample; by 1995q1 the creation of the Euro was highly likely; the date of the launch of the Euro was officially announced in December 1995, as mentioned above. (As a robustness check, we also estimated the model for 1999-2013; the key results remain unchanged.) The Appendix provides a complete description of the model and of the econometric methodology.

Our model builds on the EU Commission's Quest III model (Ratto, Roeger and in't Veld (2009)), an empirical New Keynesian Dynamic General Equilibrium with rigorous microeconomic foundations. Recently, much research effort has been devoted to the estimation of macroeconomic models of this type; see, e.g., Christiano, Eichenbaum and Evans (2005), Kollmann, Roeger and in't Veld (2012), Kollmann, Ratto, Roeger and in't Veld (2013), Kollmann (2013). This class of models is widely used for research and for macro policy analysis. The literature shows that this class of models captures well key features of macroeconomic fluctuations in a range of countries—for example, these models typically generate second moments (standard deviations and correlations) of key macro variables that are close to empirical moments. This is also the case for the model here (see Appendix).[6]

Our model assumes three countries: Germany, the REA and the ROW. The German block of the model is rather detailed, while the REA and ROW blocks are more stylized. The German block assumes two representative households: One household has a low rate of time preference and holds financial assets ('saver household'). The other household has a higher rate of time preference, and borrows from the 'saver household' using her housing stock as collateral. We assume that the loan-to-value ratio (ratio of borrowing to the value of the collateral) fluctuates exogenously, and that the collateral constraint binds at all times. (This structure, with patient and impatient households and exogenous loan-to-value shocks, builds on Iacoviello and Neri (2010).) Both households provide labour services to goods producing firms, and they accumulate housing capital—worker welfare depends on their consumption, hours worked and stock of housing capital. The patient household owns the German goods producing sector and the construction sector; in equilibrium, the patient household also holds financial assets (government debt, foreign bonds).

[6]There are few empirical macro models for Germany. Pytlarczyk (2005) estimated a two-country DSGE model with 1980-2003 data for German and the Euro Area. His model is more stylized than our model; no data on the external balance are used--no implications for the external balance are discussed. However, Pytlarczyk's parameter estimates share some of the broad features of our estimates, e.g. his results also support gradual demand adjustment (consumption habit persistence) and nominal stickiness.

German firms maximize the present value of the dividend stream paid to the patient (capitalist) household. We assume that German firms rent physical capital from saver households at a rental rate that equals the risk-free interest rate plus an exogenous stochastic positive wedge; that wedge hence creates a gap between the marginal product of capital and the risk-free interest rate. This is a short-cut for analyzing financial frictions facing firms (e.g., Buera and Moll (2012)). German firms export to the REA and the ROW. The production technology allows for variable capacity utilization and capital and labour adjustment costs; household preferences exhibit habit formation in consumption (i.e. sluggish consumption adjustment to income shocks). These model features help to better capture the dynamics of the German current account and of other German macro variables. The German block also assumes a government that finances purchases and transfers using distorting taxes and by issuing debt. The German block assumes exogenous shocks to preferences, technologies and policy variables that alter demand and supply conditions in markets for goods, labour, production capital, housing, and financial assets.

The models of the REA and ROW economies are simplified structures with fewer shocks; specifically, the REA and ROW blocks each consist of a New Keynesian Phillips curve, a budget constraints for a representative household, demand functions for domestic and imported goods (derived from CES consumption good aggregators), and a production technology that use labour as the sole factor input. The REA and ROW blocks abstract from productive capital and housing. In the REA and the ROW there are shocks to labour productivity, price mark ups, and the subjective discount rate, as well as monetary policy shocks, and shocks to the relative preference for domestic vs. imported consumption goods. [7]

All exogenous variables follow independent univariate autoregressive processes. In total, 46 exogenous shocks are assumed. Other recent estimated DSGE models likewise assume many shocks (e.g., Kollmann (2013)), as it appears that many shocks are needed to capture the key dynamic properties of macroeconomic and financial data. The large number of shocks used here is also dictated by the large number of observables used in estimation (as the number of shocks has to be at least as large as the number of observables to avoid stochastic singularity of the model). In order to evaluate alternative hypotheses about the causes of the German external surplus, data on a relatively large number of variables have to be used—we use data on 44 macroeconomic and financial variables for Germany, the REA and the ROW (see Appendix).

We now provide a (slightly) more detailed overview of key model components:

Monetary policy

Monetary policy in the Euro Area is described by an interest rate (Taylor) rule. We assume that the pre-1999 policy rate is the German short-term government bond rate, denoted by i_{t+1}^{DE}. During EMU (1999-), the policy rate is taken to be a weighted average of i_{t+1}^{DE} and of the REA short-term government bond rate, i_{t+1}^{REA}:

$$i_{t+1}^{EA} = s i_{t+1}^{DE} + (1-s) i_{t+1}^{REA}, \quad (1)$$

where $s=0.275$ is the average share of German GDP in EA GDP during the sample period. The policy rate is set as a function of the lagged policy rate, of the year-on-year Euro Area inflation rate (GDP deflators), of the year-on-year growth rate of Euro Area real GDP, and of

[7] We set each country's net foreign assets (NFA) at zero in steady state (and thus the steady state current account and net exports too are zero). In the long run, NFA is expected to converge to its steady state—however convergence is slow. Short- and medium term model dynamics thus does not depend on the assumed NFA steady state; our estimation results are robust to assuming non-zero steady state NFA.

a random disturbance.[8] (The average sovereign bond rate defined in (1) tracks very closely the actual ECB policy rate, during the period 1999-2013; correlation: 0.97.)

Interest rate spreads

We assume that the uncovered interest rate parity conditions that link German, REA and ROW interest rates are disturbed by exogenous shocks (e.g. McCallum (1994), Kollmann (2002)):

$$i_{t+1}^{EA} = i_{t+1}^{ROW} + E_t \Delta \ln e_{t+1}^{EA,ROW} + \rho_t^{EA,ROW}, \quad (2)$$

$$i_{t+1}^{REA} = i_{t+1}^{DE} + E_t \Delta \ln e_{t+1}^{REA,DE} + \rho_t^{REA,DE}, \quad (3)$$

where $e_t^{j,k}$ is the nominal (effective) exchange between countries *j* and *k*, defined as the price of one unit of country-*k* currency, in units of the country-*j* currency. The rate of depreciation of the EA currency against the ROW currency is a weighted average of the rates of appreciation of the German and REA currencies (vis-à-vis the ROW):

$$\Delta \ln e_{t+1}^{EA,ROW} = s \Delta \ln e_{t+1}^{DE,ROW} + (1-s) \Delta \ln e_{t+1}^{REA,ROW} . \quad (4)$$

$\rho_t^{EA,ROW}$ and $\rho_t^{REA,DE}$ are exogenous stationary disturbances that drive wedges between the (average) EA interest rate and the ROW interest rate, and between the REA and German interest rates; those wedges can reflect limits to arbitrage (due to transaction costs or short-sales constraints), biases in (subjective) expectations about future exchange rates, or risk premia. In what follows, we will refer to $\rho_t^{EA,ROW}$ and $\rho_t^{REA,DE}$ as 'risk premia'.

Since the introduction of the Euro, $e_t^{REA,DE}$ has been constant; thus $\Delta \ln e_{t+1}^{DE,ROW} = \Delta \ln e_{t+1}^{REA,ROW}$ holds after the launch of the Euro. During the run-up to the Euro (1995-1998), the bilateral REA/German exchange rate only showed muted fluctuations (see Figure 3.c). We assume that agents believed the REA/German exchange rate to follow a random walk during the 1995-1998 transition period, i.e. that $E_t \Delta \ln e_{t+1}^{REA,DE} = 0$. This assumption allows to construct a time series for the German-REA risk premium: $\rho_t^{REA,DE} = i_{t+1}^{REA} - i_{t+1}^{DE}$.[9] We feed the REA-German risk premium into our model to assess the effect of the convergence of REA and German interest rates on macroeconomic variables and the German external balance. Our empirical measure of the ROW interest rate i_{t+1}^{ROW} is the short-term US government bond rate; the USD exchange rate is taken as our empirical measure of $e_{t+1}^{EA,ROW}$.

Investment in productive capital and firm financing conditions

In the model, German good producing firms rent the physical capital stock from the patient (capitalist) households. Goods producing firms equate the marginal product of capital to the rental rate. The rental rate equals the risk-free interest rate plus an exogenous random positive wedge. The production function is subjected to exogenous total factor productivity (TFP)

[8] We assume that in 1995-98 (before the launch of the Euro), the Bundesbank set monetary policy for all countries in the (future) Euro Area. The parameters of the policy rule are assumed to be the same in 1995-98 and in 1999-2012 (any discrepancies between Bundesbank and ECB policy rules are thus captured by the residual of the policy rule). Assuming instead that pre-1999 the Bundesbank responds only to German output and inflation would be technically challenging, as this would introduce a break in the policy rule. Standard solution and estimation algorithms for linear(ized) models (as used here) require equations with time-invariant coefficients.

[9] During the 1995-1998 run-up to the Euro, the (future) member countries already made a commitment to keep stable bilateral exchange rates. The Maastricht Treaty stipulated that a (future) member country of the Euro Area had to abstain from devaluing its currency for at least two years (before joining the EA), against any other member country. Hence, it seems reasonable to assume that expected exchange rate depreciation was zero (or close to zero) in 1995-1998. During this period the REA nominal exchange rate appreciated slightly against the DM (by 3.85%). The compounded 1995-98 REA-Germany interest rate differential was much greater: 8.77%.

shocks; the accumulation of production capital is affected by shocks to investment efficiency (e.g., Fisher (2006) and Justiniano et al. (2008)).

Fiscal policy

The government purchases domestically produced and imported intermediate goods that are used for government consumption, and for investment in public capital; the government also pays unemployment benefits and pensions to households. Government spending is financed using taxes on consumption, labour income and capital income, and by issuing public debt. All government spending items and the tax rates are set according to feedback rules that link those fiscal variables to the stock of debt (in a manner that ensures government solvency), and to real output. The fiscal policy rules are also affected by exogenous autocorrelated disturbances.

External demand conditions and foreign trade shocks

Consumption and investment are composite goods that are produced by combining locally produced and imported intermediate goods that are imperfect substitutes. The volume of German foreign trade, hence, depends on the relative price between German and foreign (REA and ROW) goods, and on domestic and foreign absorption. We use data on foreign real activity and on the foreign price level, in the model estimation. We refer to shocks to foreign real activity as 'external demand shocks', as these shocks affect the demand for German exports. The model also assumes preference shocks that shift the desired combination between domestic and imported intermediates, and shocks to the market power (mark up) of exporters.

Labour market reforms and wage restraint

In the model, the government pays unemployment benefits to unemployed workers (those benefits are equivalent to a subsidy for leisure). We capture the effect of the German labour market reforms by treating the unemployment benefit ratio as an autocorrelated exogenous variable. We feed the historical benefit ratio (Figure 4.d) into the model. We assume that German wages are set by a labour union that acts like a monopolist in the labour market. Union power, as manifested in the wage markup (i.e. markup of the real wage rate over workers' marginal rate of substitution between consumption and leisure) follows an autocorrelated process.

Private saving and financial conditions shocks

To capture the rise in German private saving, the model allows for exogenous shocks to households' rate of time preference, referred to as 'private saving shocks'. We also assume that the loan-to-value ratio faced by impatient households (borrowers) is time-varying.

Pensions

To keep the model simple, we assume infinitely-lived German households (i.e. we do not consider overlapping generations). Each household has a fixed time endowment that is normalized at unity. That time endowment is used for market labour, leisure and retirement. We assume that time spent in retirement (R) is exogenous. In the empirical estimation, we take the fraction of the population in retirement as a proxy for R. The pension paid to a given household is modeled as a government transfer; the pension is proportional to R and the market wage rate, w: pension= rr *R*w, where the 'pension replacement rate' rr is an exogenous random variable. We use the empirical replacement rate (Figure 5.b) as a measure of 'rr', in the model estimation.

4. Results

The Appendix reports posterior estimates of all model parameters. The estimation indicates that the German steady state income share of financially unconstrained households ('savers') is high (0.54). German households exhibit relatively strong habit persistence (habit parameter: 0.70), and so do REA and ROW households (habit parameters: 0.67 and 0.90). German households have an intertemporal substitution elasticity below unity (0.58). The German (Frisch) labour supply elasticity is 0.82. German nominal wage and price stickiness is moderate: the average price-change interval is 3 quarters, while the average wage-change interval is 2 quarters. (Despite the modest degree of nominal wage stickiness, the impulse responses show that the real wage rate exhibits substantial sluggishness.) The substitution elasticity between domestic and imported products is high (2.11) in Germany, close to unity (1.13) in the REA and below unity (0.74) in the ROW.

To explain the key mechanisms operating in the model, we now present impulse responses to selected shocks. We then describe shock decompositions of historical time series, implied by the estimated model. All model properties are evaluated at posterior estimates (modes) of the model parameters. Other detailed estimation results are reported in the Appendix.

4.1. Impulse response functions

We now discuss dynamic responses to shocks that matter most for the German external balance. We begin by discussing shocks to German aggregate supply (shocks to German TFP and investment efficiency, and to German unemployment benefits), and then discuss German saving shocks, shocks to German government consumption and investment, a shock to the REA-Germany risk premium, and a ROW demand shock.

Positive German aggregate supply shocks: TFP and investment efficiency increase, unemployment benefit ratio

Figure 6.a shows dynamic responses to a permanent rise in **German TFP**. In the short-run, price stickiness and capital and labour adjustment costs prevent a rapid expansion of German output. Hence, the shock triggers a gradual increase in German GDP (the maximum response of GDP is reached 5 years after the shock), and of the German real wage rate. Due to habit formation in consumption (and because of the presence of collateral-constrained households), aggregate German consumption too rises very gradually—in fact more slowly than GDP; hence, the German saving rate (nominal saving/nominal GDP) rises. On impact, the German labour input falls slightly, due to the sluggish adjustment in aggregate demand--employment only rise with a four quarter delay. Productive investment in Germany too falls slightly, on impact, before rising. Importantly, investment rises *less* than GDP (due to strong investment adjustment costs) and, hence, the investment rate (nominal investment/nominal GDP) *falls*. The shock also leads to a gradual fall in the German price level, and to a depreciation of the German real exchange rate vis-à-vis the REA. The policy interest rate falls, but only very slightly, as EA monetary policy targets EA-wide aggregate GDP and inflation. Due to the gradual fall in the German price level, the German (expected) real interest rate rises, which also contributes to the initial fall in German productive investment. The sluggish rise in German absorption and the improvement in German price competitiveness (fall in the relative German/REA output price) implies that German net exports and the German current account *rise* persistently. The rise in German net exports is accompanied by a persistent fall in REA net exports. Domestic demand in REA increases supported by the decline in the policy rate.

The net effect on REA GDP is small, initially positive but turning negative in later years—and note that the reduction in REA GDP is markedly smaller than the rise in German GDP.

The predicted fall in foreign GDP in response to a positive shock to home productivity is a common feature of open economy DSGE models (e.g., Backus, Kehoe and Kydland (1992), Kollmann (2013)). By contrast, the sign of the net exports response hinges on the speed of adjustment of consumption and investment, and is thus parameter-dependent. Our model estimates suggest very sluggish German consumption adjustment (strong habit effects) to a German TFP increase. In the absence of habit formation, absorption would initially rise more strongly than current GDP, due to consumption smoothing by local households who expect their *future* income to rise more than current income, and thus net exports and the current account would then fall (e.g. Obstfeld and Rogoff (1996)).[10]

Figure 6.b shows dynamic responses to a positive shock to German **private sector investment efficiency** (production capital). Qualitatively, the response of most variables are similar to the responses to a positive TFP shock: the investment efficiency shock raises German real GDP, consumption and investment. However, German output rises less strongly, while consumption rises by less, investment rises by more than in response to a positive TFP shock. The positive investment efficiency shock triggers a fall in the relative price of investment goods, relative to the GDP deflator. This negative price response implies that a positive investment efficiency shock triggers a *fall* in the (nominal) investment rate. The change in the saving rate exceeds the fall in the investment rate, and thus the German current account *rises*.

Figure 6.c reports dynamic responses to a **German labour market reform**—captured here by an exogenous permanent reduction in the German unemployment benefit ratio (unemployment benefit divided by wage income per employee). The benefits cut raises German labour supply, which lowers the real wage rate. It thus leads to a long-lasting expansion of German employment, and of German GDP, and to an improvement in German competitiveness. Although the competitiveness gain is persistent, it is gradually eroded as real wages adjust in the longer run. The lower unemployment transfer payment reduces the consumption of collateral-constrained German households. Aggregate consumption initially declines but rises (above the unshocked path) after six years (due to the increase in GDP which raises the consumption of saver households). However, consumption adjusts sluggishly to the rise in GDP, and the German saving rate rises persistently. German investment falls, on impact, due to a rise in the German real interest rate, but investment increases in the medium-term, as the (permanent) rise in the German labour supply triggers a permanent rise in the German capital stock. REA output rises slightly in the short term, and then falls slightly below its unshocked path. German net exports increase, while REA net exports fall. The effects of this shock on German GDP and on German net exports are thus similar to the responses triggered by a positive TFP shock--but note that the German benefits reduction raises REA output in the short run.

Positive German aggregate supply shocks are, hence, a candidate for explaining the acceleration of German GDP growth after 2005. These shocks are also consistent with other salient facts about the German economy after 2005: a high trade balance (and current account) surplus, low inflation (relative to the REA) and a high saving rate.

Positive German private saving shock, shocks to pension replacement rate and to old-age dependency ratio

[10]The other shocks discussed below (except the saving shock) too move the German GDP and trade balance (and current account) in the same direction. In the model, the German current account is thus procyclical, consistent with 1995-2013 data.

Figure 6.d shows dynamic responses to a positive German private saving shock, namely a persistent fall in the **German subjective rate of time preference**. The shock triggers a long-lasting reduction in German aggregate consumption, and it hence raises the German saving rate. The resulting increase in the marginal utility of consumption raises households' (desired) labour supply, which induces a gradual fall in the German (real) wage rate, and in the German price level. Because of sluggish price and wage adjustment, the short- to medium-term response of German GDP and employment is, however, dominated by the fall in consumption—i.e. GDP and employment fall initially, before rising above their unshocked path (due to the increased labour supply). The rise in private saving lowers the nominal interest rate, however the fall in German inflation leads to an initial rise in the German *real* interest rate, and German investment falls on impact (but then increases). REA aggregate demand rises (due to fall in EA-wide interest rate), and REA net exports fall (also because of a fall in German demand for REA goods). Initially, REA GDP is slightly positive, but then falls slightly below its unshocked path.

A cut in the **pension replacement rate** too raises German GDP, the German saving rate (due to fall in consumption) and net exports. A positive shock to the **old-age dependency ratio** (i.e. to the number of German retirees) lowers German employment (due to labor supply reduction) and output; consumption and investment fall too, but more gradually than output, and thus German next exports (and the current account) *fall*. (The historical decompositions of the current account discussed below show that shocks to the pension replacement rate and to the number of retirees had a smaller role for the German saving-investment gap than rate-of-time preference shocks.)

German fiscal shocks

Figure 6.e reports responses to a positive shock to **German government consumption**. The shock raises German GDP, but crowds out German consumption and investment, and it reduces German net exports, and raises REA output. A 1 Euro rise in government purchases raises German output by 0.56 Euro, lowers German net exports by 0.35 Euro, and raises REA GDP by 0.02 Euro. Thus, German expansionary fiscal policy lowers German net exports, but only has a very small effect on REA GDP. In order to reduce German net exports by 1% of GDP, a fiscal impulse worth 2.85% of GDP would be required, which amounts to a 15% increase in government purchases. In other terms, even very sizable fiscal policy shocks only have a modest effect on net exports (and on the current account). (Modest trade balance responses to fiscal shocks in the same range are also reported by other empirical studies; see, e.g., Beetsma and Giuliodori (2010)).

Figure 6.f shows dynamic responses to a positive shock to **German public investment**. The shock has a sizable effect on German GDP that grows over time. Private consumption increases, and German net exports fall slightly during the first 4 years after the shock. Initially, private investment falls, but in the medium terms private investment rises, as the rise in government capital raises the productivity of private production capital. REA GDP falls, in the very short term, but rises subsequently. [11]

Fall in spread between REA bonds and German bonds

Figure 6.g shows dynamic responses to a persistent **fall in the REA-German bond spread** (risk premium) $\rho_t^{REA,DE}=i_{t+1}^{REA}-i_{t+1}^{DE}$. The shock triggers a persistent fall in the (nominal and real) REA interest rate, and a rise in the EA policy rate. REA absorption and GDP and the

[11]The responses of real activity are muted by a rise in the policy rate. When monetary policy is constrained by the zero lower bound (ZLB), the interest rate fails to rise, and REA GDP increases already on impact.

(relative) REA price level rise, while REA net exports fall. The rise in the policy rate triggers a sharp and persistent fall in German investment, and a fall in German consumption. The German investment rate falls, while the saving rate rises. German GDP rises due to strong REA demand, and German net exports increase. The effects on German and REA net exports are very persistent. These predictions are consistent with a number of developments in the run-up to the Euro when the REA-German interest rate spread fell rapidly: namely rapid REA growth and a worsening of the REA trade balance. However, empirically German net exports were basically flat before the launch of the Euro, which suggests that other factors must have off-set the effect of the spread shock on German net exports.

Positive shock to ROW (Rest of World) aggregate demand
Finally, Figure 6.h shows responses to a rise in **ROW aggregate demand** triggered by a persistent rise in the ROW subjective discount rate. The shock raises ROW absorption, which increases demand for German and REA exports, and thus German and REA GDP rise. This triggers a rise in the EA policy rate, which reduces German investment by increasing financing costs. Again, the German investment rate falls, while the saving rate rises. ROW net exports fall, while German and REA net exports rise. Hence, the ROW real activity shock is consistent with high German net exports and low German investment.

4.2. Historical decompositions

To quantify the role of different shocks as drivers of endogenous variables, we plot the estimated contribution of the different shocks to historical time series. Figures 7.a-7.e show historical decompositions of the following German macroeconomic variables: the current account (divided by nominal GDP); the saving rate; the investment rate; year-on-year real GDP growth; and year-on-year inflation (GDP deflator). Figures 8.a-8.b show decompositions of the REA trade balance (divided by REA nominal GDP) and of REA real GDP growth. The lines with black lozenges show the historical data. In each Figure, the horizontal line represents the steady state value (of the variable plotted in the respective Figure). (In the model, the steady state year-on-year growth rate of German and REA GDP is 1.08%; steady state annual inflation is 2%.) For each period (quarter), the vertical bars show contributions of different (groups of) shocks to the historical data. For the sake of legibility, related disturbances are grouped together (see below). Vertical bars above the horizontal (steady state) line represent positive shock contributions to the variable considered in the Figure, while bars below the horizontal line represent negative contributions. Sums of all shock contributions equal the historical data.

We plot the contributions of the following (groups of) exogenous shocks originating in Germany: (1) TFP and investment efficiency (see bars labeled ‘technology’); (2) Wage mark up (‘Labour wedge’); (3) Unemployment benefit ratio (‘Unemployment benefit’); (4) Old-age dependency ratio (‘Retirees’); (5) Pension replacement rate; (6) Subjective rate of time preference (‘Private saving’); (6) Fiscal policy; (7) Firm finance wedge; (8) Household loan-to-value ratio and risk premium on housing capital (‘housing financing conditions’). In addition, we show the contribution of disturbances to: (1) REA-German interest rate spread (‘REA risk premium’); (2) shocks originating in the REA and ROW, and shocks to the relative preference for German vs. imported goods (‘External demand and trade’). The remaining shocks are markedly less important drivers of German variables, and are hence combined into a category labeled ‘other shocks’.[12]

[12]Also included in ‘other shocks’ are the ‘base trajectories’, i.e. the dynamic effects of initial conditions (i.e. of predetermined states in the first period of the sample).

Figures 8.a and 8.b (decompositions of REA net exports and GDP growth) show the contributions of the (groups of) shocks originating in Germany, as well as the contributions of 'REA aggregate demand' shocks and of 'REA aggregate supply' shocks, and of 'REA external demand and trade' shocks (ROW aggregate demand and supply shocks, and shocks to the relative preference for REA goods vs. goods imported by the REA).

The historical decomposition shows that the following shocks had a noticeable **positive** effect on the **German current account**, at different times: (i) positive German technology shocks, between the late 1990s and the global financial crisis; (ii) the fall in the REA-German risk premium, between 1995 and 1999; (iii) positive external demand shocks, due to strong ROW and REA growth, especially in 2004-08; (iv) the 2003-05 German labour market reforms (captured in the model by the reduced generosity of unemployment benefits); (v) sizable positive shocks to the saving rate, from 2004 to the end of the sample; (vi) a rise of German firms' investment wedge, after the collapse of the dot-com bubble, and in the aftermath of the global financial crisis.

German **technology shocks** had a persistent positive effect on the German investment rate, according to the estimated model, and boosted the German current account by up to 1.5% of GDP during the early 2000s, i.e. during the phase during which the current account rose sharply. The positive contribution of technology shocks to the German current account between the early 2000s and the financial crisis mainly reflects the fact that these shocks (in particular investment efficiency shocks) lowered the German investment rate (see above discussion of impulse responses). During the 2009 financial crisis, TFP and investment efficiency fell noticeably in Germany—this explains why the influence of technology shocks on the German current account has been much weaker since the crisis.

Aggregate supply shocks were key drivers of German GDP: the booms in 2000-2001 and 2006-2007 are both accounted for by sizable positive supply shocks. Aggregate supply shocks also had a noticeable effect on German inflation: positive technology shocks in the first half of the sample period lowered German inflation; negative technology shocks during the Great Recession prevented a drop in inflation.

