What drives the German current account?  
And how does it affect other EU member states? (*)

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We estimate a three-country model using 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 labor 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 had a modest effect on the German trade balance and on German real activity. The key shocks that drove the rise in German net exports tended to worsen the REA trade balance, but only had a weak effect on REA real activity.

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1. Introduction
The German current account (CA) has undergone spectacular fluctuations in recent decades. In the 1990s, the German CA was in deficit, but close to balance—however after the advent of the Euro (1991), the CA shifted to steadily increasing surpluses, vis-à-vis both the rest of the Euro Area (REA) and the rest of the world (ROW). During the financial crisis, German capital flows to the REA fell abruptly, but the overall German CA surplus bounced back rapidly and reached record levels (185 bill. EUR in 2012, i.e. 7% of German GDP), due inter alia to a strong rise in the surplus vis-à-vis Asia. As result of these developments, Germany has become one of the major surplus countries in the world, only surpassed by China. These developments are at the heart of heated debates about the role of intra-Euro Area external imbalances for the crisis in Europe—and about a new macro-prudential system in Europe (see Lane (2012) and Chen, Milesi-Ferretti and Tressel (2012) for discussions of capital flows in the Euro Area). 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’. Economic theory suggests that a country’s CA 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 is thus crucial for positive and normative evaluations of the CA, and for policy advice (Obstfeld and Rogoff (1996), Obstfeld (2012), Kollmann (1998, 2001, 2004)). This underscores the importance of analyzing the CA using a structural model that captures the relevant shocks, and their transmission to the macroeconomy. This paper therefore studies the German CA using an estimated state-of-the art Dynamic Stochastic General Equilibrium (DSGE) model with three countries: Germany, the REA and the ROW. The model assumes a rich set of demand and supply shocks in goods, labor and asset markets, and it allows for nominal and real rigidities, and financial frictions. (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)).
Our results show that simple mono-causal explanations of the German surplus are insufficient. The surplus reflects a succession of distinct shocks. We devote particular attention to the following shocks: (i) an increase in financial integration in Europe that led to the convergence of REA interest rates to German rates before the launch of the Euro (1999); (ii) strong growth in emerging economies which boosted demand for German exports; (iii) far-reaching labor market and social security reforms in Germany during the period 2002-2005 that led to a reduction in unemployment benefits, thereby raising the German labor supply; (iv) depressed domestic demand in Germany due to positive shocks to the German saving rate (related to pension reform and population ageing).
According to the estimated model, German labor market reforms had a positive effect on German GDP and German net exports; 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. Strong ROW growth contributed positively to German and REA GDP and net export. Positive shocks to German household saving (linked to

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1 Throughout this paper, the term ‘Euro Area’ (EA) refers to the 17 countries that are members of the Euro Area as of this writing (2013). 11 of these countries have been members since the launch of the Euro (1999): Austria, Belgium, Germany, Finland, France, Luxemburg, Ireland, Italy, Netherlands, Portugal and Spain. Greece (2001), Slovenia (2007), Cyprus (2008), Malta (2008), Slovakia (2009) and Estonia (2011) joined later. REA is an aggregate of the EA less Germany.

2 The purpose of that review will be to determine whether the German surplus is benign or harmful for the EU economy. In the latter case, the EU Commission would have the authority to force Germany to take corrective actions.
population ageing) depressed aggregate demand in Germany, and thereby lowered German and REA GDP, while raising German net exports. Higher financial integration (i.e. the 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 German net exports. However financial integration was a less important driver of the German CA surge than the other key shocks that were just mentioned. All in all, the key shocks that drove German real activity and net exports only had a minor effect on real activity in the REA. In other terms, real activity in the REA was largely driven by domestic factors rather by German economic conditions.

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 labor 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. 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.

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 present paper is also 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 (2009), Benigno and Romei (2012)). By contrast, the paper here analyzes a rapid and persistent current account ‘surge’ that follows a prolonged period of current account balance.

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.

2. Macroeconomic conditions and the German external account, 1991-2012
Germany’s current account (CA) and net exports (NX) during the period 1991-2012 are plotted in Figure 1.a. The Figure shows that the dynamics of the German CA is closely linked to that of NX. After close-to-balance positions in the 1990s, the trade balance has been in persistent surplus since the early 2000s. The trade surplus and the current account peaked at 7.4% of GDP in 2007 before falling to about 6% in the global recession 2008-9 and then reaching 7% of GDP in 2012; this has led to a substantial positive international investment position (representing 35% of German GDP in 2011), see Figure 1.b. Net external transfers and investment income show an increase (from negative to positive values) starting in 2003, but the overwhelming part of the CA surplus since the early 2000s is linked to a rise in net exports.