The **convergence of REA interest rates to German rates** had a persistent small but noticeable positive effect on German current account between the late 1990s and the mid-2000s (see bars labeled 'REA Risk premium shocks' in Figure 7.a). Interest rate convergence increased REA demand and thus REA imports from Germany. Because of monetary policy tightening in response to interest rate convergence (see Figure 6.g), German aggregate demand fell, in response to convergence, which led to declining domestic demand and a rise in German saving.

As discussed above, interest rate convergence occurred rapidly after the creation of the Euro had irrevocably been announced in late 1995—interest rate convergence had ended when the Euro was launched on 1.1.1999. This explains why the impact of interest rate convergence on the German current account was strongest between 1999 and 2002 (accounting for about +1% of the current account/GDP ratio). However, during that time the German current account was still negative—the current account actually fell slightly between 1998 and 2001. According to our estimates, interest rate convergence had a very small positive effect on German GDP (due to stronger REA demand for German exports), unit labour cost and inflation.

The convergence of REA interest rates to German levels had a markedly stronger negative effect on the REA trade balance—interest rate convergence contributed especially to the sharp fall in REA net exports in 1998-2001 (see Figure 8.a). Interest rate convergence also contributed to the 1997-1999 boom in REA activity (see Figure 8.b). According to one prominent hypothesis, REA-German interest rate convergence triggered a massive capital outflow from Germany that sharply lowered domestic German GDP and investment growth

(e.g., Sinn, 2006, 2010, 2013). Our analysis does not support this view. The estimated model does suggest that interest rate convergence lowered investment in Germany and raised the German current account, but only by a modest amount. Also, the timing of interest rate convergence does thus not match the sharp rise in the German current account--the latter occurred several years after convergence. In closely related analyses, Hale and Obstfeld (2013), in't Veld et al. (2013), Reis (2013) and Fernández-Villaverde, Garicano and Santos (2013) argue that the capital inflows experienced by Spain and other Euro Area periphery countries were largely driven by interest rate convergence. While our model estimates show that interest rate convergence mattered for the REA trade balance, we find that other shocks had an even more pronounced role for REA net exports—especially ROW demand shocks and domestic REA aggregate demand shocks (see below). (It should be noted that the REA aggregate considered in the present paper includes a broader set of countries than the periphery countries studied by Hale and Obstfeld (2013), in't Veld et al. (2013), Reis (2013) and Fernández-Villaverde, Garicano and Santos (2013).)

The historical decomposition shows that strong **external demand** (from the REA and the ROW) in the 2000s contributed importantly to the increase in the German current account. In this period, German exports benefited from the boom in the REA and from strong ROW growth. In particular, due to her strong trade links with the new EU member states, Germany benefited from the post-accession booms in those states. In the 2009 recession, the external demand contribution turned abruptly negative. Since the crisis, lower net exports to the slowly growing REA have been nearly fully offset by net export gains to the ROW. The positive external demand shocks prior to the financial crisis essentially crowded out German consumption spending and investment. At the same time, stronger external demand has increased German inflation. Hence the effect of strong world demand is mitigated by its impact on German trade competitiveness.[13]

The cuts in unemployment benefits introduced during the 2003-2005 **labour market reforms** raised German GDP, according to the model estimates. The labour market reforms raised household labour supply, and increased the German saving rate, but only had a negligible effect on the investment rate. Due to the sluggishness of German aggregate demand, the labour market reforms had a long-lasting positive effect on the German current account. The reforms contributed to a decline in unit labour costs, and thus increased German price competitiveness. Spillovers of German labour market reforms to REA real activity were very weak, but the reforms made a negative contribution to REA net exports. [14] The sizable **rise in the old-age dependency ratio** (see bars labeled 'Retirees') is another important shock to the German labor market. In particular, it amounts to a negative labor supply shock—it lowered GDP and the saving rate, due to the sluggishness of consumption demand. Thus, positive shocks to the number of retirees worsened the German current account. By contrast, as discussed in a Box below, a 'news shock' that raises the predicted *future* old-age dependency ratio *improves* the current account.

The contribution of shocks to the German **firm financing wedge** varies across the sample period. These shocks raised the German current account in periods of elevated financing costs, i.e. in the aftermath of dot-com bubble and of global financial crisis. During those periods, firm financing shocks contributed to a fall on the German investment rate; these shocks also tended to lower the German saving rate, but markedly less than the

[13] We simulated a counterfactual scenario assuming independent monetary policy in Germany and a flexible exchange rate between Germany and the REA. According to our estimates, external demand from the ROW has benefited both Germany and the REA (see below), and would thus only have had a minor effect on the German current account, under a floating exchange rate.

[14] Figure 7.a also shows that wage mark up shocks contributed slightly to the rise in the German current account during the early 2000s (due to a fall in the estimated mark up).

investment rate. By contrast, firm financing shocks lowered the current account shortly before the financial crisis. Thus, shocks to firm financing costs do not explain the persistent German current account improvement.

Unlike other EA economies, Germany experienced a persistent fall in real house prices. The fall in German real house prices is mainly driven in the model by positive shocks to risk premia on housing capital; these shocks tightened the credit constraints of German non-Ricardian households, triggered a fall in housing investment; this explains the persistent positive contribution of shocks to '**housing financing conditions**' to the German current account surplus.

The contribution of German **fiscal policy shocks** to the German external surplus is estimated to be minor over the sample. [15] Only in the last year is there a small positive contribution of the fiscal consolidation to the trade surplus.

Positive **'Private saving'** shocks (i.e. positive shocks to the German subjective discount rate) account for an increasingly more important share of the German current account surplus after 2003. Note, especially, that these shocks explain more than half of the German current account surplus after 2008. The negative shocks to the **German pension replacement rate** had a positive but much more modest effect on the German current account, after 2006 (generating roughly a rise of the German current account of 1% of GDP).

Note also that the German 'Private saving' shock contributed to low German inflation (as that shock depressed aggregate demand in Germany). This shock has furthermore contributed negatively to German GDP and labour cost growth; it had a negative effect on import demand and a positive impact on exports (due to external competitiveness gains).

As discussed in Section 2, demographic projections indicate that, in the coming decades, the old-age dependency ratio will rise further markedly, while the replacement rate will fall further. Furthermore, over time, projected dependency ratios has been revised upwards noticeably. For example, according to the 2000 projection of the German Federal Statistical Office, the predicted dependency ratio (number of persons aged 65+ relative to persons aged 20 to 64) in the year 2040 was 35.9%. The projection (for 2040) was raised to 36.8%, 38.7% and 39.2% in the 2003, 2006 and 2009 projections, respectively. (The Statistical Office publishes demographic projections every three years.). Note that we do not feed German demographic variables predicted beyond the sample period into the model. Nor do we use information about the successive revisions in demographic projections. Hence, it seems plausible that, by abstracting from long-run demographic information, the estimated model underestimates the true contribution of German population ageing for the German current account. It seems plausible that the 'private saving' shock might reflect demographic information that is not captured by in-sample demographic data.

Ageing and pensions were the subject of intense public debate, in Germany, around the turn of the century--those debates led to deep pension reforms, in 2001-2004 (see Box). These public debates arguably raised awareness and concerns about demographic issues in the German public. In addition, the pensions reforms provided new tax incentives for private pension saving—our model abstracts from these tax incentives.

Illustrative simulations discussed in the Box below suggest that an upward revision of long-term demographic projections has a sizable and persistent positive effect on the German current account. However, it would be technically challenging to estimate a model variant with shocks to long-run demographic information, i.e. with demographic 'news

[15]Other empirical studies (for a range of countries) too report small estimates of the contribution of fiscal shocks to the variance of the trade balance; see, e.g., Adolfson et al. (2007).

shocks' (especially as official demographic projections are only released every three years). We leave estimation of such a model for future research.

In summary, it seems plausible that the shocks to the German discount factor (that accounts for a high share of the rise in the German current account) might reflect information on long-term demographic trends that is not captured by in-sample demographic data. However, we cannot precisely quantify the contribution of those long-term demographic trends to the German current account surplus. The estimated negative shocks to the German subjective discount rate may thus also capture other adverse shocks to German consumption demand.

The major shocks that increased the German current account have tended to *reduce* **REA net exports** (see Figure 8.a). For example, the German savings shocks had a large and persistent negative effect on REA net exports. This is due to the fact that a reduction of German domestic demand has adverse effects on REA real activity. In recent years, German labour market reforms, too, have tended to lower REA net exports (due to the positive effect of those reforms on German price competitiveness). German TFP shocks had persistent adverse effects on REA net exports until the financial crisis—however, after the crisis, German TFP shocks have raised REA net exports. Another important factor which has contributed to the fall in REA net exports before the global financial crisis was the decline of the REA interest rate spread which has noticeably stimulated REA aggregate demand.

However, we also identify an important autonomous REA aggregate demand component, which especially over the period from 2005 to 2008 has contributed strongly to a worsening of the external balance--that REA aggregate demand component was most likely associated with housing and asset booms in some REA countries.[16] With the collapse of those booms, the emergence of REA banking problems and REA fiscal consolidation, REA aggregate demand began to exert a less negative effect on REA net exports--and even has started to contribute positively to REA net exports from the beginning of 2012.

As shown in Figure 8.a, ROW external demand fluctuations have also tended to boost REA net exports, especially during the years 2001-2006, and in 2012-13 (during this period ROW GDP growth noticeably exceeded REA and German growth).

REA GDP was largely driven by domestic aggregate supply and demand shocks. The spillovers of German shocks to REA GDP are relatively weak. It can be noted that REA and German aggregate supply shocks have tended to co-move positively. By contrast, Germany tended to experience negative aggregate demand shocks before the crisis, whereas the REA mainly received positive aggregate demand shocks, during that period. The poorer performance of the REA economy compared to the German economy since the financial crisis is to a large degree driven by adverse REA aggregate demand shocks. Labour market reform, too, has contributed to the better performance of Germany after the crisis (the unemployment rate has been falling in Germany after the crisis, while unemployment rose sharply in the REA).

[16] Empirically, house price increases are often associated with a trade balance deterioration (e.g., Aizenman and Jinjarak (2013), Chinn et al. (2013), European Commission (2012a), Gete (2010), Obstfeld and Rogoff (2010)). The REA block of the model here abstracts from housing (see above). As pointed out by a referee, the shocks to the REA subjective discount rate (assumed in the model) might capture the effect of REA house price bubbles.

Box: Demographic news shocks and the German current account

Between 2000 and 2009 we identify a gradual increase of the contribution of the 'Private Savings' shock on the German current account surplus (see Figure 7.a). This box explores to what extent this shock could reflect "demographic news" related to revised expectations about demographic trends and the cost of ageing.

German pension reforms

Demographic pressure became an important topic in the political debate in Germany and resulted in three pension reforms (2001, 2003, 2004)—which raised awareness among the German population about looming demographic problems. Importantly, the pension reform in 2001 constituted a regime shift in the German pension system. The so called 'Altersvermögensergänzungsgesetz' or 'old-age wealth accumulation law' (2001) froze contributions to the pay-as-you-go system by gradually reducing pension benefits and by providing tax subsidies for building up a third pillar of the pension system (the so-called 'Riester-Rente'). The aim of this reform was to gradually reduce the pension generosity of the representative pensioner ('Eckrentner') from a net replacement rate of 71% in 2000 to 68% in 2030. However, it turned out that this reform was not sufficient to stabilize the German pension system. Two further reforms lowered the generosity of the pension system: (i) The 'Rentenversicherung-Nachhaltigkeitgesetz' or 'sustainability of pensions law' (2003/2004) introduced a so-called sustainability factor which links future benefits to life expectancy and the employment rate; the German Council of Economic Advisers (2004) estimated that the sustainability factor will reduce pensions by 7.7% in 2030. (ii) The 'Alterseinkünftegesetz' or 'old-age income law' (2004) phased-in the taxation of pension benefits; from 2005, pensioners had to pay income taxes on 50% of their pensions; this share will rise to 100% in 2040.

These three pension reforms imply a combined decline of the pension replacement rate by about 20% until 2030 (Werding 2013).

News on demographic trends and the benefit replacement rate

Though it is difficult to quantify the public's awareness about demographic pressures, regular demographic projections by the German Statistical Office provide information about revisions undertaken by professional demographic forecasters in the 2000s. As shown in Table B1, the projected old-age dependency ratios for years after 2020 were markedly revised upwards between 2003 and 2006.

Table B1: Germany – Old-Age dependency ratio projections, various vintages
(Number of persons aged 65+ relative to persons aged 20 to 64 in %)

	1999	2001	2005	2008	2010	2020	2030	2040	2050	2060
2000 projection	25.4	:	:	:	33.1	35.9	46.9	56.2	56.0	:
2003 projection	:	27.5	:	:	32.8	36.8	48.2	55.3	56.4	:
2006 projection	:	:	31.7	:	33.6	38.7	52.2	61.4	64.3	:
2009 projection	:	:	:	33.7	:	39.2	52.8	61.9	64.4	67.4

Assumptions: Fertility rate 1.4, net migration 100 000 p.a., baseline life expectancy. Source: German Federal Statistical Office, 9./10./11./12. Bevölkerungsvorausberechnung 2000/ 2003/2006/2009

Modelling the effects of demographic and pension news shocks

Both the revisions on demographic projections and the pension reforms signal a fall in future income to German households. Forward looking households should respond to this by increasing their savings rate.

To quantify the impact of ageing-related news shocks, we use our model to compute the perfect foresight path of German current account implied by the 2003 projection of the German dependence ratio for the years 2006-2050. We compare that baseline path of the current account to the path implied by the 2006 demographic projection and by a gradual (linear) decline of the pension replacement rate by 20% until 2030. (The paths of the dependency ratio and of the replacement rate are assumed constant from 2050 and 2030, respectively). The first line of the Table ('Scenario 1') below shows the difference between these two projected current account paths (as a % of GDP). That difference reflects the effect of demographic news on the current account.

An additional important aspect of demographic projections relates to the fiscal cost of ageing in terms of higher expenditure for health and long term care. The EU Commission's Ageing Report (2009) projects that these old-age related fiscal expenditures will increase roughly by the same proportion as pension payments. We take account of this fiscal dimension of ageing by also considering an alternative scenario ('Scenario 2') that combines the news shocks about the dependency ratio and the replacement rate with the assumption that government consumption rises gradually (linearly) by 1% of GDP until 2050. This is a rough estimate (based on the 2009 Ageing Report) of extra ageing-related government consumption implied by the demographic news shock.

Because of their adverse real income effects, German households respond to the news shocks by increasing saving in order to smooth consumption over time. Habit persistence prevents a rapid adjustment of the savings rate, and the current account rises gradually by close to 3% of GDP over a period of 5 years, under Scenario 1. This sizeable effect is in the range of the estimated contribution of the 'private savings shocks' to the increase in the German current account during the mid-2000s, according to the historical decomposition reported in Figure 7.a. The current account response depends on the fiscal cost of ageing; in Scenario 2, the peak effect of the news shock on the current account is about 10% stronger than in Scenario 1.

Table B2: Impact of demographic news shock on the German current account (% of GDP)

Year	1	2	3	4	5	6	7	8	9	10
Scenario 1	0.9	1.9	2.4	2.7	2.8	2.8	2.7	2.6	2.5	2.3
Scenario 2	0.8	1.9	2.5	2.8	2.9	3.0	3.0	2.9	2.7	2.6

5. Scenarios for the German external balance

Although uncertainty about future shocks makes it impossible to fully anticipate the further evolution of the German current account, we can characterize the likely impact of current drivers in the years to come. The contribution of the German saving rate to the current account is slowly falling. It is likely that the savings rate will decline further, given the fact that high saving cohorts (population aged between 30 and 55) will decrease as a share of the total population. A factor holding back a faster decline in saving could be precautionary savings related to the financial and sovereign debt crises.

A further factor that might contribute to a gradual fall in the current account surplus is that German residential investment is likely to pick up in the near term, given low real interest rates in Germany. Although the tradable content of construction is low, this will raise

non-housing consumption and hence reduce the current account, due to the complementarity between housing and non-housing consumption. The discussion above has focused on the reduction of benefit replacement rates as a key element of the labour market reforms of the early 2000s. In the framework of our model, benefit reduction increases the labour supply. Due to the sluggish response of domestic demand, the labour supply expansion translates initially more into real wage decline than higher employment, which only increases gradually. The fall in wage and production costs improves the price competitiveness of German goods in foreign and domestic markets and improves the German current account. However, the model suggests that the positive effect of permanent labour market reform on the German current account is only temporary, since employment and associated wage increases stimulate domestic demand (private consumption). According to the model estimates, the current account increase reaches its maximum around 7 years after the reform. After that, the current account declines gradually in response to growing domestic demand. This implies that the contribution of past labour market reforms to the current account surplus is likely to fall in future years. In addition the policy debates in Germany about the distributional impact of the labour market reforms has led to plans by the new German government to introduce a minimum wage law which is likely to further increase German wages. Moreover, structural reforms currently undertaken in REA countries will boost REA growth and competitiveness, and accelerate the erosion of Germany's competitive advantage. The contribution of fiscal policy shocks for the German current account has been modest during the estimation period. However, in view of the current discussions in Germany about the need to raise public infrastructure investment, future fiscal policy too may contribute to a reduction in the German external surplus.

The German non-tradables (services) sector lacks competition (barriers to entry into the retail, crafts and health sectors), and it is sometimes argued that reforms boosting competition and productivity in the German non-tradables sector (services) would lower the German external surplus. The model here cannot be used to evaluate that view, as it does not include a non-tradables sector. However, several recent papers have studied the effects of structural reforms in the non-tradables sector (modeled as a positive shock to non-tradables productivity or a reduction in the mark ups changed by firms that produce non-tradables); see, e.g., Forni et al. (2010), Vogel (2011, 2013) and Gomes et al. (2013) who use rich DSGE models of open economies that closely resemble the model used here. These analyses suggest that reform in the non-tradables sector has a strong positive effect on GDP, but that the effect on net exports is modest—in fact, net exports may actually rise. The reason for this is that the domestic tradable good producing sector uses non-tradable inputs—hence, measures that boost the efficiency of the non-tradables sector improve a country's *external* competitiveness.[17]

[17] Dustmann et al. (2014) document that low wage growth in the German non-tradables sector contributed to the competitiveness of the German exports sector--more than 70% of the total input used by the German exports sector are domestically produced. These strong *domestic* input linkages suggest that an aggregative model (without non-tradables vs. tradables distinction) may be suited for understanding the German macroeconomy.

6. Conclusions

We have developed a three-country DSGE model and estimated that model using quarterly 1995-2013 data for Germany, the rest of the Euro Area (REA) and the rest of the world (ROW). We used that model to analyze the causes of Germany's substantial and persistent current account surplus, and its effect on the REA. Our results show that simple mono-causal explanations of the German surplus are insufficient. The surplus reflects a succession of distinct shocks. According to our estimates, the most important factors driving the German surplus were positive shocks to the German saving rate and to ROW demand for German exports, as well as German labour market reforms and other positive German aggregate supply shocks. Those shocks had a noticeable negative effect on REA net exports, but only a modest effect on REA real activity. We expect the contribution of past German labour market reforms to the current account surplus to decline in future years as wage growth picks up again. One policy conclusion from our analysis could be that similar reforms were needed in EA deficit countries. Structural reforms in the REA will boost growth and improve external balances there, eroding Germany's competitive advantage. As far as savings are concerned, illustrative model simulations suggest increased awareness about future demographic developments and pension generosity could explain a sizable and persistent positive effect on the German current account. To the extent that this holds, it would not call for corrective policy actions. Regarding public demand, Germany's sound fiscal position provides space for a less restrictive fiscal policy; the rise in German demand would reduce the external surplus and help to achieve a rebalancing in the EA, albeit by a modest amount.

REFERENCES

Adalet, M., B. Eichengreen (2007): "Current account reversals--always a problem?", In: R. Clarida (ed.), 'G7 Current Account Imbalances: Sustainability and Adjustment', Chicago: University of Chicago Press.

Adolfson, M., S. Laséen, J.Lindé, M. Villani (2007): "Bayesian estimation of an open economy DSGE model with incomplete pass-through", Journal of International Economics. Journal of International Economics 72, 481-511.

Adjemian, S., H. Bastani, M. Juillard, F. Karamé, J. Maih, F. Mihoubi, G. Perendia, M. Ratto, S. Villemot (2011): "DYNARE: Reference Manual, Version 4". DYNARE Working Paper Series, 1.

Aizenman, J. and Y. Jinjarak (2013): "Real estate valuation, current account and credit growth patterns, before and after the 2008-09 crisis", NBER Working Paper No 19190.

Backus, D., P. Kehoe, F. Kydland (1992): "International real business cycles", Journal of Political Economy 100, 745-775.

Beetsma, R. and M. Giuliodori (2011): "The effects of government purchases shocks: review and estimates for the EU", Economic Journal 121, F4-F32.

Buera, F., B. Moll (2012): "Aggregate Implications of a Credit Crunch", NBER WP 17775.

Carton, B., K. Hervé (2012): "Euro area real effective exchange rate misalignements", La Lettre du CEPII, No 319 - 19 April 2012

Chen, R., G-.M. Milesi-Ferretti, T. Tressel (2012): "External imbalances in the euro area," IMF Working Paper 12/236.

Chinn, M., B. Eichengreen and H. Ito (2013): "A forensic analysis of global imbalances", Working Paper, University of Wisconsin.

Christiano, L., M. Eichenbaum, C. Evans (2005): "Nominal rigidities and the dynamic effects of a shock to monetary policy", Journal of Political Economy 113, 1–45.

Deutsche Bundesbank (2011): "Germany's external position against the background of increasing economic policy surveillance", Monthly Report, October 2011, pp. 41-59.

Dustmann, C., B. Fitzenberger, U. Schönberg, A. Spitz-Oeber (2014): "From sick man of Europe to Economic superstar: Germany's resurgent economy", Journal of Economic Perspectives 28, 167-188.

Erceg, C., L. Guerrieri, C. Gust (2006): "SIGMA: a new open economy model for policy analysis", International Journal of Central Banking 2, 1-50.

European Commission (2009): "Ageing report: economic and budgetary projections for the EU-27 member states 2008-2060".

European Commission (2012a): "Current account surpluses in the EU", European Economy 9/2012.

European Commission (2012b): "Scoreboard for the surveillance of macroeconomic imbalances". European Economy Occasional Paper 92.

European Commission (2013): "Alert Mechanism Report 2014."

European Commission (2014): "Macroeconomic imbalances - Germany 2014", European Economy Occasional Paper no.174.

Fernández-Villaverde, J., L. Garicano, T. Santos (2013): "Political credit cycles: the case of the Eurozone", Journal of Economic Perspectives 27, 145-166.

Fisher, J. (2006): "The dynamic effects of neutral and investment-specific technology shocks", Journal of Political Economy 114, 413-52.

Fornaro, L. (2013): "Debt deleveraging, debt Relief and liquidity traps," Manuscript, CREI.

Flassbeck, H. (2012), "German mercantilism and the failure of the Eurozone", Manuscript.

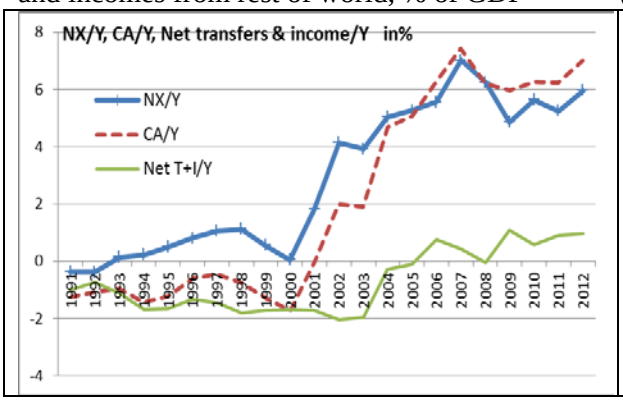
Forni, L., A. Gerali and M. Pisani (2010): "Macroeconomic effects of greater competition in the service Sector: the case of Italy", Macroeconomic Dynamics 14, 677-708.

German Council of Economic Advisors (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung) (2011): "Herausforderungen der demografischen Wandels."
Gete, P. (2010): "Housing markets and current account dynamics", Working Paper, Georgetown University.
Gomes, S., P. Jacquinot, M. Mohr and M. Pisani (2013): "Structural reforms and macroeconomic performance in the Euro Area countries: a model-based assessment", International Finance 16, 23-44.
Hale, G., M. Obstfeld (2013): "The Euro and the geography of international debt flows", Working Paper, San Francisco Fed and UC Berkeley.
Hobza, A., S. Zeugner (2013): "The imbalanced balance and its unraveling: current accounts and financial flows in the Euro Area", Working Paper, DG-ECFIN, European Commission.
Huefner, F., I. Koske (2010): "Explaining household saving rates in G7 countries: implications for Germany", OECD Economics Department Working Papers 754.
Iacoviello, M. M., S. Neri (2010): "Housing market spillovers: evidence from an estimated DSGE model." American Economic Journal, Macroeconomics 2, 125–164.
In 't Veld, J. (2013), "Fiscal consolidations and spillovers in the Euro area periphery and core", European Economy, Economic Papers, No 506.
In't Veld, J., R. Raciborski, M. Ratto, W. Roeger (2011): "The recent boom-bust cycle: the relative contribution of capital Flows, credit Supply and asset bubbles," European Economic Review 55, 386-406.
In 't Veld, J., R. Kollmann, B. Pataracchia, M. Ratto, W. Roeger (2013): "International capital flows and the boom-bust cycle in Spain," Working Paper, DG-ECFIN, EU Commission.
International Monetary Fund (2013a): "Germany: 2013 article IV consultation", IMF Country Report No. 13/255.
International Monetary Fund (2013b): "External balance assessment (EBA) methodology: technical background", manuscript.
Jacob, P. and G. Peersman (2013): "Dissecting the dynamics of the US trade balance in an estimated equilibrium model," Journal of International Economics 90, 302-315.
Justiniano, A., G. Primiceri, A. Tambalotti (2008): "Investment shocks and business cycles," Journal of Monetary Economics 57, 132-145.
Kollmann, R. (1998): "U.S. trade balance dynamics: the role of fiscal policy and productivity shocks and of financial market linkages," Journal of International Money and Finance 17, 637-669.
Kollmann, R. (2001): "The exchange rate in a dynamic-optimizing business cycle model with nominal rigidities: a quantitative investigation", *Journal of International Economics*, Vol. 55, pp.243-262.
Kollmann, R. (2002): "Monetary policy rules in the open economy: effects of welfare and business cycles," Journal of Monetary Economics 49, 989-1015.
Kollmann, R. (2004): "Welfare effects of a monetary union: the role of trade openness," Journal of the European Economic Association, Vol. 2, pp. 289-301.
Kollmann, R., W. Roeger, J. in't Veld (2012): "Fiscal policy in a financial crisis: standard policy vs. bank rescue measures," American Economic Review 102, 77-81
Kollmann, R. (2013): "Global banks, financial shocks and international business cycles: evidence from an estimated model," Journal of Money, Credit and Banking 45(S2), 159-195.
Kollmann, R., M. Ratto, W. Roeger and J. in't Veld (2013): "Fiscal policy, banks and the financial crisis," Journal of Economic Dynamics and Control, Vol. 37, pp. 387-403.
Krugman, P. (2013): "Those depressing Germans," New York Times (November 3).

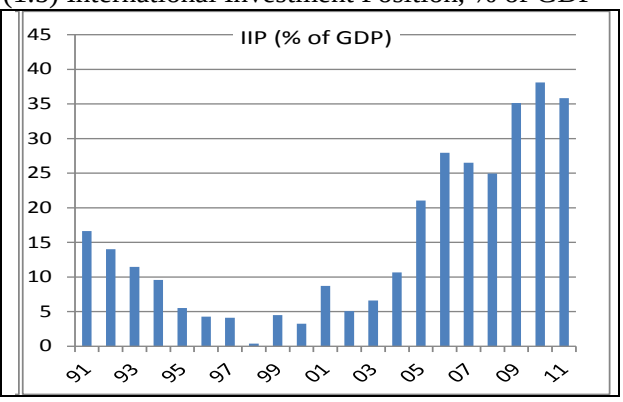
Lagarde, C. (2012): Interview with 'Die Zeit' weekly newspaper (Dec. 27, 2012).
Lane, P. (2012): "Capital flows in the Euro Area," Working Paper, Trinity College Dublin.
Louanges, M. (2005): "Is Germany on its way to regaining its European benchmark status," PIMCO European Perspectives (September 2005).
McCallum, B. (1994): "A reconsideration of the uncovered interest parity relationship," Journal of Monetary Economics 33, 105-132.
Mendoza, E. (2010): "Sudden stops, financial crises, and leverage," American Economic Review 100, 1941–1966
Milesi-Ferretti, GM, A. Razin (1998): "Sharp reductions in current account deficits--An empirical analysis," European Economic Review 42, 897-908.
Obstfeld, M., K. Rogoff (1996): "Foundations of international macroeconomics", MIT Press.
Obstfeld, M. and K. Rogoff (2010): "Global imbalances and the financial crisis: products of common causes." In: Glick, R., Spiegel, M. (Eds.), Asia and the Global Financial Crisis. Federal Reserve Bank of San Francisco, San Francisco, pp.131-172.
Obstfeld, M. (2012): "Does the current account still matter?" American Economic Review 102, 1-23.
Organisation for Economic Co-operation and Development (2013): "Employment and labor market statistics."
Pytlarczyk, E. (2005): "An estimated DSGE model for the German economy within the euro area," Discussion Paper No 33/2005, No 33/2005.
Ratto M, W. Roeger and J. in 't Veld (2009) , "QUEST III: an estimated open-economy DSGE model of the Euro Area with fiscal and monetary policy", Economic Modelling 26, 222-233
Reis, R. (2013): "The Portuguese slump-crash and the Euro-crisis," Brookings Papers on Economic Activity, 143-193.
Sinn, H-W. (2003): "The laggard of Europe," CESifo Forum Vol. 4, Special Issue No. 1.
Sinn, H.-W. (2006): "The pathological export boom and the bazaar effect: how to solve the German puzzle," The World Economy, Vol. 29, No. 9, pp. 1157-1175.
Sinn, H.-W. (2010): "Rescuing Europe," CESifo Forum, Vol. 11, special issue, pp.1-22.
Sinn, H.-W. (2013): "Jetzt hilft nur durchwursteln," ifo Standpunkt 150.
Statistisches Bundesamt (2003): "9. Bevölkerungsvorausberechnung."
Statistisches Bundesamt (2006): "10. Bevölkerungsvorausberechnung."
Statistisches Bundesamt (2009): "11. Bevölkerungsvorausberechnung."
Statistisches Bundesamt (2012): "12. Bevölkerungsvorausberechnung."
U.S. Department of the Treasury (2013): "Report to congress on international economic and exchange rate policies." (October 30, 2013)
Vogel, L. (2011): "Structural reforms and external rebalancing in the Euro Area: A model-based analysis," European Economy, Economic Papers 433.
Vogel, L. (2013): "Nontradable sector reform and external rebalancing in Monetary Union: a model-based analysis," Working Paper, DG-ECFIN, European Commission.
Werding, M. (2013): "Alterssicherung, Arbeitsmarktdynamik und neue Reformen: Wie das Rentensystem stabilisiert werden kann," Bertelsmann Stiftung: Gütersloh
Wolf, M. (2013): "Germany is a weight on the world," Financial Times (November 5).

Figure 1: The German current account, net exports, consumption and investment

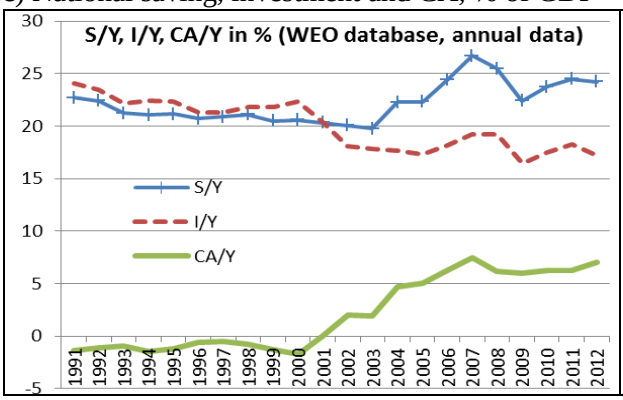
(1.a) Current Account, net exports, net transfers and incomes from rest of world, % of GDP



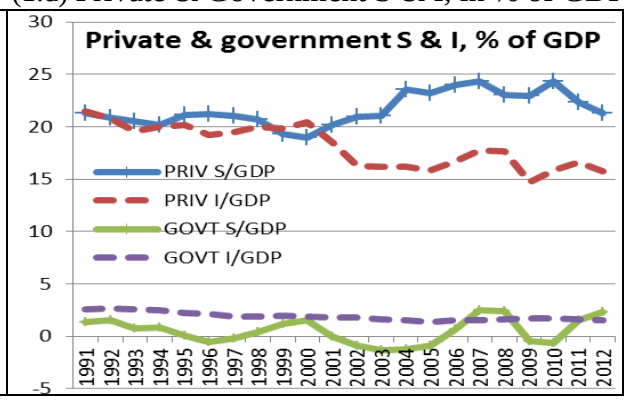
(1.b) International Investment Position, % of GDP



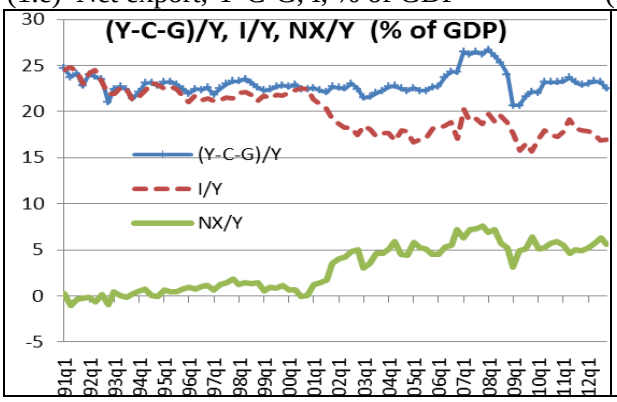
(1.c) National saving, investment and CA, % of GDP



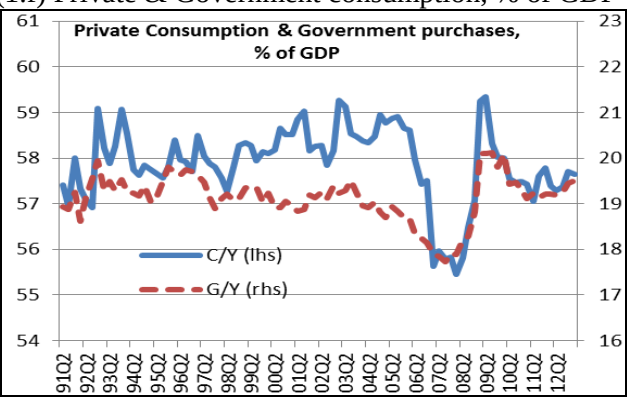
(1.d) Private & Government S & I, in % of GDP



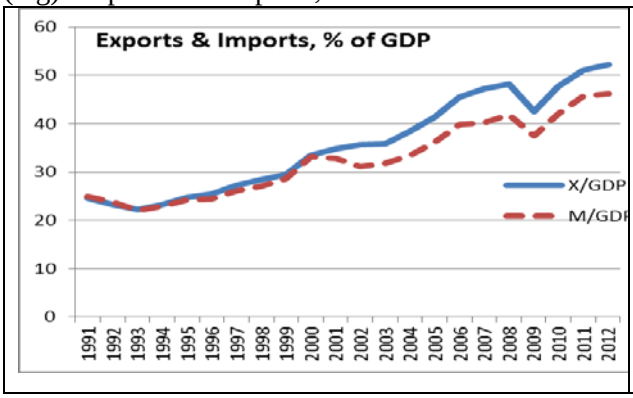
(1.e) Net export, Y-C-G, I, % of GDP



(1.f) Private & Government consumption, % of GDP



(1.g) Exports and Imports, % of GDP



(1.h) Total net exports of Germany; German NX to REA; REA net imports; EA net exports

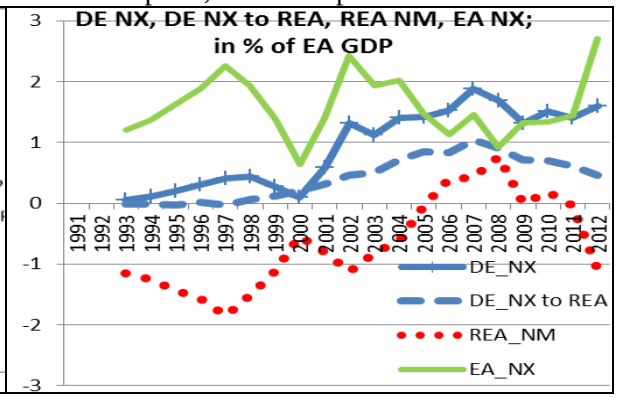


Figure 2: Real activity (DE: Germany)

(2.a) Germany: real GDP & aggregate demand components (2.b) YoY GDP growth rates (Germany, REA, ROW)

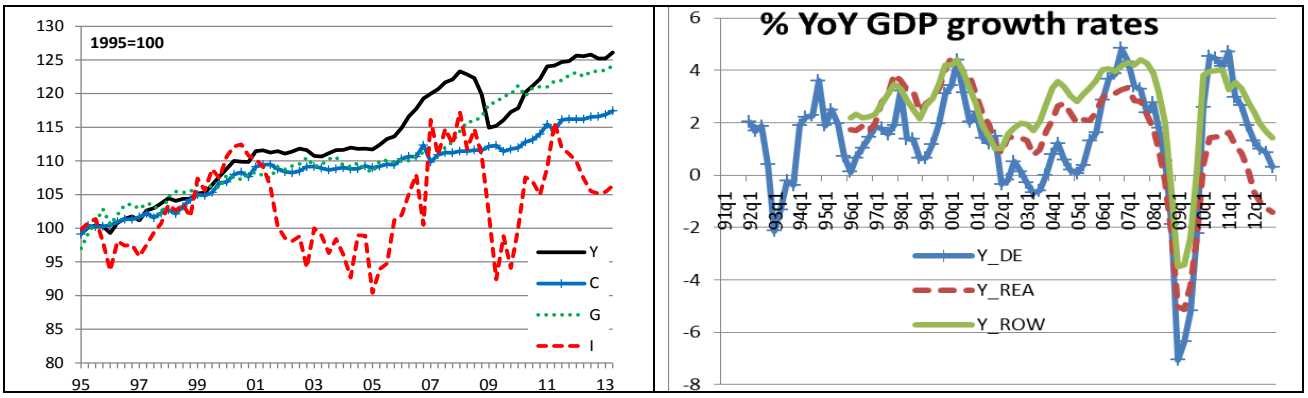
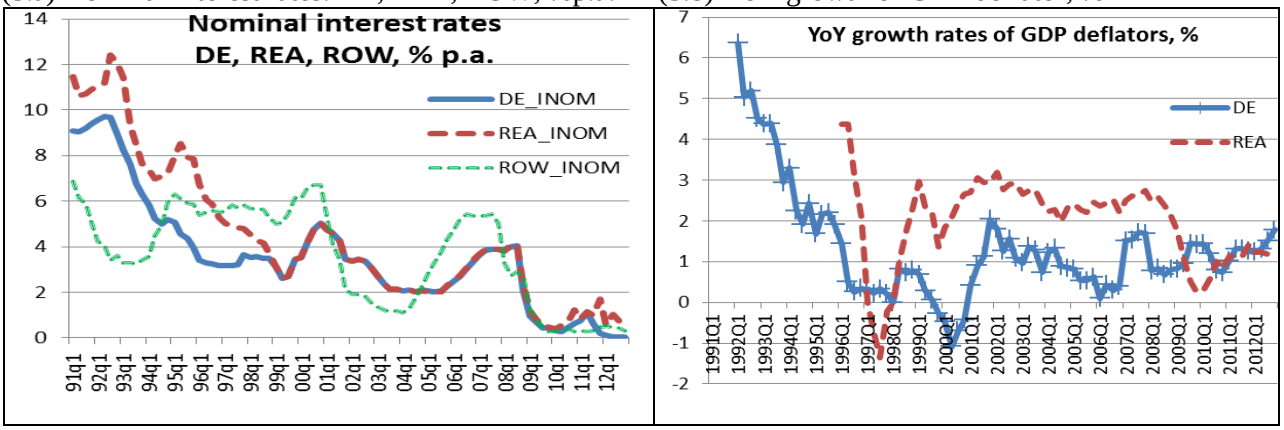
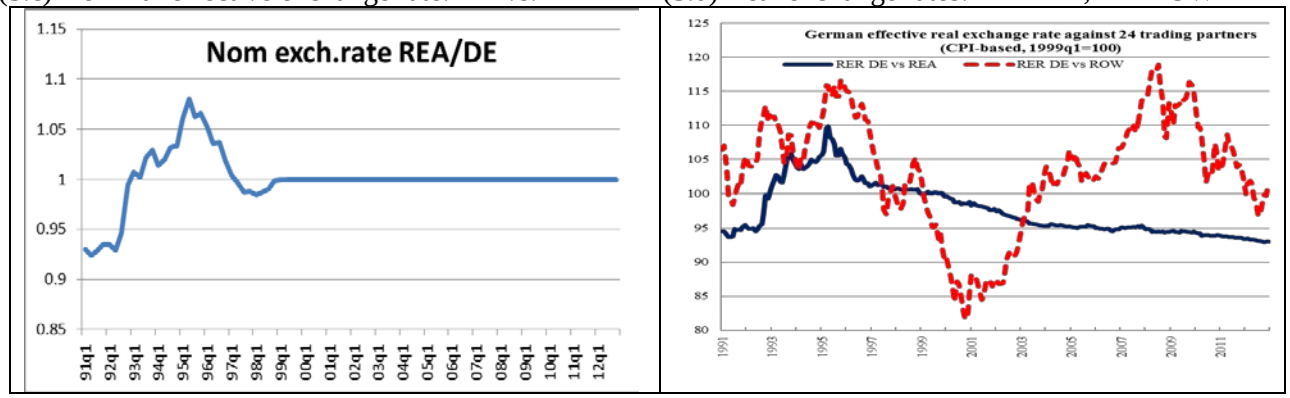


Figure 3: Interest rates, inflation, exchange rates (DE: Germany)

(3.a) Nominal interest rates: DE, REA, ROW, %p.a. (3.b) YoY growth of GDP deflator, %



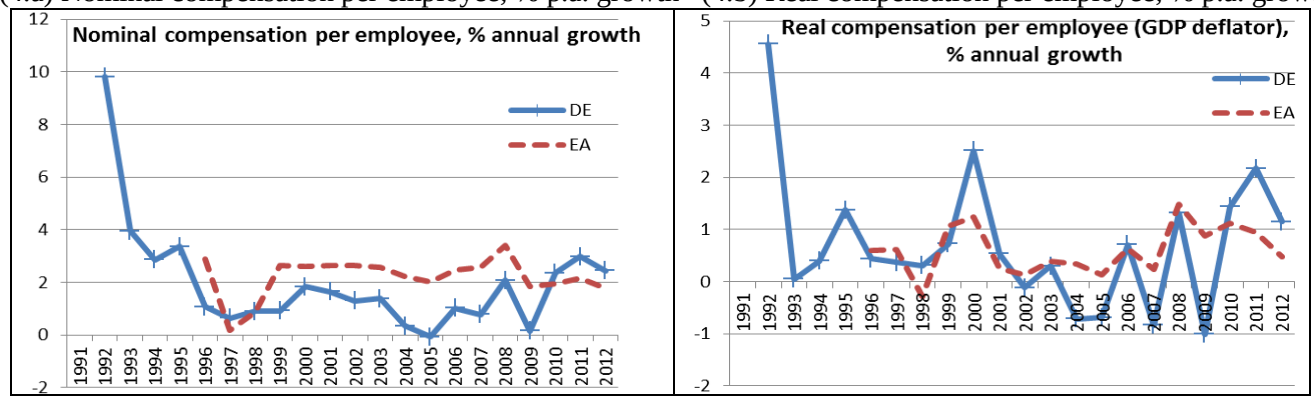
(3.c) Nominal effective exchange rate: DE vs. REA (3.d) Real exchange rates: DE-REA; DE-ROW



Rise: DE appreciat.; exch. rate 1999-2012 normalized at 1 Rise: DE appreciation

Figure 4: Wages, unit labor costs, unemployment benefits (DE: Germany)

(4.a) Nominal compensation per employee, % p.a. growth (4.b) Real compensation per employee, % p.a. growth



(4.c) Nominal unit labor cost, DE & EA (2005=100) (4.d) Average unemployment benefit ratio, Germany

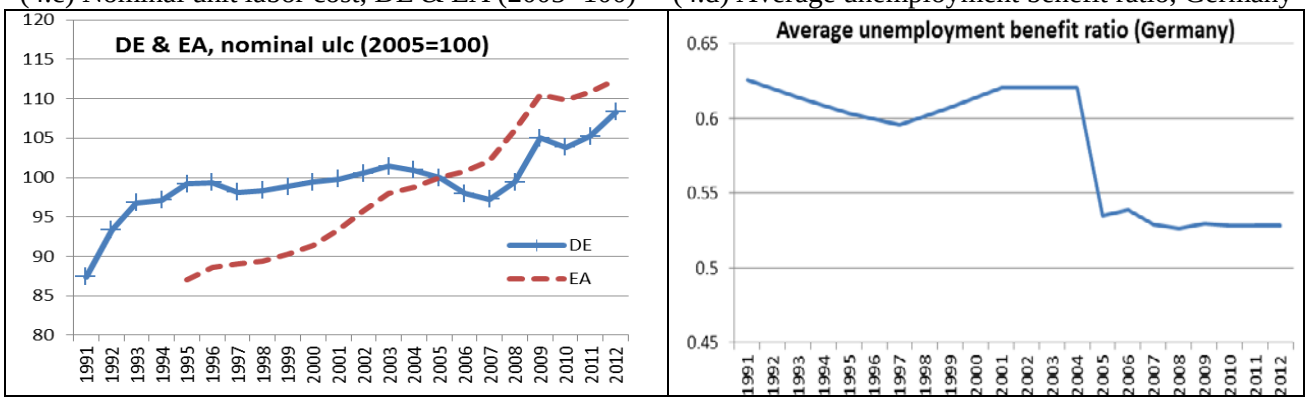
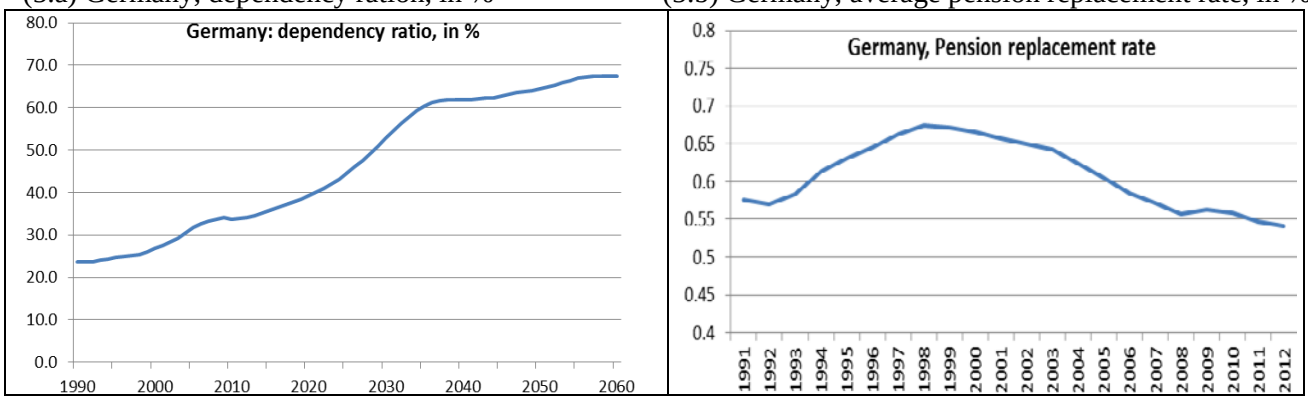


Figure 5: Demographics and pensions: Germany

(5.a) Germany, dependency ration, in % (5.b) Germany, average pension replacement rate, in %



2011-2060: projections (German Council of Economic Advisors (2011))

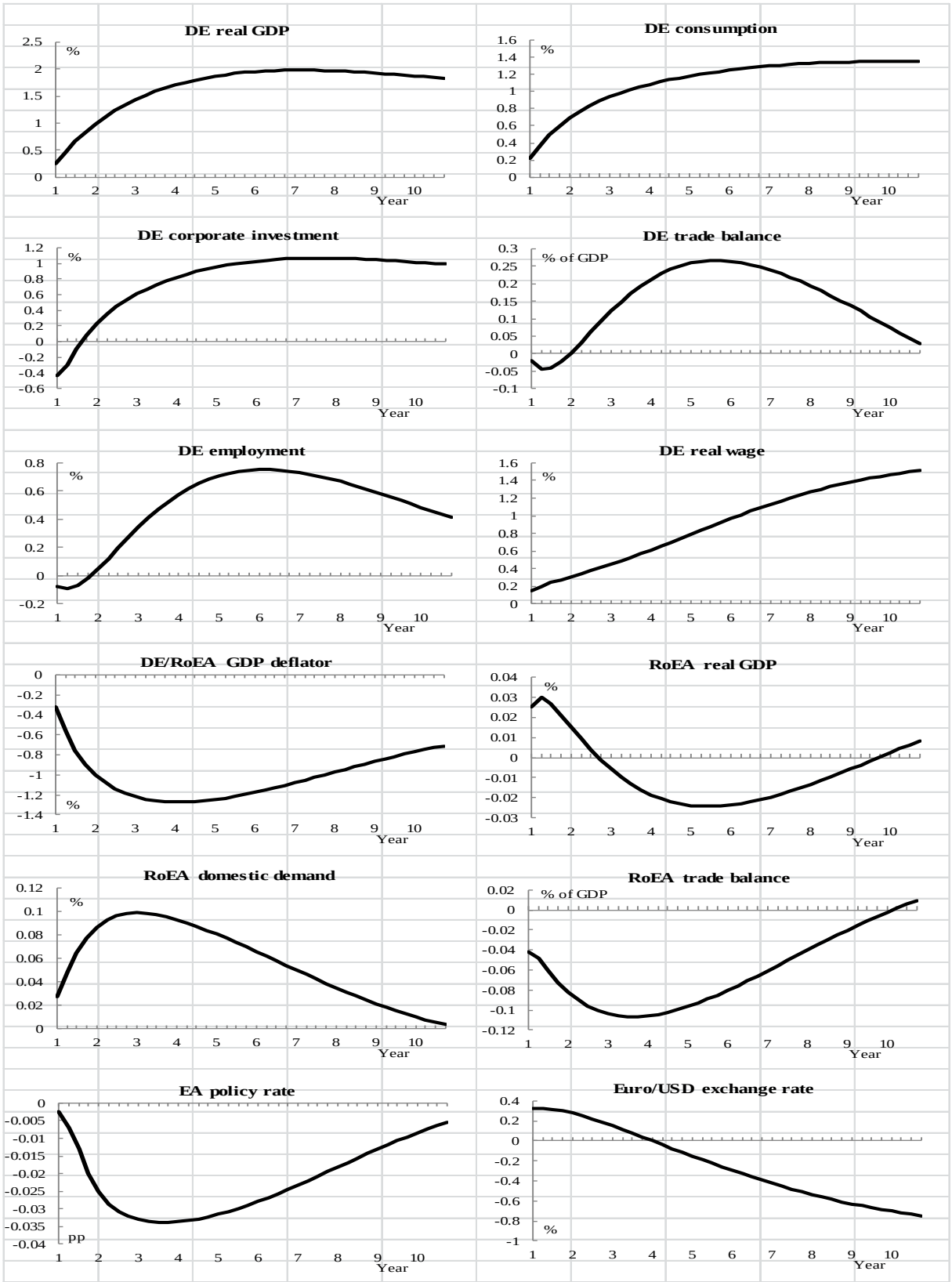


Figure 6.a Positive shock to German TFP

Dynamic responses to a positive 1 standard deviation innovation to German TFP are shown. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

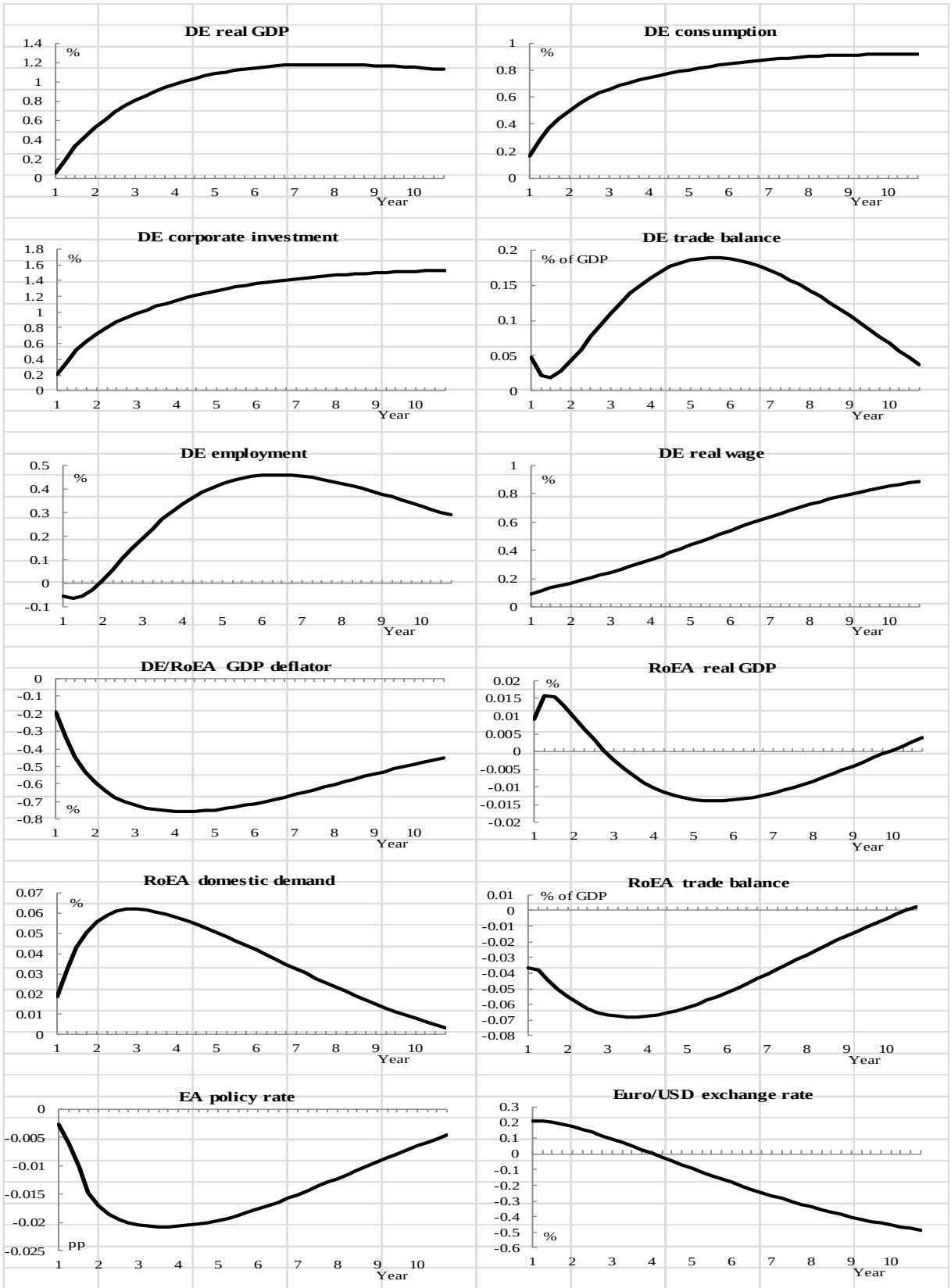


Figure 6.b Positive shock to German investment efficiency (production capital)

Dynamic responses to a positive 1 standard deviation innovation to German investment efficiency (productive capital) are shown. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

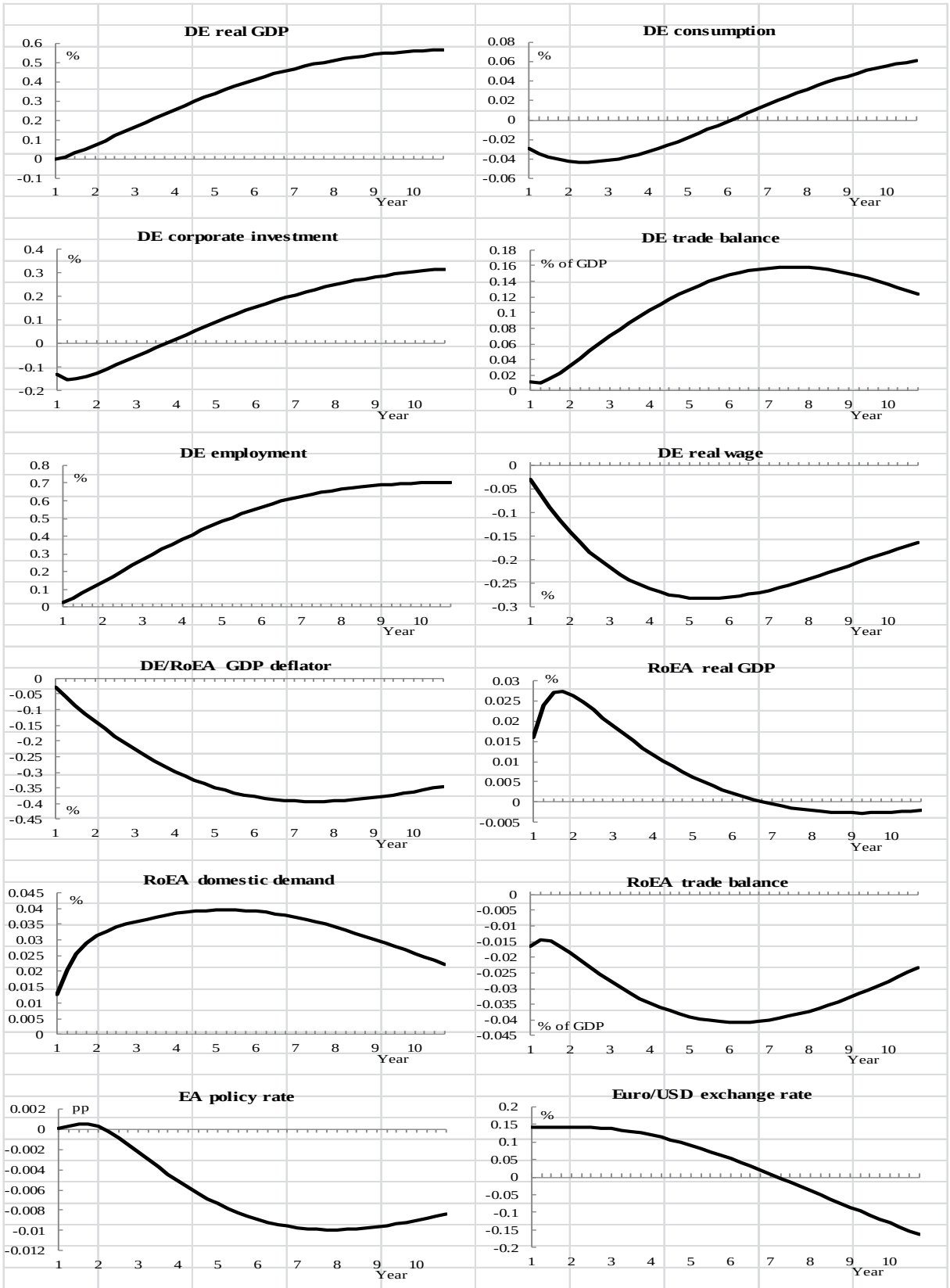


Figure 6.c Cut in German unemployment benefit ratio

Dynamic responses to a permanent 1 percentage point reduction in the German unemployment benefit ratio are shown. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

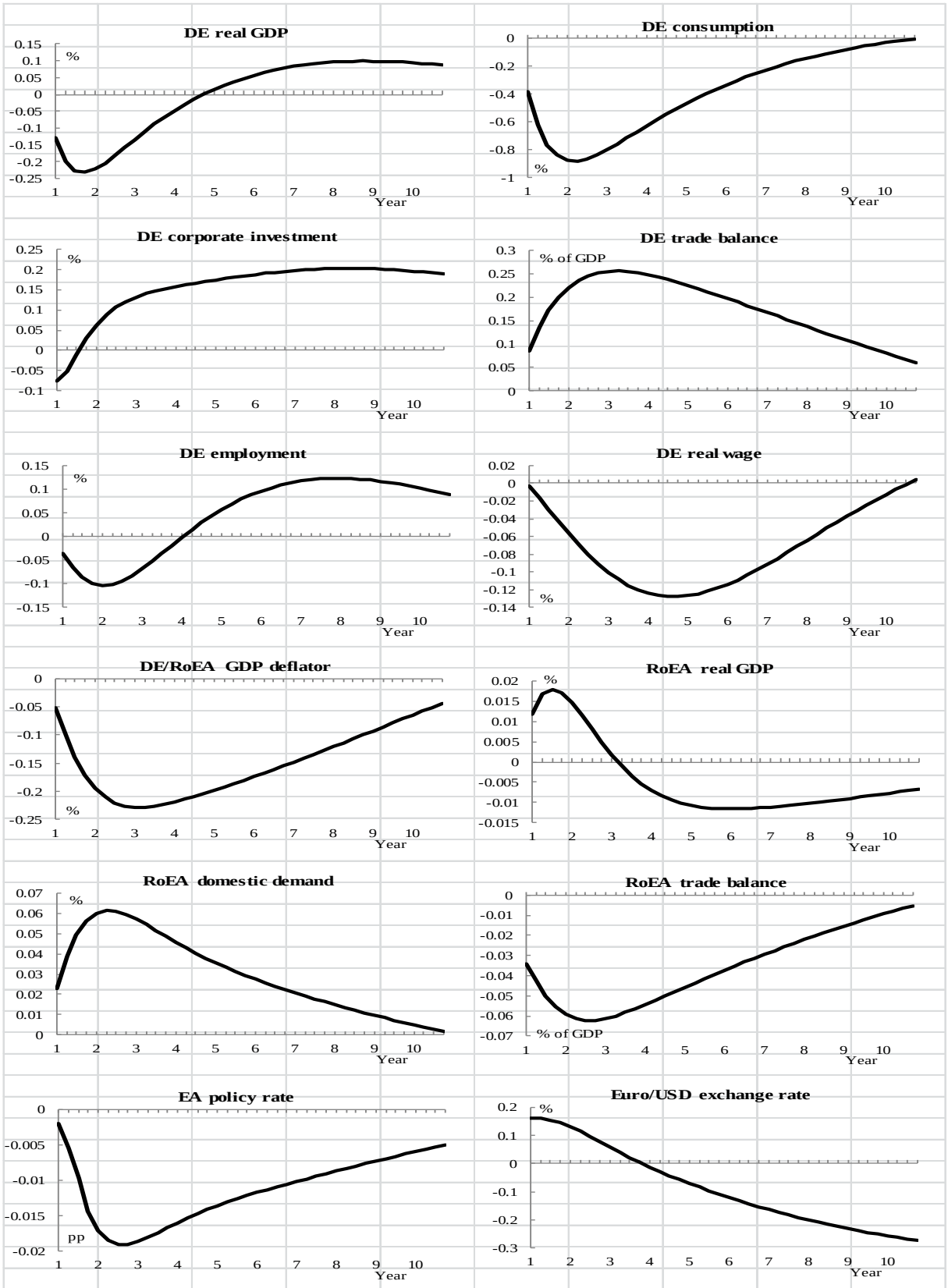


Figure 6.d Positive German saving shock (fall in subjective rate of time preference)

The Figure shows dynamic responses to a negative 1 standard deviation innovation to the rate of time preference of German households. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

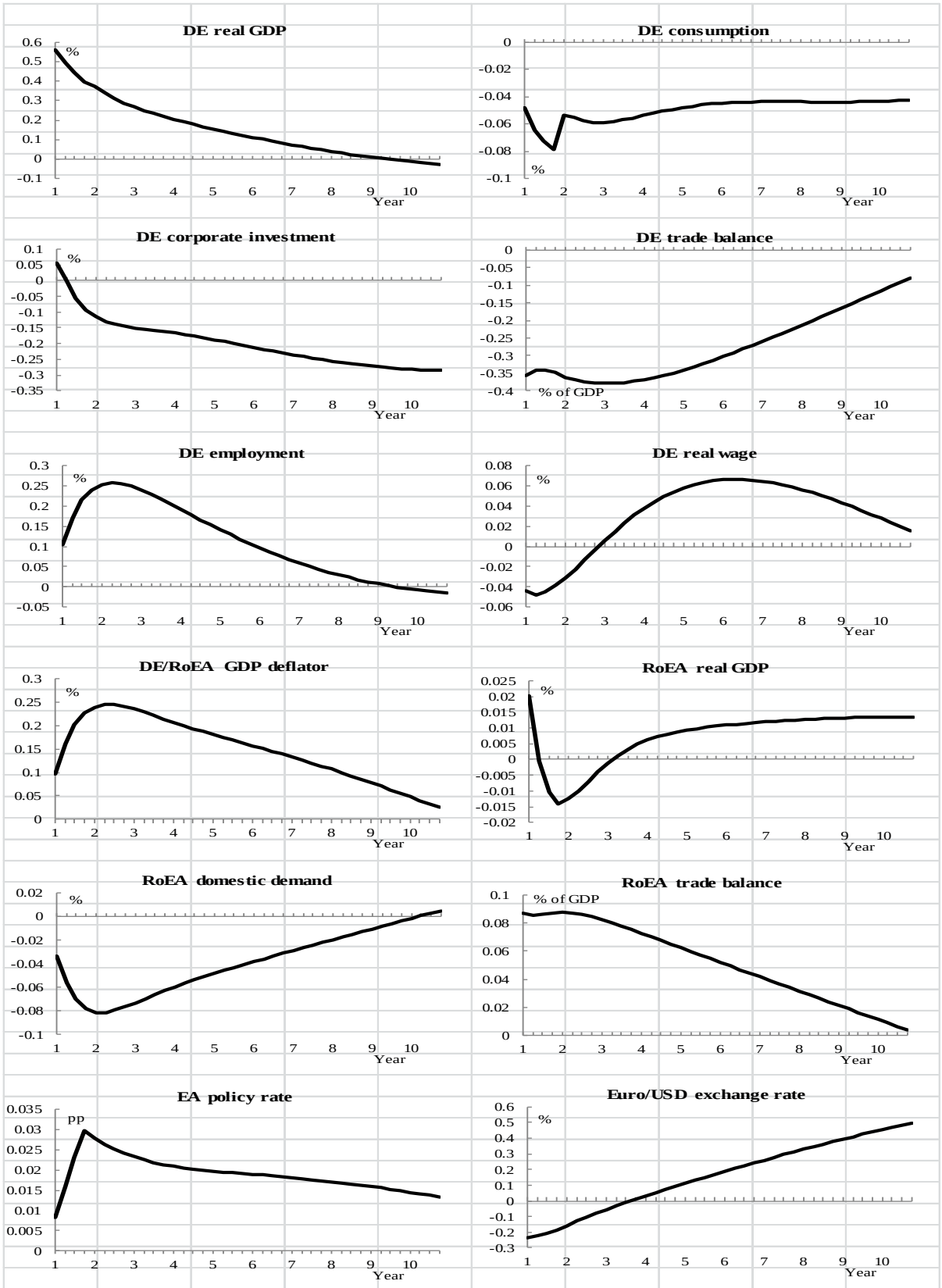


Figure 6.e Positive shock to German government consumption

Dynamic responses to a positive 1% of GDP innovation to German government consumption are shown. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

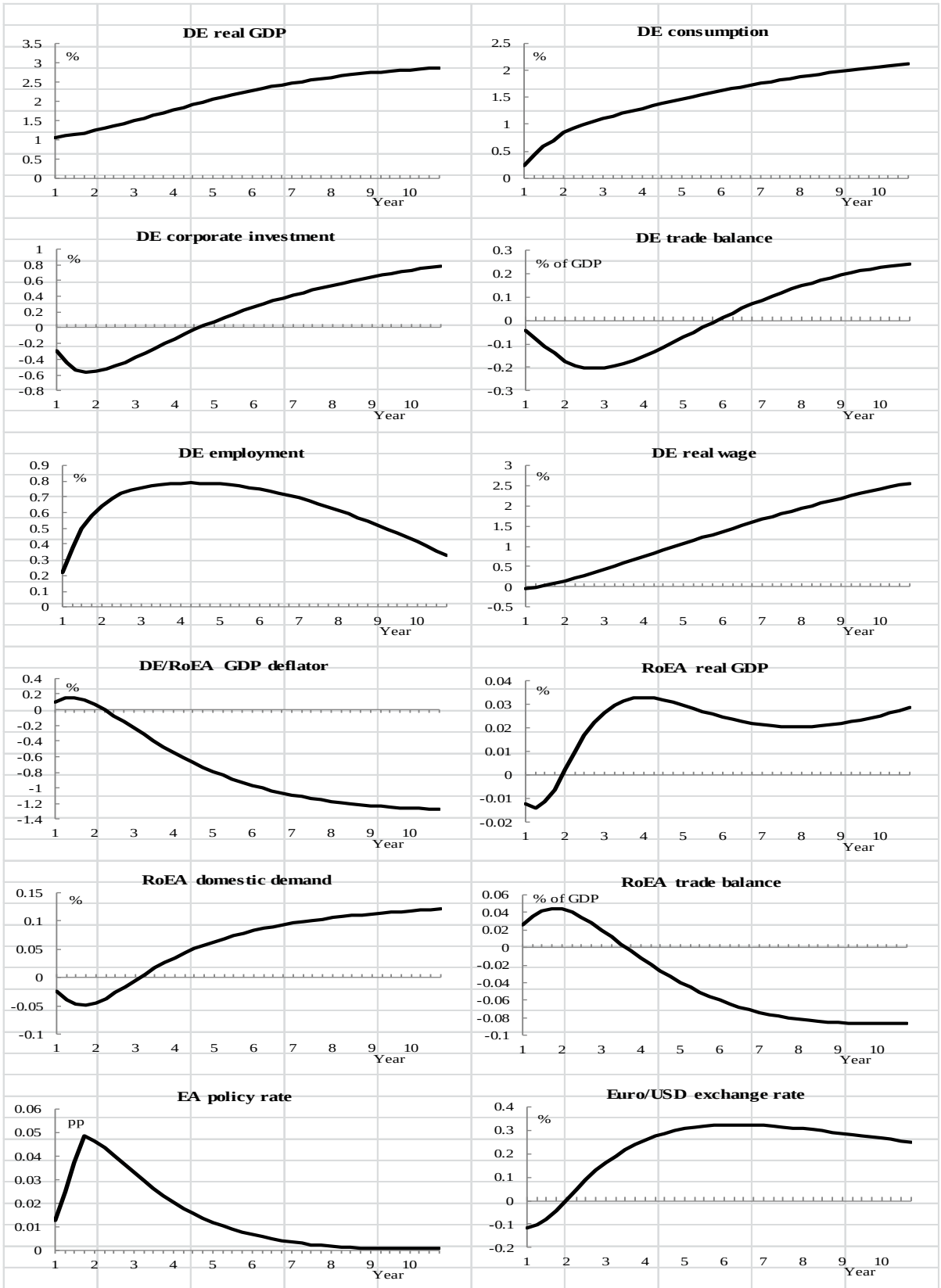


Figure 6.f Positive shock to German government investment

Dynamic responses to a positive 1% of GDP innovation to German government investment are shown. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

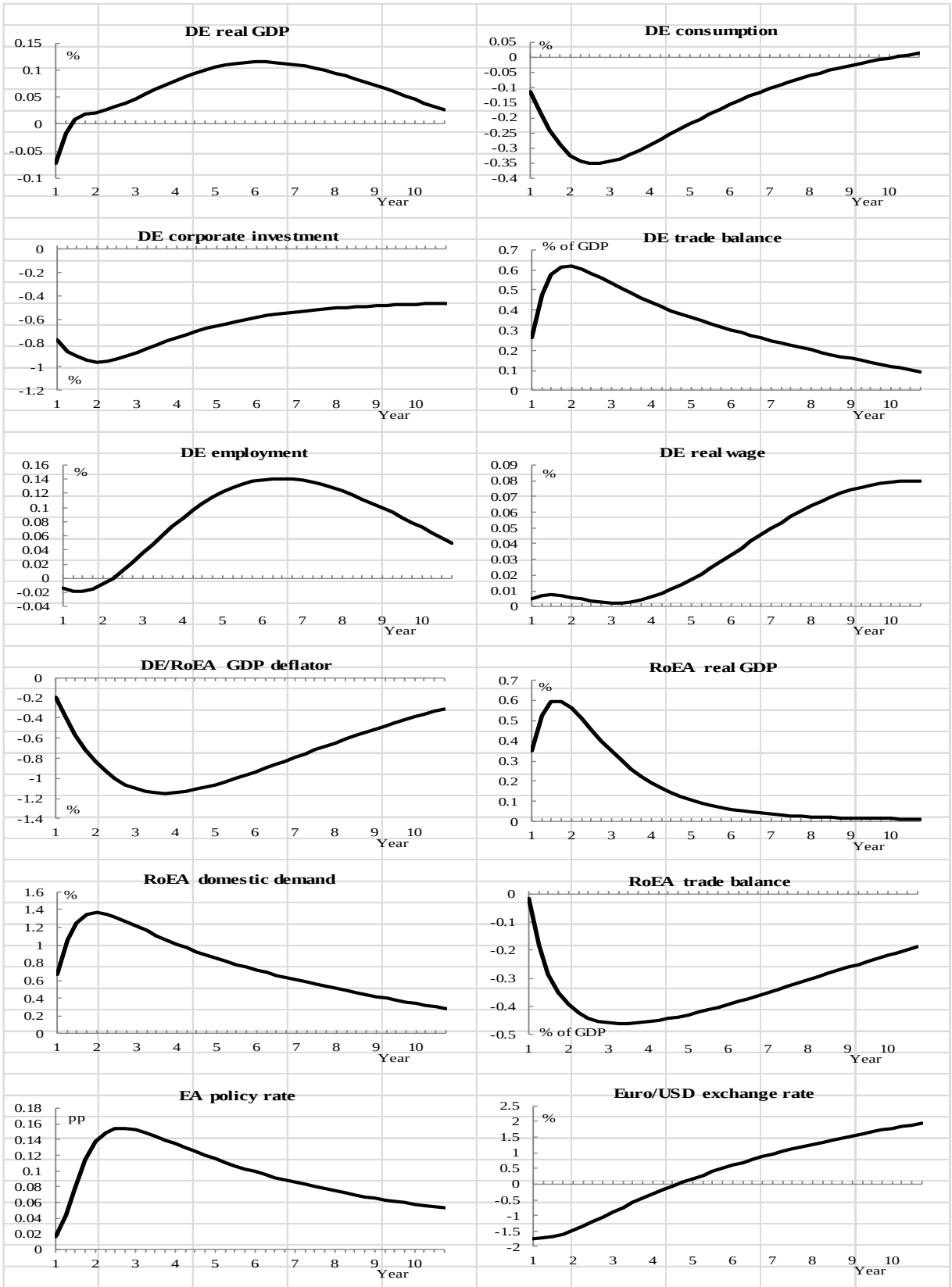


Figure 6.g Fall in REA-German risk premium

The Figure shows dynamic responses to a negative 1 percentage point innovation to difference between REA bonds and German bonds. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

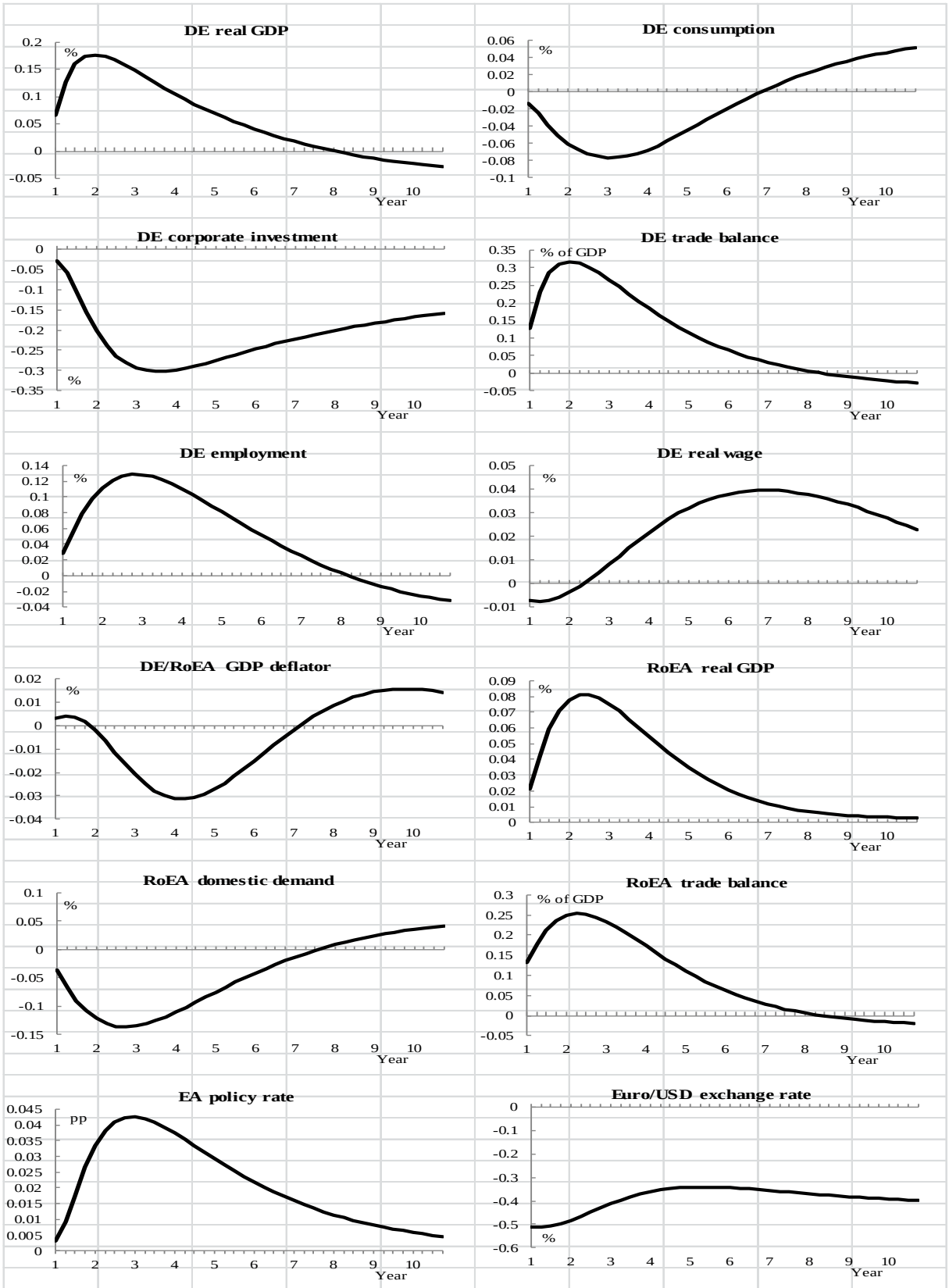
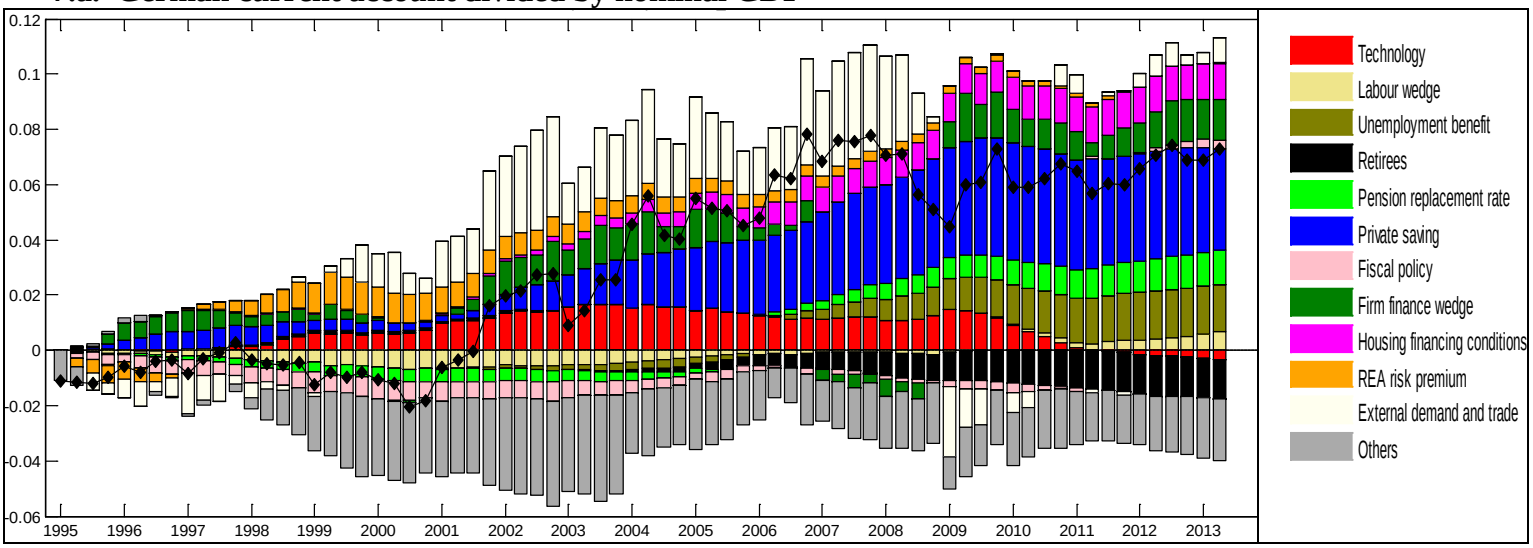


Figure 6.h Rest-of-world aggregate demand shock

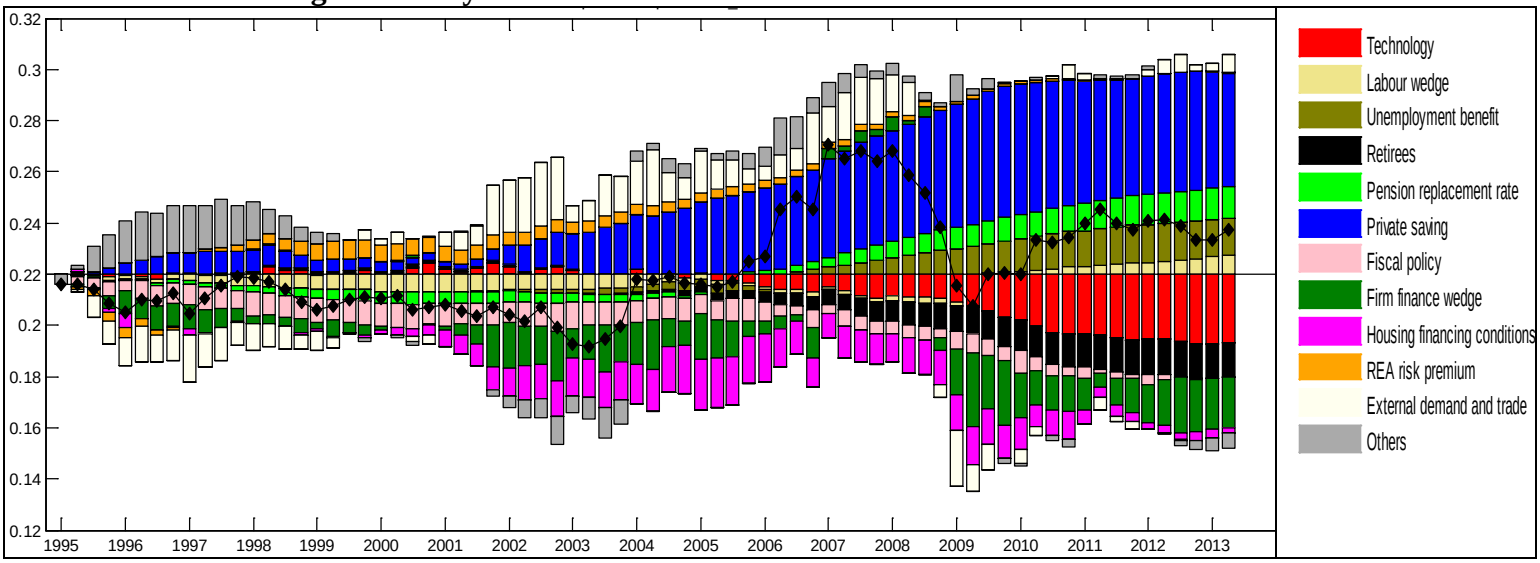
The Figure shows dynamic responses to a persistent 1 standard deviation increase in the subjective discount rate of ROW agents. Interest rate responses (% p.a.) are expressed as differences from unshocked path; trade balance responses are shown as % differences from unshocked path normalized by steady state domestic GDP; responses of other variables shown as relative % deviations from unshocked paths. A rise in the Euro/USD exchange rate corresponds to a Euro depreciation.

Figure 7. Historical decompositions of German macroeconomic variables

7.a. German current account divided by nominal GDP



7.b. German saving divided by nominal GDP



7.c. German nominal investment divided by nominal GDP

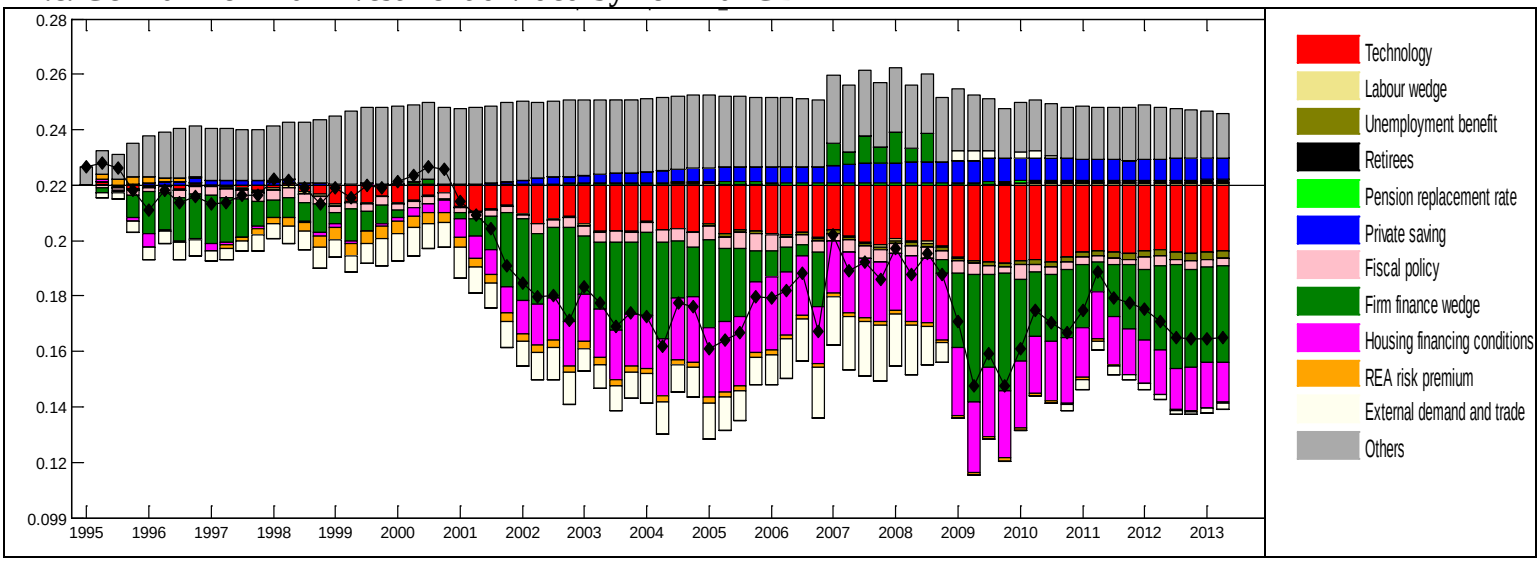
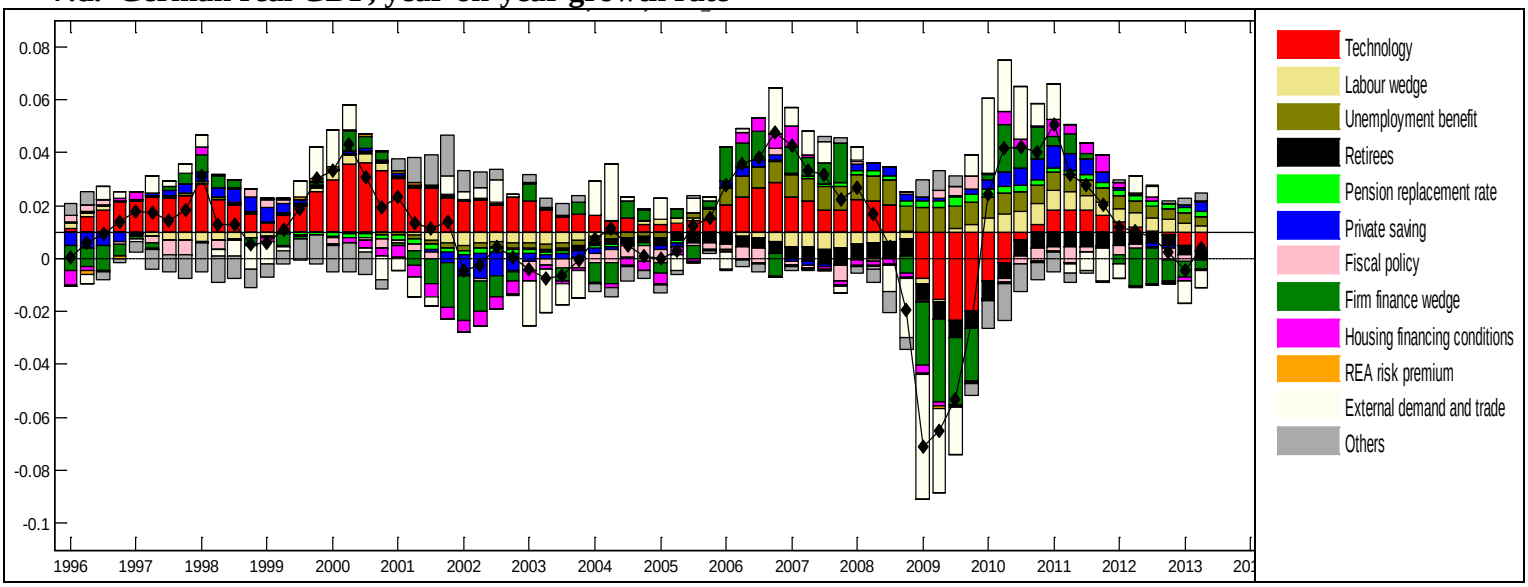
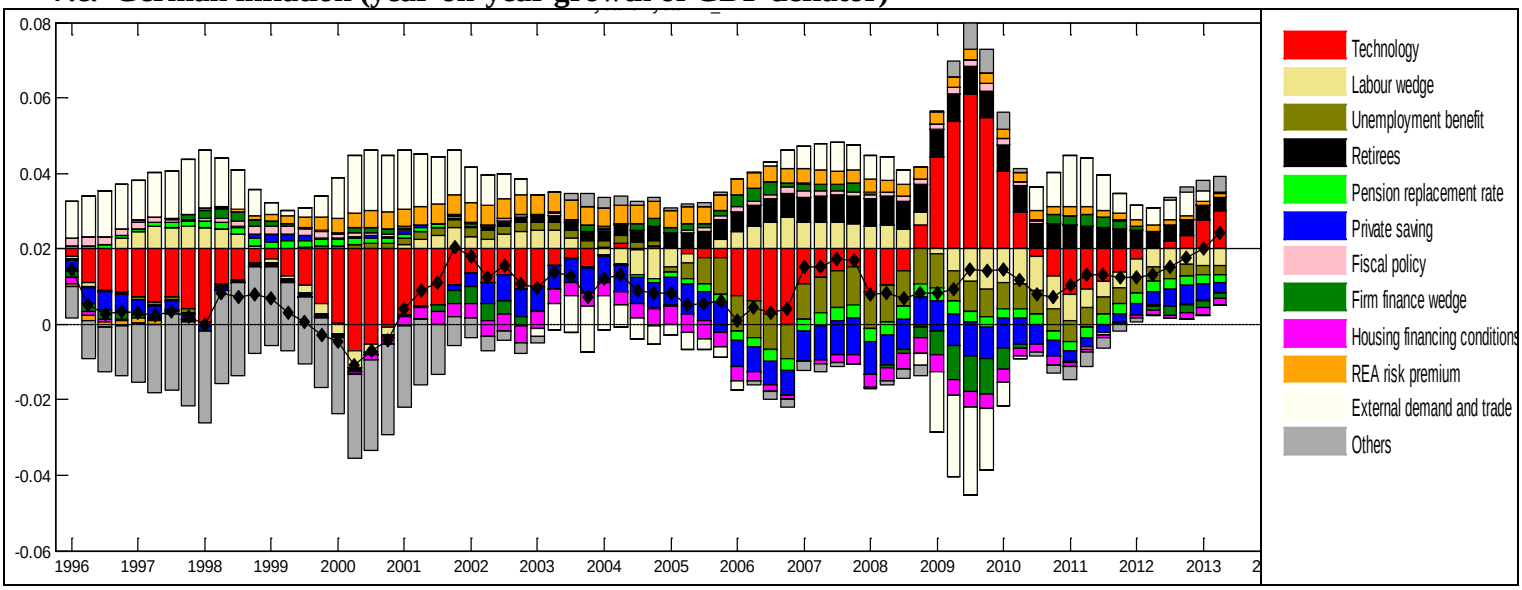


Figure 7—continued

7.d. German real GDP, year-on-year growth rate



7.e. German inflation (year-on-year growth of GDP deflator)

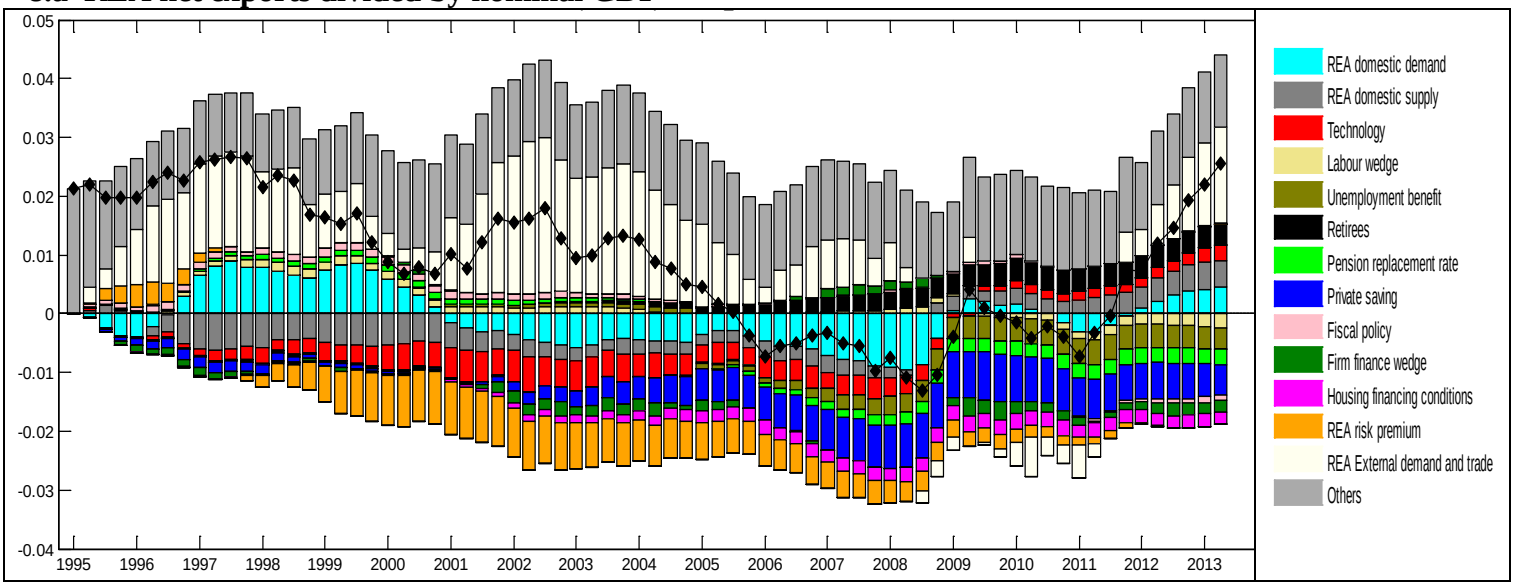


Note: The lines with black lozenges show the historical data. Thin horizontal line represents steady state values. Vertical bars show contributions of different types of shocks to the historical data. Vertical bars above the horizontal (steady state) line represent positive shock contributions to the historical data., while bars below the horizontal line represent negative contributions. Sum of contributions of all shocks equal the historical data.

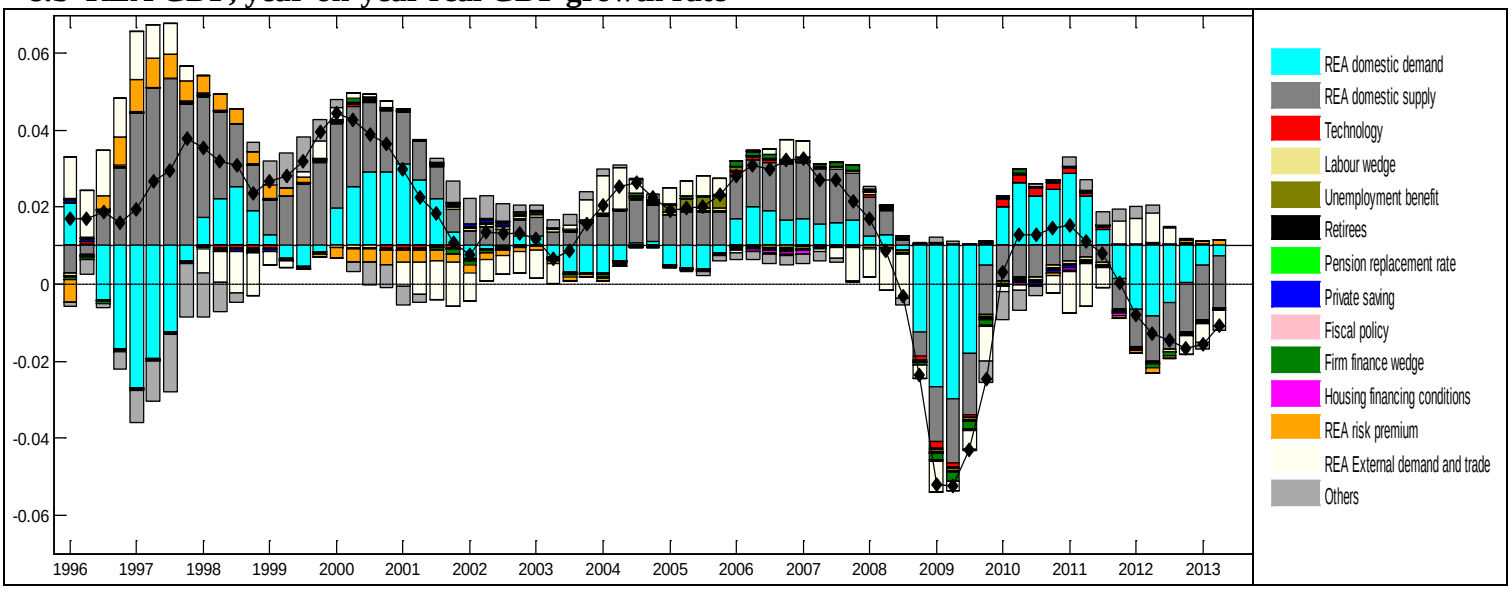
Contributions of the following (groups of) exogenous shocks originating in Germany are plotted: (1) TFP and investment efficiency (bars labeled 'technology'); (2) Wage mark-up ('Labour wedge'); (3) Unemployment benefit ratio ('Unemployment benefit'); (4) Old-age dependency ratio ('Retirees'); (5) Pension replacement rate; (6) Subjective rate of time preference ('Private saving'); (6) Fiscal policy; (7) Firm finance wedge; (8) Household loan-to-value ratio and risk premium on housing capital ('household financing conditions'). In addition, we show the contribution of disturbances to: (1) REA-German interest rate spread ('REA risk premium'); (2) shocks originating in the REA and ROW, and shocks to the relative preference for German vs. imported goods ('External demand and trade'). The remaining shocks are combined into a category labeled 'Other shocks'.

Figure 8. Historical decompositions of REA macroeconomic variables

8.a REA net exports divided by nominal GDP



8.b REA GDP, year-on-year real GDP growth rate



Note: The lines with black lozenges show the historical data. Thin horizontal line represents steady state values. Vertical bars show contributions of different types of shocks to the historical data. Vertical bars above the horizontal (steady state) line represent positive shock contributions to the historical data, while bars below the horizontal line represent negative contributions. Sum of contributions of all shocks equal the historical data.

Contributions of (1) 'REA domestic demand shocks,' and (2) 'REA domestic supply shocks' are plotted. In addition, we show the contributions of the following shocks originating in Germany: (1) TFP and investment efficiency (bars labeled 'technology'); (2) Wage mark-up ('Labour wedge'); (3) Unemployment benefit ratio ('Unemployment benefit'); (4) Old-age dependency ratio ('Retirees'); (5) Pension replacement rate; (6) Subjective rate of time preference ('Private saving'); (6) Fiscal policy; (7) Firm financing wedge; (8) Household loan-to-value ratio and risk premium on housing capital ('household financing conditions'). Also shown are the contributions of: (1) REA-German interest rate spread ('REA risk premium'); (2) shocks originating in the ROW, and shocks to the relative preference for REA goods vs. goods imported by the REA ('REA external demand and trade'). The remaining shocks are combined into a category labeled 'Other shocks'.

APPENDICES

A. Detailed model description
B. Observables and data sources
C. Econometric methodology and estimation results
D. Sensitivity analysis

A. Model description

The model is an extension of the QUEST model estimated on euro area data by Ratto et al. (2009), and similar model versions have been estimated on Spanish data (in't Veld et al., 2012) and on US data (in't Veld et al., 2011).

We consider a three-region set-up with Germany, the rest of the euro area (REA) and the rest of the world (RoW). The German block of the model is rather detailed, while the REA and RoW blocks are more stylized.

The German block assumes two representative households: One household has a low rate of time preference and holds financial assets ('saver household'). The other household has a higher rate of time preference, and borrows from the 'saver household' using her housing stock as collateral. We assume that the loan-to-value ratio (ratio of borrowing to the value of the collateral) fluctuates exogenously, and that the collateral constraint binds at all times. Both households provide labour services to goods producing firms, and they accumulate housing capital. Worker welfare depends on their consumption, hours worked and stock of housing capital. The patient household owns the German goods producing sector and the construction sector; in equilibrium, the patient household also holds financial assets (government debt, foreign bonds).

German firms maximize the present value of the dividend stream paid to the patient (capitalist) household. We assume that German firms rent physical capital from saver households at a rental rate that equals the risk-free interest rate plus an exogenous stochastic positive wedge; that wedge hence creates a gap between the marginal product of capital and the risk-free interest rate. German firms export to the REA and the RoW. The production technology allows for variable capacity utilization and capital and labour adjustment costs. Household preferences exhibit habit formation in consumption. These model features help to better capture the dynamics of the current account and other macro variables of the German economy. The German block also assumes a government that finances purchases and transfers using distorting taxes and by issuing debt. The German block assumes exogenous shocks to preferences, technologies and policy variables that alter demand and supply conditions in markets for goods, labour, production capital, housing, and financial assets.

The models of the REA and RoW economies are simplified structures with fewer shocks; specifically, the REA and RoW blocks each consist of a New Keynesian Phillips curve, a budget constraints for a representative household, demand functions for domestic and imported goods (derived from CES consumption good aggregators), and a production technology that use labour as the sole factor input. The REA and RoW blocks abstract from productive capital and housing. In the REA and the RoW there are shocks to labour productivity, price mark ups, and the subjective discount rate, as well as monetary policy shocks, and shocks to the relative preference for domestic vs. imported consumption goods.

The behavioral relationships and technology are subject to autocorrelated shocks denoted by U_t^k, where *k* stands for the type of shock. The logarithm of $u_t^k \equiv \ln U_t^k$ will generally follow an AR(1) process with autocorrelation coefficient ρ^k and innovation ε_t^k.[18] The following sections describe the

[18] Lower cases denote logarithms, i.e. $z_t \equiv \ln Z_t$. Lower cases are also used for ratios and rates. In particular, we define $p_t^j \equiv P_t^j / P_t$ as the relative price of good j w. r. t. the GDP deflator. Domestic variables are without

modelling of the Germany block of the model, external linkages and the REA and RoW parts in detail.

A.1. Firms

A.1.1. Final goods producers

Firms operating in the final goods production sector are indexed by *j*. Each firm produces a variety of the domestic good which is an imperfect substitute for varieties produced by other firms. Because of imperfect substitutability, firms are monopolistically competitive in the goods market and face a downward-sloping demand function for goods. Domestic final good producers sell the goods and services to domestic and foreign households, investment and construction firms and governments.

Output is produced with a Cobb-Douglas production function using firm capital K_t^j, employment L_t^j and public infrastructure KG_t as inputs and the TFP scaling factor A_t:

(1) $$Y_t^j = A_t (ucap_t^j K_t^j)^{1-\alpha} (U_t^Y L_t^j)^{\alpha} (KG_t)^{1-\alpha_G} .$$

The economy-wide labour-augmenting productivity shock u_t^Y follows a random walk with drift.

Employment at the firm level L_t^j is a CES aggregate of labour supplied by individual households i:

(2) $$L_t^j \equiv \left(\int_0^1 L_t^{i,j\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}} .$$

where $\theta > 1$ determines the degree of substitutability between different types of labour. The firms also decide about the degree of capacity utilization ($ucap_t^j$).

The output of the final goods sector Y_t is a CES aggregate of the output of individual firms j:

(3) $$Y_t \equiv \left(\int_0^1 Y_t^{j\frac{\eta-1}{\eta}} dj \right)^{\frac{\eta}{\eta-1}} ,$$

where η indicates the degree of substitutability between the varieties j that determines the steady-state price mark-up of final goods and gives the demand for individual varieties as:

(4) $$Y_t^j = (p_t^j)^{-\eta} Y_t .$$

The firms invest I_t^j into productive capital. The capital stock evolves according to:

(5) $$K_t^j = I_t^j + (1-\delta^K) K_{t-1}^j$$

with δ^K being the rate of capital depreciation adjusted by trend population and productivity growth.

The firms face technological and regulatory constraints that restrict the price setting, employment, investment and capacity utilization decisions. The following convex functional forms are chosen:

(6)
$$adj^P(P_t^j) = \frac{1}{2}\gamma_P (\Delta P_t^j)^2 Y_t$$
$$adj^L(L_t^j) = \frac{1}{2}\gamma_L (\Delta L_t^j)^2 w_t$$
$$adj^i(I_t^j) = \frac{1}{2}\gamma_K \left(\frac{I_t^j}{K_{t-1}} - \delta^K\right)^2 p_t^I K_{t-1} + \frac{1}{2}\gamma_I (\Delta I_t^j)^2 p_t^I$$
$$adj^{ucap}(ucap_t^j) = (\gamma_{ucap,1}(ucap_t^j - 1) + \gamma_{ucap,2}(ucap_t^j - 1)^2) p_t^I K_t^j$$

The objective of the firm is to maximize the stream of expected after-tax (t_t^K) profits:

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regional superscript. We use the superscript W for variables relating to the rest of the world (ROW) and EA for variables relating to the euro area.

(7) $$\mathrm{E}_0\sum_{t=0}^{\infty}\frac{\beta^r}{U_t^{\beta}}((1-t_t^K)(p_t^jY_t^j-w_tL_t^j)+t_t^K\delta p_t^IK_t^j-p_t^II_t^j-adj_t^j),$$

where p_t^I the unit price of capital installment and adjustment costs are:

(8) $$adj_t^j\equiv adj^P(P_t^j)+adj^L(L_t^j)+adj^I(I_t^j)+adj^{ucap}(ucap_t^j).$$

In each period of time, firm j decide about capital, investment, labour demand, capacity utilization and product prices optimally given the production technology, adjustment costs and the demand function for firm output.

The first-order conditions from the maximization of (7) under (1) and (4)-(6) are:

(9) $$q_t^j+(ucap_t^j-1)(\gamma_{ucap,1}+\gamma_{ucap,2}(ucap_t^j-1))=(1-\alpha)\frac{\varepsilon_t^jY_t^j}{p_t^IK_t^j}+t_t^k\delta+\frac{1-\delta}{1+r_t^k}E_t\frac{p_{t+1}^I}{p_t^I}q_{t+1}^j$$

(10) $$q_t^j=1+\gamma_K(\frac{I_t^j}{K_{t-1}^j}-\delta^K)+\gamma_I\Delta I_t^j-\frac{\gamma_I}{1+r_t^r}E_t\frac{p_{t+1}^I}{p_t^I}\Delta I_{t+1}^j$$

(11) $$(1-t_t^K)w_t(1+u_t^w)=\frac{\varepsilon_t^j\alpha Y_t^j}{L_t^j}-\gamma_Lw_t\Delta L_t^j+\frac{\gamma_L}{1+r_t^r}E_t(w_{t+1}\Delta L_{t+1}^j)$$

(12) $$(1-\alpha)\frac{\varepsilon_t^jY_t^j}{p_t^IK_t^j}=ucap_t^j(\gamma_{ucap,1}+2\gamma_{ucap,2}(ucap_t^j-1))$$

(13) $$\varepsilon_t^j=(1-t_t^K)(1-(\frac{1}{\eta}+u_t^{\varepsilon}))-\frac{\gamma_P}{\eta}(\frac{1}{1+r_t^r}(sfpE_t\pi_{t+1}^j+(1-sfp)\pi_{t-1}^j)E_t\frac{Y_{t+1}}{Y_t}-\pi_t^j),$$

where w_t is the real wage, ε_t^j is the inverse of the steady-state price mark-up and sfp the degree of forward-looking behavior among price setters in forming inflation expectations.

A.1.2. Residential construction

Monopolistically competitive firms h in the residential construction sector use new land I_t^L sold by (Ricardian) households and final goods J_t^{Con} to produce new houses with a CES technology:

(14) $$I_t^H=\left(s_L^{\frac{1}{\sigma_L}}I_t^{L\frac{\sigma_L-1}{\sigma_L}}+(1-s_L)^{\frac{1}{\sigma_L}}I_t^{Con\frac{\sigma_L-1}{\sigma_L}}\right)^{\sigma_L/(\sigma_L-1)}$$

The providers of construction services are monopolistically competitive and face quadratic price adjustment costs:

(15) $$adj^{Con}(P_t^{Con})=\frac{1}{2}\gamma_{Con}(\Delta P_t^{Con})^2\ .$$

The stock of available land is determined by the exogenous growth of land supply less the use of land in current construction:

(16) $$Land_t=(1+g^L+u_t^{gL})Land_{t-1}-I_t^L$$

The first-order conditions for the demand for construction services and land and for the pricing of these inputs and the produced houses are:

(17) $$I_t^L=s^L(\frac{P_t^L}{P_t^H})^{-\sigma_L}I_t^H$$

(18) $$I_t^{Con}=(1-s^L)(\frac{P_t^{Con}}{P_t^H})^{-\sigma_L}I_t^H$$

(19) $$p_t^{Con}=1+u_t^{pcon}-\gamma_{Con}(\frac{1}{1+r_t^r}(sfp^{Con}E_t\pi_{t+1}^{Con}+(1-sfp^{Con})\pi_{t-1}^{Con})-\pi_t^{Con})$$

(20) $$E_t\frac{p_{t+1}^L}{p_t^L}=\frac{1+r_t^l}{1+g^L+u_t^{gL}}$$

(21) $p_t^H = (s_L (p_t^L)^{1-\sigma_L} + (1-s_L)(p_t^{Con})^{1-\sigma_L})^{1/(1-\sigma_L)}$

where sfp^{Con} is the degree of forward-looking behavior in the formation of construction price expectations and r_t^l the real return on land. New and existing houses are perfect substitutes. Households can make capital gains or suffer capital losses depending on house price fluctuations.

A.1.3. Investment goods producers

There is a perfectly competitive investment goods production sector which combines domestic and foreign final goods, using the same CES aggregator as private consumption (see below), to produce investment goods for the domestic economy. Denote the CES aggregate of domestic and foreign inputs used by the investment goods sector with I_t^{inp}, then real output of the investment goods sector is produced by the following linear production function:

(22) $I_t = I_t^{inp} U_t^{PI}$

in which U_t^{PI} is a technology shock specific to the production technology for investment goods, which follows a random walk $u_t^{PI} = u_{t-1}^{PI} + \varepsilon_t^{PI}$. The price of investment goods relative to consumption goods follows as:

(23) $p_t^I U_t^{PI} = p_t^C$.

A.2. Households

The household sector consists of a continuum of households $i \in [0;1]$. The fraction s^r of the households is Ricardian and indexed by the superscript r; the fraction $1-s^r$ is credit-constrained households indexed by the superscript c.

Period utility has the same functional form for both types of households. It is specified as nested CES aggregate of consumption (C_t^i) and housing services (H_t^i) plus utility from leisure ($1-L_t^i$). We also allow for habit persistence in consumption (h^C). The temporal utility for household i is given by:

(24) $$U(C_t^i, H_t^i, 1-L_t^i) = \frac{1}{1-\sigma}\left(\left[\left(\frac{C_t^i - h^C C_{t-1}^i}{1-h^C}\right)^{\frac{\sigma_H-1}{\sigma_H}} + (s_H^i)^{\frac{1}{\sigma_H}} H_t^{i\,\frac{\sigma_H-1}{\sigma_H}}\right]^{\frac{\sigma_H}{\sigma_H-1}}\right)^{1-\sigma}$$

$$+\frac{\vartheta}{1-\kappa} U_t^L (1 - RETIR_t - YOUNG_t - L_t^i)^{1-\kappa} (U_t^{PTOT})^{1-\sigma}$$

where σ is the inverse of the intertemporal elasticity of substitution, $RETIR_t$ is the exogenous population share of retired persons and $YOUNG_t$ is the exogenous population share of young persons and:

(25) $(U_t^{PTOT})^{(\alpha+\alpha_G-1)/\alpha} = U_t^Y (U_t^{PI})^{(1-\alpha)/\alpha}$

a scaling factor for balanced growth. Households supply differentiated labour services L_t^i that are assumed to be equally distributed across Ricardian and credit-constrained households.

A.2.1 Ricardian households

Ricardian households have full access to financial markets. These households hold domestic government bonds (B_t^G) and bonds issued by other domestic and foreign households (B_t^r, $B_t^{F,DE}$)[19],

[19] Net foreign assets ($B_t^{F,DE}$ and analogously $B_t^{F,RE}$) denominated in RoW currency (here, USD); $e_t p_t^{RW}$ and p_t^{RE} are, respectively, the RoW and REA GDP deflators relative to DE GDP prices.

domestic corporate shares (S_t), the stock of land ($Land_t$) still available for building new houses and part of the housing stock (H_t^r). In addition, Ricardian households keep bank deposits (D_t^r). There are specific risk premia attached to the different assets.

The Ricardian households receive labour income, returns to financial assets, revenue from selling land to the residential construction sector and profit income from the firms owned by the households. Profit income of final-goods producers is paid as dividend to shareholders. Profit income from the construction sector is Pr_t^H , and profit income from banks is Pr_t^B .[20] All domestic firms are owned by domestic Ricardian households. The households consume final goods, invest into residential property and supply labour. The government levies social security contributions on labour income (ssc_t) and lump-sum taxes (TAX_t), taxes labour income (t_t^W) and household final demand (t_t^C) and pays lump-sum transfers (TR_t). The Ricardian budget constraint in real terms with all prices expressed relative to the domestic GDP deflator is:

$$
\begin{aligned}
&(1+t_t^C)\,p_t^C C_t^r + (1+t_t^C)\,p_t^H I_t^{H,r} + B_t^r + B_t^G + e_t\,p_t^{RW} B_t^{F,DE} + D_t^r + \sum_{j=1} S_t^j + p_t^L Land_t \\
&+adj^W(W_t^i) + adj^H(I_t^{H,r}) = (1+r_{t-1}^c)B_{t-1}^r + (1+r_{t-1}^b - rprem_{t-1}^b)B_{t-1}^G \\
&+(1+r_{t-1}^{RW} - rprem_{t-1}^{RW,DE})e_t\,p_t^{RW} B_{t-1}^{F,DE} + (1+r_{t-1}^{d,r} - rprem_{t-1}^d)D_{t-1}^r + (1+r_{t-1}^k - rprem_{t-1}^k)\sum_{j=1} S_{t-1}^j \\
&+(1+r_{t-1}^l - rprem_{t-1}^l)\,p_t^L Land_{t-1} + p_t^L I_t^L + PR_t^H + PR_t^B + (1-t_t^W - ssc_t)w_t L_t^{i,r} + TR_t - TAX_t \\
&+BEN_t(1 - RETIR_t - YOUNG_t - NPART_t - L_t^r)
\end{aligned}
\tag{26}
$$

Wage adjustment and the investment decisions w.r.t. housing are subject to convex adjustment costs:

$$
\begin{aligned}
adj^W(W_t^i) &= \frac{1}{2}\gamma_W\left(\frac{W_t^i}{W_{t-1}^i} - 1\right)^2 W_{t-1}^i \\
adj^H(I_t^{H,r}) &= \frac{1}{2}\gamma_H\left(\frac{I_t^{H,r}}{H_{t-1}^r} - \delta^H\right)^2 p_t^H H_{t-1}^r + \frac{1}{2}\gamma_{Ih}(\Delta I_t^{H,r})^2\,p_t^H
\end{aligned}
\tag{27}
$$

The stock of housing owned by Ricardian households follows:

$$
H_t^r = I_t^{H,r} + (1-\delta^H)H_{t-1}^r . \tag{28}
$$

The Ricardian households maximize welfare $\mathrm{E}_0\sum_{t=0}^{\infty}\frac{\beta^r}{U_t^\beta}U(C_t^r, 1-L_t^r, H_t^r)$ as the discounted sum of expected period utility subject to the constraints (26)-(28). The discount factor β^r is subject to random shocks U_t^β that add exogenous changes to the intertemporal consumption path. Welfare maximization gives the standard first-order optimality conditions for consumption, demand for housing, residential investment and asset holding decisions by the Ricardian household:

$$
\beta^r E_t\frac{U_{C,t+1}^r}{U_{C,t}^r} = \frac{U_t^\beta}{1+r_t^r}E_t\frac{(1+t_{t+1}^C)\,p_{t+1}^C}{(1+t_t^C)\,p_t^C} \tag{29}
$$

$$
q_t^{H,r} = \frac{p_t^C}{p_t^H}\frac{U_{H,t}^r}{U_{C,t}^r} + \frac{1-\delta^H}{1+r_t^{h,r}}E_t\frac{(1+t_{t+1}^C)\,p_{t+1}^H}{(1+t_t^C)\,p_t^H}q_{t+1}^{H,r} \tag{30}
$$

$$
q_t^{H,r} = 1 + \gamma_H\left(\frac{I_t^{H,r}}{H_{t-1}^r} - \delta^H\right) + \gamma_{Ih}\Delta I_t^{H,r} - \frac{1}{1+r_t^r}\gamma_{Ih}E_t\frac{p_{t+1}^H}{p_t^H}E_t\Delta I_{t+1}^{H,r} \tag{31}
$$

[20] Banks take deposits from Ricardian and credit-constrained households, pay interest on deposits and transfer the operating profit to their Ricardian owners. As banks do not play a fundamental role in financial intermediation between households and firms or between Ricardian and credit-constrained households in the underlying model version, the paper abstains from a detailed description of banks.

For asset holdings the no-arbitrage conditions together with the definition of the asset-specific risk premia give:

(32) $r_t^b = r_t^r + rprem^b + \omega^b(\frac{B_{t-1}}{4Y_{t-1}} - by^{tar})$

(33) $r_t^d = r_t^r + rprem^d - \omega^{d,r}(C^r / D^r)^{\kappa_d}$

(34) $r_t^{h,r} = r_t^r + u_t^{rpremh}$

(35) $r_t^k = r_t^r + rprem^k + u_t^{rpremk}$

(36) $r_t^l = r_t^r + rprem^l(val_t^L - \frac{p_t^L Land_t}{Y_t})$

(37) $r_t^r = r_t^{EA} + E_t\pi_{t+1}^{EA} - E_t\pi_{t+1} - rprem^e(\frac{B_t^{F,DE} - B_t^{F,RE}}{Y_t^{RW}}) + u_t^{rpremde}$

(38) $r_t^{RE} = r_t^{EA} + E_t\pi_{t+1}^{EA} - E_t\pi_{t+1}^{RE} - rprem^e\frac{s^{de}}{1-s^{de}}(\frac{B_t^{F,RE} - B_t^{F,DE}}{Y_t^{RW}}) + u_t^{rpremre}$

(39) $r_t^{EA} = r_t^{RW} + E_t\pi_{t+1}^{RW} - E_t\pi_{t+1}^{EA} + E_t(\frac{e_{t+1}}{e_t} - 1) - rprem^e\frac{s^{de}}{1-s^{de}}(\frac{B_t^{F,DE} + B_t^{F,RE}}{Y_t^{RW}}) + u_t^{rpremea}$

where r_t^{EA} is the policy rate in the euro area in real terms, π_t^{EA}, π_t^{RE} and π_t^{RW} is GDP price inflation in the euro area aggregate, the REA and the RoW, s^{de} is the share of Germany in euro area GDP, e_t is the EUR/USD nominal exchange rate, and $B_t^{F,RE}$ is the NFA position of the REA. The debt-elastic interest rate premium on households induces stationarity in the NFA position (e.g., Kollmann, 2002). The interest elasticity w.r.t. the NFA position is also an important behavioral parameter in our analysis as it describes the risk tolerance of foreign creditors.

A.2.2 Credit constrained households

Credit-constrained households differ from Ricardian households in two respects: they have a higher rate of time preference ($\beta^c < \beta^r$), and they face a collateral constraint on their borrowing. They borrow B_t^c exclusively from domestic Ricardian households.

The budget constraint of credit-constrained households in real terms with all prices expressed relative to the domestic GDP deflator is:

(40) $(1+t_t^C)p_t^C C_t^c + (1+t_t^C)p_t^H I_t^{H,c} + (1+r_{t-1}^c)B_{t-1}^c + D_t^c + adj^W(W_t^i) + adj^H(I_t^{H,c}) = B_t^c + TAX_t$
$+TR_t + (1+r_{t-1}^d)D_{t-1}^c + (1-t_t^W - ssc_t)w_t L_t^{i,c} + BEN_t(1 - RETIR_t - YOUNG_t - NPART_t - L_t^c)$

with wage adjustment costs as in (27) and adjustment costs on housing investment:

(41) $adj^H(I_t^{H,c}) = \frac{1}{2}\gamma_H(\frac{I_t^{H,c}}{H_{t-1}^c} - \delta^H)^2 H_{t-1}^c + \frac{1}{2}\gamma_{Ih}(\Delta I_t^{H,c})^2$

The stock of housing owned by credit-constrained households evolves according to:

(42) $H_t^c = I_t^{H,c} + (1-\delta^H)H_{t-1}^c$

The collateral constraint determines the borrowing capacity of the credit-constrained households:

(43) $(1+r_t^c)B_t^c = \rho^{d,c}(1+r_{t-1}^c)B_{t-1}^c + (1-\rho^{d,c})\chi_t^c E_t(p_{t+1}^H(1+\pi_{t+1}))H_t^c$

where the loan-to-value ratio that is imposed by Ricardian lenders is subject to a stochastic shock $\chi_t^c = \chi^c + u_t^\chi$.

The credit-constrained households maximize welfare $\mathrm{E}_0\sum_{t=0}^{\infty}\frac{\beta^c}{U_t^{\beta}}U(C_t^c,1-L_t^c,H_t^c)$ as the discounted sum of expected period utility subject to the constraints (40)-(43). The first-order conditions for consumption and housing are:

(44) $$\beta^c E_t\frac{U_{C,t+1}^c}{U_{C,t}^c}=\frac{U_t^{\beta}(1-(1+r_t^c)\psi_t)}{(1+r_t^c)(1-\rho^{d,c}E_t\psi_{t+1})}E_t\frac{(1+t_{t+1}^C)p_{t+1}^C}{(1+t_t^C)p_t^C}$$

(45) $$q_t^{H,c}=1+\gamma_H(\frac{I_t^{H,c}}{H_{t-1}^c}-\delta^H)+\gamma_{Ih}\Delta I_t^{H,c}-\frac{1-(1+r_t^c)\psi_t}{(1+r_t^c)(1-\rho^{d,c}E_t\psi_{t+1})}\gamma_{Ih}E_t\frac{p_{t+1}^H}{p_t^H}E_t\Delta I_{t+1}^{H,c}$$

(46) $$q_t^{H,c}=\frac{p_t^C}{p_t^H}\frac{U_{H,t}^c}{U_{C,t}^c}+\frac{(1-(1+r_t^c)\psi_t)(1-\delta^H)}{(1+r_t^{h,c})(1-\rho^{d,c}E_t\psi_{t+1})}E_t\frac{(1+t_{t+1}^C)p_{t+1}^H}{(1+t_t^C)p_t^H}q_{t+1}^{H,c}+\frac{(1-\rho^{d,c})\psi_t}{1+t_t^C}\chi_t^cE_t\pi_{t+1}^H$$

where ψ_t^c is the Lagrange multiplier of the collateral constraint. The interest rate for collateral-constrained households is:

(47) $$r_t^c=(1-s^d)r_t^r+s^dr_t^d$$

Furthermore we have $r_t^{h,c}=r_t^c+u_t^{rpremh}$ and $r_t^d=r_t^r-\omega^{d,c}(C^c/D^c)^{\kappa_d}$, where the latter is analogous to (33) for Ricardian households and pins down the deposit holding by credit-constrained consumers.

A.2.3 Wage setting

Trade unions are maximizing a joint utility function for each type of labour i. It is assumed that types of labour are distributed equally over Ricardian and credit-constrained households with their respective population weights. Nominal rigidity in wage setting is introduced in the form of adjustment costs for changing wages. The wage adjustment costs are borne by the household.

The trade unions set wages by maximizing a weighted average of the utility functions of Ricardian and credit-constrained households. The wage rule is obtained by equating a weighted average of the marginal utility of leisure to a weighted average of the marginal utility of consumption times the real wage adjusted for a wage mark-up:

$$\left(\frac{s^rU_{1-L,t}^r+(1-s^r)U_{1-L,t}^c}{s^rU_{C,t}^r+(1-s^r)U_{C,t}^c}(1+t_t^C)p_t^C\right)^{1-\rho_w}\left((1-\frac{1}{\theta})\left((1-t_{t-1}^W-ssc_{t-1})w_{t-1}-BEN_{t-1}\right)\right)^{\rho_w}$$

(48) $$=(1-\frac{1}{\theta})((1-t_t^W-ssc_t)w_t-BEN_t)+\frac{\gamma_W}{\theta}w_t(\pi_t^W-(1-sfw)\pi_{t-1})$$
$$-\frac{1}{1+r_t^r}\frac{\gamma_W}{\theta}w_t(E_t\pi_{t+1}^W-(1-sfw)\pi_t))$$

The wage mark-up fluctuates around $1/\theta$, which is the inverse of the elasticity of substitution between different varieties of labour services. Fluctuation in the wage mark-up arises because of wage adjustment costs (27). Real benefits in GDP prices equal the replacement rate rimes the real wage:

(49) $$BEN_t=b_t^Uw_t$$

The ratio of the marginal utility of leisure to the marginal utility of consumption is a natural measure of the reservation wage. If the ratio is equal to the consumption wage net of benefit payments to non-working parts of the labour force, the household is indifferent between, on the one hand, supplying an additional unit of labour and spending the additional income on consumption or, on the other hand, not increasing labour supply.

The specification (48) also allows for real wage inertia ρ_w. Unit labour costs are $ulc_t=w_tL_t/Y_t$, which equals the wage share in domestic income.

A. 3 Trade and the current account

In order to facilitate aggregation we assume that households, investment goods producers and the government have identical preferences across goods used for private consumption, public expenditure

and investment. Let $Z^{n,i} \in \left\{C^{n,i}, I^{n,i}, C^{G,n}\right\}$ be demand by an individual household, investment good producer or the government in country $n = DE, RE, RW$. Then their preferences are given by the utility function:

$$(50) \qquad Z_t^{n,i} = \left((s^{d,n} - u_t^{M,n})^{\frac{1}{\sigma_M^n}} (Z_t^{d,n,i})^{\frac{\sigma_M^n - 1}{\sigma_M^n}} + (1 - s^{d,n} + u_t^{M,n})^{\frac{1}{\sigma_M^n}} (Z_t^{f,n,i})^{\frac{\sigma_M^n - 1}{\sigma_M^n}} \right)^{\sigma_M^n/(\sigma_M^n - 1)}$$

where $Z^{d,n,i}$ and $Z^{f,n,i}$ are indexes of demand across the continuum of differentiated goods produced in the domestic economy and abroad, respectively. The home bias parameter $s^{d,n}$ can be subject to random shocks $u_t^{M,n}$.

Households, firms and governments in country/region n have preferences over imports from country/region m given by

$$(51) \qquad Z^{f,n} = \left(\sum_m (s^{n,m})^{\frac{1}{\sigma_1^n}} Z^{f,n,m\,\frac{\sigma_1^n - 1}{\sigma_1^n}} \right)^{\sigma_1^n/(\sigma_1^n - 1)}$$

where $Z^{f,n,m}$ are indexes of demand across the continuum of differentiated goods produced in exporting regions m, and $s^{n,m}$ is the bilateral import share parameter.

The elasticity parameters σ_M^n and σ_1^n determine the price elasticity of bilateral imports. In general we find that goods and services produced in Germany and the REA are closer substitutes to each other, while goods produced in the RoW are stronger complements to goods produced in the EA. This is reflected by $\sigma_1^{DE}, \sigma_1^{RE} < 1$ and by $\sigma_1^{RW} > 1$ and $\sigma_M^{RW} < 1$.

German exporters buy final domestic goods X_t and transform them into exportable goods using a linear technology, so that export prices are given by:

$$(52) \qquad p_t^{X,DE} = \frac{1}{1 - u_t^{PX} - \gamma_{Px}(sfp^x E_t \pi_{t+1}^{X,DE} + (1 - sfp^x)\pi_{t-1}^{X,DE} - \pi_t^{X,DE}) / (1 + r_t^r)},$$

where u_t^{PX} is a price setting shock, γ_{Px} quantifies price adjustment costs and $sfpx$ is the degree of forward-looking in expectations. For the REA and the RoW we set $u_t^{PX} = 0$ and $\gamma_{Px} = 0$, so that the regions' export prices $p_t^{X,RE} = p_t^{RE}$ and $p_t^{X,RW} = p_t^{RW}$.

Importers buy foreign goods at quantity M_t from foreign exporters and sell them on the domestic market, charging the domestic currency price:

$$(53) \qquad p_t^{M,DE} = \frac{(s^{DE,RE}(p_t^{X,RE})^{1-\sigma_1^{DE}} + s^{DE,RW}(e_t p_t^{X,RW})^{1-\sigma_1^{DE}})^{1/(1-\sigma_1^{DE})}}{1 - u_t^{PM,DE} - \gamma_{Pm}(sfp^m E_t \pi_{t+1}^{M,DE} + (1 - sfp^m)\pi_{t-1}^{M,DE} - \pi_t^{M,DE}) / (1 + r_t^r)},$$

where u_t^{PM} is a price setting shock, γ_{Pm} quantifies price adjustment costs and $sfpm$ is the degree of forward-looking in expectations. For the REA and RoW we set $u_t^{PM} = 0$ and $\gamma_{Pm} = 0$ to obtain:

$$(54) \qquad p_t^{M,RE} = \frac{(s^{RE,DE}(p_t^{X,DE})^{1-\sigma_1^{RE}} + s^{RE,RW}(e_t p_t^{X,RW})^{1-\sigma_1^{RE}})^{1/(1-\sigma_1^{RE})}}{1 - u_t^{PM,RE}},$$

$$(55) \qquad e_t p_t^{M,RW} = \frac{(s^{RW,DE}(p_t^{X,DE})^{1-\sigma_1^{RW}} + s^{RE,RW}(p_t^{X,RW})^{1-\sigma_1^{RW}})^{1/(1-\sigma_1^{RW})}}{1 - u_t^{PM,RW}},$$

German import demand allows for some inertia in demand adjustment (ρ_m) and is given by:

(56) $$\frac{M_t^{DE}}{C_t + \frac{p_t^I}{p_t^C} I_t + \frac{p_t^G}{p_t^C} G_t} = \left((1 - s^{d,DE} + u_t^{M,DE}) (\frac{p_t^M}{p_t^C})^{-\sigma_M^{DE}} \right)^{1-\gamma_m^{DE}} (\frac{M_{t-1}^{DE}}{C_{t-1} + \frac{p_{t-1}^I}{p_{t-1}^C} I_{t-1} + \frac{p_{t-1}^G}{p_{t-1}^C} G_{t-1}})^{\gamma_m^{DE}}$$

For REA and RoW imports we have analogous expressions:

(57) $$\frac{M_t^{RE}}{Y_t^{d,RE}} = \left((1 - s^{d,RE} + u_t^{M,RE}) (\frac{p_t^{M,RE}}{p_t^{C,RE}})^{-\sigma_M^{RE}} \right)^{1-\gamma_m^{RE}} (\frac{M_{t-1}^{RE}}{Y_{t-1}^{d,RE}})^{\gamma_m^{RE}}$$

(58) $$\frac{M_t^{RW}}{Y_t^{d,RW}} = \left((1 - s^{d,RW} + u_t^{M,RW}) (\frac{p_t^{M,RW}}{p_t^{C,RW}})^{-\sigma_M^{RW}} \right)^{1-\gamma_m^{RW}} (\frac{M_{t-1}^{RW}}{Y_{t-1}^{d,RW}})^{\gamma_m^{RW}}$$

where Y_t^d is domestic demand in the REA and RoW, respectively, as defined below. Exports of reach region are determined by the import demand of the other regions:

(59) $$\begin{aligned} X_t^{DE} &= M_t^{RE,DE} + M_t^{RW,DE} \\ X_t^{RE} &= M_t^{DE,RE} + M_t^{RW,RE} \\ X_t^{RW} &= M_t^{DE,RW} + M_t^{RE,RW} \end{aligned}$$

with bilateral import demand:

(60) $$M_t^{DE,RE} = s^{DE,RE} (\frac{p_t^{X,RE}}{p_t^{M,DE}})^{-\sigma_1^{DE}} M_t^{DE}$$

(61) $$M_t^{DE,RW} = s^{DE,RW} (\frac{e_t p_t^{X,RW}}{p_t^{M,DE}})^{-\sigma_1^{DE}} M_t^{DE}$$

(62) $$M_t^{RE,DE} = s^{RE,DE} (\frac{p_t^{X,DE}}{p_t^{M,RE}})^{-\sigma_1^{RE}} M_t^{RE}$$

(63) $$M_t^{RE,RW} = s^{RE,RW} (\frac{e_t p_t^{X,RW}}{p_t^{M,RE}})^{-\sigma_1^{RE}} M_t^{RE}$$

(64) $$M_t^{RW,DE} = s_t^{RW,DE} (\frac{p_t^{X,DE}}{e_t p_t^{M,RW}})^{-\sigma_1^{RW}} M_t^{RW}$$

(65) $$M_t^{RW,RE} = s^{RW,RE} (\frac{p_t^{X,REW}}{e_t p_t^{M,RW}})^{-\sigma_1^{RW}} M_t^{RW}$$

Consumer prices relative to the GDP deflator follow from (50) as:

(66) $$p_t^C = ((1 - s^{d,DE} + u_t^{M,DE})(p_t^M)^{1-\sigma_M^{DE}} + (s^{d,DE} - u_t^{M,DE}))^{1/(1-\sigma_M^{DE})} U_t^{Pc}$$

Real GDP in Germany equals the sum of its components:

(67) $$Y_t = p_t^C C_t + p_t^G C_t^G + p_t^I I_t + p_t^{Con} (I_t^{Con} + I_t^G) + TB_t,$$

where $TB_t^{DE} \equiv p_t^{X,DE} X_t^{DE} - p_t^{M,DE} M_t^{DE}$ is the trade balance.

The current account is the sum of net investment income from abroad, the trade balance and the transfer account (TA_t):

(68) $$CA_t^{DE} \equiv r_{t-1}^{RW} e_t p_t^{RW} B_{t-1}^{F,DE} + TB_t^{DE} + TA_t^{DE}$$

The net international investment position (NIIP) equals the cumulated current account plus valuation effects:

(69) $$e_t p_t^{RW} B_t^{F,DE} = (1 + r_{t-1}^{RW}) e_t p_t^{RW} B_{t-1}^{F,DE} + TB_t^{DE} + TA_t^{DE} + (u_t^{BWREV,DE} + u_t^{BW,DE}) Y_t$$

Economy-wide savings correspond to $S_t \equiv CA_t^{DE} + p_t^I I_t + p_t^{Con} (I_t^{Con} + I_t^G)$.

A.4. Policy

Government expenditure and receipts can deviate temporarily from their long-run levels in systematic response to budgetary or business-cycle conditions and in response to idiosyncratic shocks. Concerning government consumption and government investment, we specify the following autoregressive equations:

(70) $$\frac{C_t^G}{U_t^{PTOT}} - \overline{C^G} = \tau_{Lag}^{CG}\left(\frac{C_{t-1}^G}{U_t^{PTOT}} - \overline{C^G}\right) - \tau^B\left(\frac{B_{t-1}}{4Y_{t-1}} - by^{tar}\right) - \tau^{DEF}\left(\frac{\Delta B_{t-1}}{Y_{t-1}} - def^{tar}\right) + u_t^{CG}$$

(71) $$\frac{I_t^G}{U_t^{PTOT}} - \overline{I^G} = \tau_{Lag}^{IG}\left(\frac{I_{t-1}^G}{U_t^{PTOT}} - \overline{I^G}\right) + u_t^{IG}$$

Government consumption reacts to the level of government debt and the government deficit relative to the associated debt and deficit targets by^{tar} and def^{tar}. The price level of government consumption may deviate from private consumer prices by a stochastic shock $p_t^C = U_t^{PG} p_t^G$. Government investment is considered to be predominantly infrastructure investment and is therefore priced at the construction price index.

The transfer system consists of two parts, the benefit $BEN_t = b^U w_t$ paid to the unemployed members of the labour force $(1 - PENS_t - YOUNG_t - NPART_t - L_t)$ and other transfers TR_t, including transfers to pensioners ($PENS_t$). Unemployment benefits and pensions are indexed to wages with replacement rates b_t^U and b_t^R, with $b_t^U = b_{t-1}^U + u_t^{BU}$ and $b_t^R = b_{t-1}^R + u_t^{BR}$. Transfers may also react to the debt-to-GDP ratio and the government deficit:

(72) $$\frac{TR_t}{U_t^{PTOT}} = \frac{b^R w_t PENS_t}{U_t^{PTOT}} - \tau^{TRB}\left(\frac{B_{t-1}^G}{Y_{t-1}} - by^{tar}\right) - \tau^{TRDEF}\left(\frac{\Delta B_{t-1}^G}{Y_{t-1}} - def^{tar}\right) + u_t^{TR}$$

The stock of public capital, which enters the production function (1), evolves according to:

(73) $$KG_t = I_t^G + (1-\delta^G) KG_{t-1}.$$

Government revenue REV_t^G consists of taxes on consumption, labour and corporate income:

(74) $$REV_t^G = t_t^C p_t^C C_t + t_t^C p_t^H I_t^H + (ssc_t + t_t^W) w_t L_t + t_t^K (Y_t - w_t L_t - \delta^K p_t^I K_t) + TAX_t$$

with $t_t^C = t_{t-1}^C + u_t^{tc}$ and $TAX_t = U_t^{PTOT} U_t^{TAX}$.

Labour income taxes follow a linear scheme, whereas labour income taxes are progressive:

(75) $$t_t^w = \tau_0^w\left(1 + \tau_1^w\left(\Delta y_t + \Delta y_{t-1} + \Delta y_{t-2} + \Delta y_{t-3} - 4\overline{\Delta y}\right)\right) \; t_t^w = \tau_0^w Y_t^{\tau_1^w}$$

with τ_0^w as the average tax rate and τ_1^w as the degree of progressivity.

The dynamics of government debt (B_t^G) is given by:

(76) $$B_t^G = (1 + r_{t-1}^g) B_{t-1}^G + p_t^G C_t^G + p_t^{Con} I_t^G + BEN_t (1 - PENS_t - YOUNG_t - NPART_t - L_t) + TR_t - REV_t^G$$

The interest rate r_t^g is the implicit interest rate that the government pays on its debt. It depends on the average maturity structure of sovereign debt $(1/(1-\rho^g))$ and the rate r_t^b on newly issued debt:

(77) $$r_t^g = \rho^g r_{t-1}^g + (1-\rho^g) r_{t-1}^b + u_t^{rpremb}$$

Monetary policy is modeled by a Taylor rule where the ECB sets the policy rate $i_t^{EA} \equiv r_t^{EA} + E_t \pi_{t+1}^{EA}$ in response to area-wide inflation and real GDP growth. The policy rate adjusts sluggishly to deviations of inflation and GDP growth from their respective target levels; the policy rule is also subject to random shocks:

(78) $$i_t^{EA} = \tau_{lag}^{M,EA} i_{t-1}^{EA} + (1 - \tau_{lag}^{M,EA})\left(\overline{r} + \pi_t^T + \tau_\pi^{M,EA} \sum_{i=0}^{3} \frac{\pi_{t-i}^{EA} - \pi_t^T}{4} + \tau_y^{M,EA} \sum_{i=0}^{3} \frac{\Delta y_{t-i}^{EA} - \overline{\Delta y}}{4}\right) + u_t^{i,EA}$$

For the pre-EMU period we assume that monetary policy in the 'Euro Area' was conducted by the Bundesbank, which was setting the German policy rate, however, already targeting Euro aggregates.

A.5. Equilibrium

Equilibrium in the domestic model economy is an allocation by the price system and by government policies such that Ricardian and credit-constrained households maximize utility, final goods producing firms, firms in the construction sector and investment goods producers maximize profits and markets clear.
The market clearing for final domestic goods corresponds to (67):

(79) $$Y_t = p_t^C C_t + p_t^I I_t + p_t^{Con}(I_t^{Con} + I_t^G) + p_t^G C_t^G + p_t^{X,DE} X_t^{DE} - p_t^{M,DE} M_t^{DE}$$

where total private consumption C_t of domestic and imported goods is the sum of Ricardian and credit-constrained consumption as their per-capita consumption multiplied by the respective population shares s^r and $1-s^r$:

(80) $$C_t = s^r C_t^r + (1-s^r) C_t^c .$$

Similarly, total housing and construction investment are defined as:

(81) $$I_t^H = s^r I_t^{H,r} + (1-s^r) I_t^{H,c}$$

(82) $$I_t^{Con} = s^r I_t^{Con,r} + (1-s^r) I_t^{Con,c}$$

and equilibrium in the labour market is given by:

(83) $$L_t = s^r L_t^r + (1-s^r) L_t^c \text{ with } L_t^r = L_t^c .$$

Credit-constrained households engage in debt contracts only with Ricardian households, i.e.:

(84) $$(1-s^r) B_t^c = s^r B_t^r .$$

Total deposits are the population-weighted sum of Ricardian and credit-constrained deposits:

(85) $$D_t = s^r D_t^r + (1-s^r) D_t^c .$$

A.6. REA and RoW blocks

Rest of the euro area (REA) and rest of world (RoW) variables are denoted by superscripts RE and RW respectively. In order to identify demand and supply shocks in the REA and the RoW we use highly aggregated DSGE models with aggregate demand modelled by aggregate IS curves that do not distinguish between private and government demand:

(86) $$\beta^r E_t \left(\frac{Y_t^{d,RE} - h^{C,RE} Y_{t-1}^{d,RE}}{Y_{t+1}^{d,RE} - h^{C,RE} Y_t^{d,RE}} \right)^{\sigma^{RE}} = \frac{U_t^{\beta,RE}}{1+r_t^{RE}}$$

(87) $$\beta^r E_t \left(\frac{Y_t^{d,RW} - h^{C,RW} Y_{t-1}^{d,RW}}{Y_{t+1}^{d,RW} - h^{C,RW} Y_t^{d,RW}} \right)^{\sigma^{RW}} = \frac{U_t^{\beta,RW}}{1+r_t^{RW}}$$

Firms' price setting is captured by a hybrid New Keynesian Phillips curve in which inflation rises in response to the region's output gap as the deviation of actual output from an exogenous stochastic trend:

(88) $$\pi_t^{RE} = \frac{1}{1+r_t^{RE}} (sfp^{RE} E_t \pi_{t+1}^{RE} + (1-sfp^{RE}) \pi_{t-1}^{RE}) + \varphi^{RE} (\ln Y_t^{RE} - \ln Y_t^{T,RE}) + u_t^{P,RE}$$

(89) $$\pi_t^{RW} = \frac{1}{1+r_t^{RW}} (sfp^{RW} E_t \pi_{t+1}^{RW} + (1-sfp^{RW}) \pi_{t-1}^{RW}) + \varphi^{RW} (\ln Y_t^{RW} - \ln Y_t^{T,RW}) + u_t^{P,RW}$$

where trend output follows:

(90) $$\ln Y_t^{T,RE} = \ln Y_{t-1}^{T,RE} - \rho^{Y,RE} (\ln Y_{t-1}^{RE} - \ln Y_{t-1}^{DE}) + u_t^{TFP,RE}$$

(91) $$\ln Y_t^{T,RW} = \ln Y_{t-1}^{T,RW} - \rho^{Y,RW} (\ln Y_{t-1}^{RW} - \ln Y_{t-1}^{DE}) + u_t^{TFP,RW}$$

GDP in the REA and the RoW equals domestic demand plus the trade balance:

(92) $Y_t^{RE} = p_t^{C,RE} Y_t^{d,RE} + p_t^{X,RE} X_t^{RE} - p_t^{M,RE} M_t^{RE}$

(93) $Y_t^{RW} = p_t^{C,RW} Y_t^{d,RW} + p_t^{X,RW} X_t^{RW} - p_t^{M,RW} M_t^{RW}$

The regions' consumer prices relative to the GDP price deflator are:

(94) $p_t^{C,RE} = ((1 - s^{d,RE} + u_t^{M,RE})(p_t^{M,RE})^{1-\sigma_M^{RE}} + (s^{d,RE} - u_t^{M,RE}))^{1/(1-\sigma_M^{RE})}$

(95) $p_t^{C,RW} = ((1 - s^{d,RW} + u_t^{M,RW})(p_t^{M,RW})^{1-\sigma_M^{RW}} + (s^{d,RW} - u_t^{M,RW}))^{1/(1-\sigma_M^{RW})}$

The REA NIIP position follows:

(96) $\frac{e_t p_t^{RW}}{p_t^{RE}} B_t^{F,RE} = (1 + r_{t-1}^{RW}) \frac{e_t p_t^{RW}}{p_t^{RE}} B_{t-1}^{F,RE} + TB_t^{RE} + TA_t^{RE} + u_t^{BW,RE} Y_t^{RE}$

where p_t^{RE} and p_t^{RW} are REA and RoW GDP process relative to the German GDP deflator. Market clearing requires $TB_t^{DE} + p_t^{RE} TB_t^{RE} = -e_t p_t^{RW} TB_t^{RW}$ and $B_t^{F,DE} + B_t^{F,RE} = -B_t^{F,RW}$.

Interest rates in the REA are determined by (78) together with (38). RoW interest rates follow from the Taylor rule:

(97) $i_t^{RW} = \tau_{lag}^{M,RW} i_{t-1}^{RW} + (1 - \tau_{lag}^{M,RW})(\overline{r} + \pi_t^T + \tau_\pi^{M,RW} \sum_{i=0}^{3} \frac{\pi_{t-i}^{RW} - \pi_t^T}{4} + \tau_y^{M,RW} \sum_{i=0}^{3} \frac{\Delta y_{t-i}^{RW} - \overline{\Delta y}}{4}) + u_t^{i,RW}$

with the RoW nominal and real rates linked by $r_t^{RW} = i_t^{RW} - E_t \pi_{t+1}^{RW}$.

B. Data description

Data on GDP and its components, government finances, interest rates and external accounts for DE and the REA are from Eurostat (Quarterly National Accounts, Government Finance Statistics, and Balance of Payment Statistics). The data on DE house prices come from the ECB Statistical Warehouse. Quarterly data are seasonally adjusted. See Table B.1 for the list of variables observed in the estimation. The data are not de-trended, only divided by the German population trend.

The construction of output, price, trade balance and interest rate series for the RoW and REA deserves more detail, which is provided below.

B.1. RoW GDP volume and GDP deflator

The data for RoW variables are constructed on the basis of data from 24 non-EA countries. The 24 countries are: Australia, Brazil, Bulgaria, Canada, China, Czech Republic, Denmark, Hong Kong, Hungary, Japan, Korea, Latvia, Lithuania, Mexico, New Zealand, Norway, Poland, Romania, Russia, Sweden, Switzerland, Turkey, United Kingdom and United States.

The data for GDP at current market prices and GDP at constant prices are taken from AMECO (Australia, Brazil, Canada, China, Hong Kong, Korea, Mexico, New Zealand and Russia) and Eurostat Quarterly National Accounts (all other countries) databases. The AMECO data are annual data that have been converted into quarterly frequency.

RoW (RW) nominal GDP is calculated as sum of nominal GDP for the 24 countries, with nominal values converted into USD with E as the exchange rate of USD to national currency:

$$YN_t^{RW} = \sum_{i=1}^{24} E_t^i YN_t^i$$

Given the currency transformation into USD, price inflation in the RoW is defined in USD terms and includes REER movements between the RoW members. The use of USD prices is consistent with using the Euro-USD exchange rate in trade equations of the model and US interest rates in the RoW monetary policy rule.

RoW nominal GDP is then normalised by its value in the base year t=0 (2005), giving the index:

$$YN_t^{RW} = YN_0^{RW} \prod_{k=1}^{t} \left(\frac{YN_k^{RW}}{YN_{k-1}^{RW}}\right)$$

To derive real GDP in the RoW, we first construct series for the 24 countries of GDP at constant domestic prices and normalise the series with GDP in the base year t=0 (2005):

$$YR_t^i = YN_0^i \prod_{k=1}^{t} \left(\frac{YR_k^i}{YR_{k-1}^i}\right)$$

RoW real GDP is then calculated as the GDP-weighted mean of the 24 country series:

$$YR_t^{RW} = \sum_{i=1}^{24} \frac{E_t^i YN_t^i}{YN_t^{RW}} YR_t^i$$

The aggregation applies time-varying weights in particular to account for the gain in relative economic weight of emerging economies over the sample period. Applying constant weights gives very similar aggregate real GDP dynamics in our case, however.

RoW inflation is the percentage change in the price level in USD terms given by the ratio:

$$P_t^{RW} = \frac{YN_t^{RW}}{YR_t^{RW}}$$

The RoW price level series measures the gap between RoW nominal GDP in USD terms and RoW real GDP as the weighted average of GDP in constant national prices. It therefore includes

fluctuations in the nominal exchange rate between the USD and the currencies of other countries in the RoW sample. Consequently, aggregate RoW prices can be expected to be less sticky at shorter frequencies than prices in one currency at the national level.

B.2. REA GDP volume and GDP deflator

Data for output and prices in the REA (RE) are derived on the basis of nominal and real GDP data for DE and the euro area (EA) aggregate, where nominal GDP is output at current euro prices and real GDP is output at constant euro prices.
RoEA nominal GDP is the difference between euro-based EA and DE nominal GDP:

$$YN_t^{RE,€} = YN_t^{EA,€} - YN_t^{DE,€}$$

The relative GDP weights allow calculating RoEA inflation based on EA and DE nominal and real GDP data:

$$\frac{P_t^{RE}}{P_{t-1}^{RE}} = \frac{\frac{P_t^{EA}}{P_{t-1}^{EA}} - \frac{YN_t^{DE,€}}{YN_t^{EA,€}}\frac{P_t^{DE}}{P_{t-1}^{DE}}}{1-\frac{YN_t^{DE,€}}{YN_t^{EA,€}}}$$

The RoEA price level relative to the base year t=0 and RoEA real GDP in prices of t=0 are:

$$P_t^{RE} = P_0^{RE}\prod_{k=1}^{t}\left(\frac{P_k^{RE}}{P_{k-1}^{RE}}\right)$$

$$YR_t^{RE} = YN_t^{RE,€} / P_t^{RE}$$

B.3. REA and RoW trade balance

Eurostat Quarterly National Accounts report nominal trade balances for Germany (TB_t^{DE}) and the total EA (TB_t^{EA}) in EUR terms. Given the regional configuration of the model, the RoW and RoEA values can be derived simply:

$$TB_t^{RW} = -TB_t^{EA}$$

$$TB_t^{RE} = -(TB_t^{DE} + TB_t^{RW})$$

B.4. Interest rates

As RoW prices are expressed in USD terms, the exchange rate between the EA and the RoW is the EUR/USD rate. The RoW nominal interest rate used in the RoW monetary policy rule and the interest parity condition determining the EUR/USD exchange rate is the 3-month money market interest rate in the United States.

Nominal interest rates for the DE and RoEA blocks are as follows. The nominal interest rate of DE corresponds to the 3-month money market rate for Germany prior to 1999. The RoEA nominal rate is calculated from the German rate and the synthetically EA rate:

$$i_t^{RE} = \frac{i_t^{EA} - \frac{YN_t^{DE,€}}{YN_t^{EA,€}} i_t^{DE}}{1-\frac{YN_t^{DE,€}}{YN_t^{EA,€}}},$$

During 1999q1-2004q2, the DE and RoEA nominal rates correspond to the 3-month money market interest rate for the EA. From 2004q3 on, DE INOM corresponds to the AAA government bond yields in the EA for 3-month maturity as published by the ECB. The corresponding RoEA rate then follows from the average EA 3-month bond yield for all ratings and the 3-month AAA rate as above.

The use of government bond rates instead of ECB policy rates for most recent periods takes into account the spreads between DE and RoEA financing costs in recent years. The ECB series for EA government bond yields start only in 2004q3, which is the reason for using ECB money market rates up to 2004q2. Comparing DE government bond yields with ECB policy rates shows that government bond yields have moved closely with money market rates during 1999-2008.

Table B.1: Observed variables in the estimation

DE	Employment
Real GDP	Wage share
Private consumption to GDP	Labour force participation rate
Government purchases to GDP	Old-age population share
Government investment to GDP	Young-age population share
Investment to GDP	Nominal interest rate
Construction investment to GDP	Nominal exchange rate
Imports to GDP	Current account to GDP
GDP deflator	Transfer account to GDP
Private consumption deflator	NFA to GDP
Government consumption deflator	Share in euro-area GDP
Investment price deflator	**REA**
Construction price deflator	Real GDP
House price deflator	GDP deflator
Import price deflator	REA nominal interest rate
Export price deflator	Trade balance to GDP
Transfers to GDP	Transfer account to GDP
Benefits to GDP	NFA to GDP
Benefit replacement rate	Euro-area nominal interest rate
VAT rate	**RoW**
Government debt to GDP	Real GDP
Government balance to GDP	GDP deflator
Effective interest on government debt	Nominal interest rate

C. Econometric methodology and parameter estimates

We calibrate selects parameters. The remaining parameters are estimated using Bayesian methods.

C.1. Calibrated parameters

We calibrate the steady state ration of German debt/annual GDP at 60%, which is close to the sample average. This implies a steady state deficit of 1.8% of GDP. The average maturity of German government debt is set at 5 years. Tax and replacement rates are calibrated on sample averages. Based on the sample average, the steady state quarterly growth rate of German nominal GDP is set 0.27%, and the steady state inflation rate is set at 0.5% per quarter. Collateral-constrained households have a steady state rate of time preference of 4%, while the steady state rate of time preference of non-constrained households is estimated. The steady state ratios of main economic aggregates (corporate investment, construction investment, government consumption and government investment) to GDP are calibrated to sample averages.

C.2. Parameter estimates

The model is estimated on quarterly data for the period 1995q1 to 2013q2 using Bayesian inference methods to estimate model parameters and shocks. We use the DYNARE toolbox for MATLAB (Adjemian et al., 2011) to conduct the first-order approximation of the model, calibrate the steady state and perform the estimation. The following Tables report the priors of all estimated model parameters as well as the corresponding posterior modes and standard deviations.

Table C.1: Calibrated parameters and steady-state ratios

Parameters and steady-state ratios	Symbol	Value	Parameters	Symbol	Value
DE			Progressive labour tax component	τ_1^w	0.800
Government debt target	by^{tar}	0.600	Persistence of government consumption	τ_{Lag}^{CG}	0.990
Loan-to-value ratio	χ^c	0.500	Persistence of government investment	τ_{Lag}^{IG}	0.990
Capacity-utilisation adjustment costs	$\gamma_{ucap,1}$	0.079	Retiree population share	$RETIR$	0.182
Labour share in production	α	0.617	Young-age population share	$YOUNG$	0.145
Public capital in production	$1-\alpha_G$	0.100	Non-participation share	$NPART$	0.085
TFP scaling factor	A	0.852	Persistence RETIR shock	ρ^{RETIR}	0.975
Capital depreciation rate	δ^K	0.025	Persistence YOUNG shock	ρ^{YOUNG}	0.975
Housing depreciation rate	δ^H	0.010	Persistence NPART shock	ρ^{NPART}	0.990
Public capital depreciation rate	δ^G	0.013	Rate of time preference credit-constrained HH	$1-1/\beta^c$	0.040
Capital requirement	$1-s^d$	0.100	Rate of time preference Ricardian HH	$1-1/\beta^r$	0.005
Elasticity of deposit rate to deposit ratio	κ_d	0.100	Substitutability between goods varieties	η	20.000
Persistence in capacity utilization	ρ^{ucap}	0.990	Substitutability between labour varieties	θ	6.000
Inertia in credit constraint	$\rho^{d,c}$	0.900	Growth rate of land stock	g^L	0.008
Housing in final demand by credit-constrained HH	s_H^{CC}	0.171	REA share in DE imports	$s^{DE,RE}$	0.397
Housing in final demand by Ricardian HH	s_H^{NLC}	2.189	RoW share in DE imports	$s^{DE,RW}$	0.603
Consumption-housing substitutability	σ_H	0.500	Persistence C^G price shock	ρ^{PG}	0.946
Forward-looking in house price expectations	sfp^h	1.000	Persistence CPI shock	ρ^{PC}	0.990
Land value	val^L	1.105	Persistence government borrowing costs	ρ^g	0.950
Utility weight of leisure	ϑ	0.072	DE share in EA output	s^{de}	0.287
Risk premium on physical capital	$rprem^k$	0.036	**REA**		
Risk premium on land	$rprem^l$	0.010	Goods market home bias	$s^{d,RE}$	0.794
Risk premium on government bonds	$rprem^b$	0.004	DE share in REA imports	$s^{RE,DE}$	0.269
Country risk premium	$rprem^e$	0.001	RoW share in REA imports	$s^{RE,RW}$	0.731
Premium on deposits	$rprem^d$	0.003	Rate of time preference of households	$1-1/\beta^{RE}$	0.005
Sensitivity of deposit rate w.r.t. to deposits (r)	$\omega^{d,r}$	0.002	Persistence of import price shock	$\rho^{PM,RE}$	0.900
Sensitivity of deposit rate w.r.t. to deposits (c)	$\omega^{d,c}$	0.003	Persistence of risk premium shock	$\rho^{rpremre}$	0.970
Steady-state G/Y share	C^G/Y	0.193	Long-run convergence	$\rho^{Y,RE}$	0.0004
Steady-state IG/Y share	I^G/Y	0.019	**RoW**		
Productive investment share in GDP	I/Y	0.127	Goods market home bias	$s^{d,RW}$	0.973
Total investment share in GDP	$(I+I^{Con}+I^G)/Y$	0.219	DE share in RoW imports	$s^{RW,DE}$	0.335
Corporate tax rate	t^k	0.201	RoW share in RoW imports	$s^{RW,RE}$	0.665
VAT rate	t^c	0.190	Rate of time preference of households	$1-1/\beta^R$	0.005
Social security contribution rate	ssc	0.170	Persistence of import price shock	$\rho^{PM,RW}$	0.900
Linear labour tax component	τ_0^w	0.200	Long-run convergence	$\rho^{Y,RW}$	0.0004

Table C.2: Estimation results for structural parameters

Parameters		Prior			Posterior	
DE		**distrib**	**mean**	**std**	**mode**	**std**
Housing stock adjustment costs	γ_H	Gamma	30	20	65.0144	33.7460
Housing investment adjustment costs	γ_{Ih}	Gamma	30	20	22.6681	14.0442
Capital stock adjustment costs	γ_K	Gamma	30	20	23.4375	8.0715
Investment adjustment costs	γ_I	Gamma	15	10	1.2041	0.9089
Import demand stickiness	γ_M	Gamma	15	10	1.2041	0.9089
Employment adjustment costs	γ_L	Gamma	30	20	84.7026	17.0872
Price adjustment costs	γ_P	Gamma	30	20	28.2326	5.6746
Construction price adjustment costs	γ_{Con}	Gamma	30	20	2.4489	1.7855
Import price adjustment costs	γ_{Pm}	Gamma	30	20	2.3066	0.0000
Export price adjustment costs	γ_{Px}	Gamma	30	20	2.6252	0.0000
Wage adjustment costs	γ_W	Gamma	30	20	2.6761	1.1170
Quadratic capacity-utilisation adjustment costs	$\gamma_{ucap,2}$	Gamma	0.02	0.008	0.0115	0.0039
Real wage inertia	ρ_w	Beta	0.5	0.2	0.9824	0.0035
Consumption habit persistence	h^c	Beta	0.7	0.1	0.6955	0.1119
Inverse of labour supply elasticity	κ	Gamma	1	0.4	1.2133	0.2569
Goods market home bias	s^d	Beta	0.65	0.06	0.6699	0.0224
Forward-looking in goods price expectations	sfp	Beta	0.7	0.1	0.9755	0.0548
Forward-looking in construction price expectations	sfp^{Con}	Beta	0.7	0.1	0.8698	0.1092
Forward-looking in import price expectations	sfp^m	Beta	0.7	0.1	0.7396	0.1009
Forward-looking in export price expectations	sfp^x	Beta	0.7	0.1	0.7427	0.1022
Forward-looking in wage expectations	sfw	Beta	0.7	0.1	0.6946	0.1157
Ricardian household share	s^r	Beta	0.5	0.15	0.5425	0.1120
Inverse of intertemporal elasticity of substitution	σ	Gamma	2	0.75	1.7378	0.3231
Price elasticity of imports	σ_M^{DE}	Gamma	1.25	0.25	2.1089	0.2858
Price elasticity of imports of different sources	σ_1^{DE}	Gamma	1.25	0.5	0.5100	0.2208
Price elasticity of land demand	σ_L	Beta	0.5	0.2	0.6161	0.0000
Land share in production of housing services	s_L	Beta	0.3	0.1	0.1049	0.0046
Response of government purchases to debt	τ^B	Beta	0.02	0.01	0.0027	0.0013
Response of government purchases to deficit	τ^{DEF}	Beta	0.02	0.01	0.0141	0.0065
Response of transfers to debt	τ^{TRB}	Beta	0.02	0.01	0.0111	0.0056
Response of transfers to deficit	τ^{TRDEF}	Beta	0.02	0.01	0.0123	0.0082
Sensitivity of bond risk premium to public debt	ω^b	Beta	0.003	0.0012	0.0025	0.0015
REA						
Import demand stickiness	γ_m^{RE}	Beta	0.8	0.1	0.5389	0.1134
Consumption habit persistence	$h^{C,RE}$	Beta	0.7	0.1	0.6691	0.0646
Forward-looking in goods price expectations	sfp^{RE}	Beta	0.7	0.1	0.9264	0.0731
Price elasticity of imports	σ_M^{RE}	Gamma	1.5	0.25	1.1299	0.0729
Price elasticity of imports of different sources	σ_1^{RE}	Gamma	0.5	0.2	0.6912	0.2566
Inverse of intertemporal elasticity of substitution	σ^{RE}	Gamma	2	0.75	2.4288	0.7582
Slope of Phillips curve	φ^{RE}	Gamma	1.1	0.05	1.0294	0.0146
Monetary policy response to inflation	$\tau_\pi^{M,EA}$	Beta	2	0.4	1.7820	0.2774
Monetary policy response to output	$\tau_y^{M,EA}$	Beta	0.3	0.2	0.1446	0.0206
Monetary policy rate persistence	$\tau_{lag}^{M,EA}$	Beta	0.7	0.1	0.8849	0.0237
RoW						
Import demand stickiness	γ_m^{RW}	Beta	0.8	0.1	0.9325	0.0320
Consumption habit persistence	$h^{C,RW}$	Beta	0.7	0.1	0.8975	0.0204
Forward-looking in goods price expectations	sfp^{RW}	Beta	0.7	0.1	0.8472	0.0663
Price elasticity of imports	σ_M^{RW}	Gamma	1.25	0.25	0.7371	0.0589
Price elasticity of imports of different sources	σ_1^{RW}	Gamma	1.25	0.5	1.9641	0.6812
Inverse of intertemporal elasticity of substitution	σ^{RW}	Gamma	2	0.75	1.3947	0.3370
Slope of Phillips curve	φ^{RW}	Gamma	1.1	0.05	1.0026	0.0000
Monetary policy response to inflation	$\tau_\pi^{M,RW}$	Beta	2	0.4	1.1419	0.0775
Monetary policy response to output	$\tau_y^{M,RW}$	Beta	0.3	0.2	0.0022	0.0027
Monetary policy rate persistence	$\tau_{lag}^{M,RW}$	Beta	0.7	0.1	0.9458	0.0079

Table C.3: Estimation results for exogenous shocks

Shocks		Prior			Posterior	
DE		**distrib**	**mean**	**std**	**mode**	**std**
Shock to time preference rate	σ^{β}	Gamma	0.01	0.004	0.0024	0.0015
Shock to goods price mark-up	σ^{ϵ}	Gamma	0.01	0.008	0.0052	0.0085
Shock to construction price mark-up	σ^{pcon}	Gamma	0.01	0.004	0.0126	0.0039
Shock to import price mark-up	σ^{PM}	Gamma	0.01	0.004	0.0244	0.0020
Shock export price mark-up	σ^{PX}	Gamma	0.01	0.004	0.0151	0.0014
Shock to government purchases	σ^{CG}	Gamma	0.01	0.004	0.0015	0.0001
Shock to government investment	σ^{IG}	Gamma	0.01	0.004	0.0012	0.0001
Shock to labour supply	σ^{L}	Gamma	0.01	0.004	0.0141	0.0041
Shock to import demand	σ^{M}	Gamma	0.01	0.008	0.0594	0.0153
Shock to consumer prices	σ^{PC}	Gamma	0.01	0.004	0.0037	0.0004
Shock to country risk premium	$\sigma^{rpremde}$	Gamma	0.001	0.0004	0.0004	0.0000
Shock to investment risk premium	σ^{rpremk}	Gamma	0.01	0.004	0.0130	0.0037
Shock to housing risk premium	σ^{rpremh}	Gamma	0.01	0.004	0.0065	0.0026
Shock to labour demand	σ^{W}	Gamma	0.01	0.004	0.0314	0.0049
Shock to TFP	σ^{Y}	Gamma	0.01	0.004	0.0168	0.0017
Shock to transfers	σ^{TR}	Gamma	0.01	0.004	0.0060	0.0011
Shock to land stock	σ^{gL}	Gamma	0.01	0.004	0.0103	0.0034
Persistence time preference shock	ρ^{β}	Beta	0.5	0.2	0.9372	0.0258
Persistence goods mark-up shock	ρ^{ϵ}	Beta	0.85	0.1	0.9191	0.0739
Persistence construction mark-up shock	ρ^{pcon}	Beta	0.5	0.2	0.9250	0.0330
Persistence import mark-up shock	ρ^{PM}	Beta	0.5	0.2	0.8168	0.0415
Persistence export mark-up shock	ρ^{PX}	Beta	0.5	0.2	0.9303	0.0215
Persistence import shock	ρ^{M}	Beta	0.5	0.2	0.5418	0.1534
Persistence country risk shock	$\rho^{rpremde}$	Beta	0.5	0.2	0.6512	0.0825
Persistence investment risk shock	ρ^{rpremk}	Beta	0.5	0.2	0.8511	0.0571
Persistence housing risk shock	ρ^{rpremh}	Beta	0.5	0.2	0.9334	0.0221
Persistence labour demand shock	ρ^{W}	Beta	0.5	0.2	0.8844	0.0440
Persistence transfer shock	ρ^{TR}	Beta	0.5	0.2	0.0249	0.1607
Persistence land stock shock	ρ^{gL}	Beta	0.5	0.2	0.8010	0.0692
REA						
Shock to price mark-up	$\sigma^{\epsilon,RE}$	Gamma	0.01	0.004	0.0023	0.0003
Shock to import demand	$\sigma^{M,RE}$	Gamma	0.01	0.008	0.0133	0.0036
Shock to monetary policy	$\sigma^{i,EA}$	Gamma	0.01	0.004	0.0009	0.0001
Shock to euro/dollar risk premium	$\sigma^{rpremea}$	Gamma	0.001	0.0004	0.0008	0.0004
Shock to country risk premium	$\sigma^{rpremre}$	Gamma	0.001	0.0004	0.0003	0.0000
Shock to time preference rate	$\sigma^{\beta,RE}$	Gamma	0.01	0.004	0.0086	0.0029
Shock to TFP	$\sigma^{TFP,RE}$	Gamma	0.01	0.004	0.0055	0.0018
Persistence import demand shock	$\rho^{M,RE}$	Beta	0.5	0.2	0.8698	0.0921
Persistence euro area risk premium	$\rho^{rpremea}$	Beta	0.5	0.2	0.5684	0.2102
Persistence time preference shock	$\rho^{\beta,RE}$	Beta	0.5	0.2	0.8004	0.0591
Persistence TFP shock	$\rho^{TFP,RE}$	Beta	0.5	0.2	0.4356	0.1832
RoW						
Shock to price mark-up	$\sigma^{P,RW}$	Gamma	0.01	0.004	0.0113	0.0012
Shock to import demand	$\sigma^{M,RW}$	Gamma	0.01	0.008	0.0140	0.0062
Shock to monetary policy	$\sigma^{i,RW}$	Gamma	0.01	0.004	0.0012	0.0001
Shock to time preference rate	$\sigma^{\beta,RW}$	Gamma	0.01	0.004	0.0134	0.0037
Shock to TFP	$\sigma^{TFP,RW}$	Gamma	0.01	0.004	0.0313	0.0036
Persistence price shock	$\rho^{\epsilon,RW}$	Beta	0.5	0.2	0.3076	0.0000
Persistence time preference shock	$\rho^{\beta,RW}$	Beta	0.5	0.2	0.8325	0.0399

Table C.4: Calibrated exogenous shocks

Shocks	Symbol	Value
DE		
Shock to unemployment benefit replacement rate	σ^{BU}	0.005
Shock to pension benefit replacement rate	σ^{BR}	0.005
Shock to RETIR shock	σ^{RETIR}	0.002
Shock to YOUNG	σ^{YOUNG}	0.002
Shock to NPART	σ^{NPART}	0.002
Shock to C^G price	σ^{PG}	0.006
Shock to government financing costs	σ^{rpremb}	0.000
Shock to consumption tax rate	σ^{tc}	0.002
Shock to lump-sum taxes	σ^{TAX}	0.015
Shock to transfer account	$\sigma^{TA,DE}$	0.010
Shock to NFA value	$\sigma^{BWREV,DE}$	0.050
NFA residual	$\sigma^{BW,DE}$	0.025
REA		
Shock to transfer account	$\sigma^{TA,RE}$	0.050
Shock to NFA value	$\sigma^{BW,RE}$	0.040

Table C.5: Model-predicted and empirical business cycle statistics (first-differenced variables)

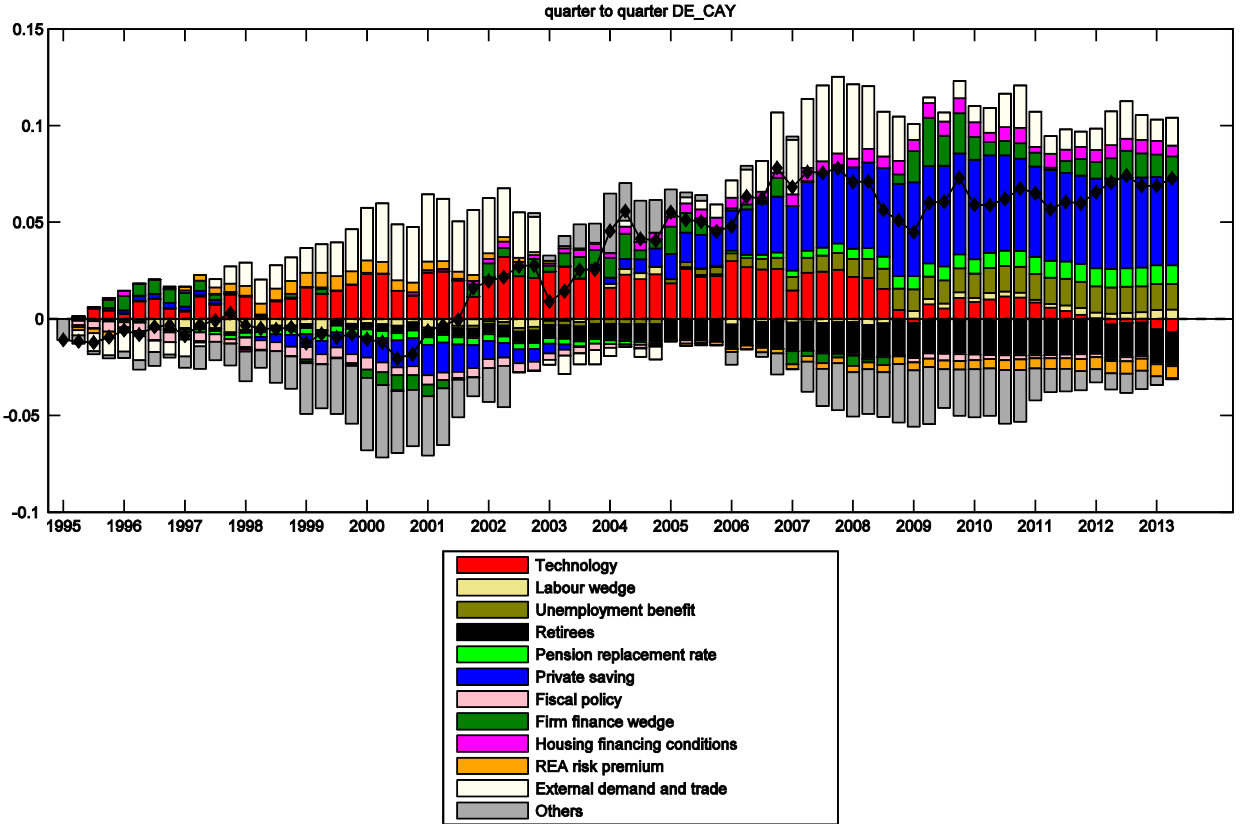
	Model		Data	
	Standard deviation, %	**Correl. with German GDP**	**Standard deviation, %**	**Correl. with German GDP**
	(1)	*(2)*	*(3)*	*(4)*
German variables				
GDP	1.02	1.00	0.86	1.00
Consumption (private)	0.87	0.42	0.59	0.26
Investment	4.66	0.31	4.09	0.39
Production capital	7.50	0.21	6.75	0.29
Government capital	6.47	0.18	5.53	0.16
Construction	3.59	0.39	2.67	0.42
Government consumption	1.00	0.10	0.86	0.07
Hours worked	0.45	0.45	0.28	0.29
Exports	3.39	0.43	3.29	0.63
Imports	2.62	0.04	2.36	0.40
Interest rate	0.40	0.02	0.38	-0.01
Inflation rate, GDP deflator	0.65	-0.35	0.40	-0.14
Inflation rate, export price	0.89	0.03	0.70	0.42
Inflation rate, import price	1.50	0.12	1.36	0.50
Exchange rate, depreciation rate	4.31	0.02	4.38	-0.02
Net exports/GDP	1.07	0.36	0.85	0.29
Current account/GDP	1.07	0.37	0.78	0.29
Saving rate	0.83	0.65	0.72	0.65
Investment rate	1.02	0.14	0.91	0.26
REA variables				
GDP	0.65	0.43	0.59	0.68
Inflation	0.40	-0.12	0.37	-0.04
ROW variables				
GDP	1.00	0.12	0.94	0.38
Inflation	2.06	0.16	1.88	0.30

Note: the Table reports model-predicted standard deviations and correlations with German GDP (Columns (1)-(2)) and the corresponding empirical statistics based on quarterly data for the period 1995q1-2013q2 (Columns (3)-(4)). All statistics pertain to first-differenced variables. Statistics for GDP, private and government consumption, investment, hours, exports and imports (in real terms) pertain to first differences of logged variables. The saving rate (investment rate) is the ratio of nominal national gross savings (investment) to nominal GDP. The ratios of net exports and of the current account to GDP are ratios of nominal variables. The empirical nominal exchange rate is the Euro-USD exchange rate. REA: Rest of Euro Area (EA less Germany). ROW: Rest of World.

D. Sensitivity analysis

Sensitivity analysis w.r.t. steady state (long-run) assumptions about German net foreign assets (NFA)

Table D.1: CA shock decomposition assuming steady state NFA equals 40% of annual GDP



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