To put these developments into perspective, Table 1 reports average current accounts of major economies (and country groups), during the period 1991-2012. During the past decade, Germany has become one of the major surplus countries in the world, only surpassed by China; the German and Chinese CA surpluses represented 0.30% and 0.35% of
world GDP, respectively, on average in 2002-2012. Figure 3 plots the CAs of Germany, Japan, China and the US—the German CA surpassed the Chinese surplus in 2012.

**Saving, investment and the German external balance**

The current account equals the difference between (nominal) gross saving (S) and gross investment (I): CA=S-I. Figure 1.c plots German saving and investment (as % of GDP). The rise in the German CA was driven by both a declining investment rate and an increasing saving rate.\(^3\) The German investment rate has trended downward during the sample period, from 24% in 1991 to 17% in 2012. The saving rate closely tracked the investment rate until the early 2000s, but then rose noticeably. That divergence between saving and investment rates explains the sharp increase in the German current account in the early 2000s.

Figures 1.d-1.g disaggregate national saving and investment into private and government S&I, and into household, and corporate S & I. We also disaggregate investment into household and non-household investment (Figure 1.h). The aggregate saving-investment gap is mainly driven by developments in the private sector; the government saving-investment balance has been less persistent and smaller. Strikingly, all of the disaggregated investment series have a downward trend (relative to GDP), including a trend decline in government investment. Household and corporate saving both rose, as a ratio of GDP, around the year 2000.

Table 2 reports German mean saving and investment rates for the period 1991-2000 (Col. (1)), and for 2002-2012 (Col. (2)). The average national saving rate in 2002-2012 exceeded the average rate in 1991-2000 by 1.94 ppt, while the average investment rate was 4.42 ppt lower in 2002-2012. About 2/3 of the rise in the mean CA/Y rate between the two sub-periods was thus driven by the fall in the investment rate. The rise in the mean private saving rate is largely driven by a rise in the corporate saving rate, while the mean household saving rate was slightly lower in 2002-2012 than in 1991-2000. By contrast, the drop in the mean investment rate (relative to GDP) is common to households (-2.20ppt), corporations (-1.55 ppt) and the government (-0.66ppt). The mean housing investment/GDP ratio fell by 1.82 ppt between 1991-2000 and 2002-2012, while non-housing investment/GDP fell by 2.60 ppt.\(^4\) While the decade-to-decade rise in the German CA is mainly driven by the fall in the investment rate, Figure 1 clearly shows that the rapid rise in the CA between 2002 and 2007 was largely driven by a rise in the saving rate. Thus, the saving rate matters greatly for the short- to medium-term dynamics of the German CA.\(^5\)

A key empirical regularity is that, for a wide range of countries, the trade and current account balances are countercyclical, i.e. negatively correlated with the ratio of domestic GDP to foreign GDP (e.g. Backus et al. (1992)). As documented in Table 3 this regularity holds for Germany too (see Columns (10)-(12)). The strong growth of the German current account and net exports after the introduction of the Euro is consistent with that

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\(^3\) The investment (saving) rate is the ratio of nominal investment (saving) to nominal GDP. All ratios of National Accounts variables to GDP discussed in the following paragraphs are ratios of nominal variables.

\(^4\) Housing investment is markedly smaller than non-housing investment—housing and non-housing investment represented 6.3% and 13.7% of GDP on average in 1991-2012. Hence, the drop in the mean housing investment/GDP ratio amounts to 25% of the mean ratio in 1991-2000.

\(^5\) To highlight this point, Table 3 reports standard deviations and cross-correlations of the German saving and investment rate, and of the current account/GDP rate, for the period 1991-2012. These moments are computed using raw (unfiltered) rates, and using rates that were linearly detrended, first-differenced and HP filtered. The raw investment rate is more volatile than the raw saving rate, and more strongly correlated (in absolute terms) with the current account than the saving rate. However, once low frequency components are removed the saving rate matters much more: the detrended saving rate is more volatile than the detrended investment rate, and more strongly correlated with the detrended current account.
countercyclical pattern, given the weak growth of relative German output, during that period (see below).

Figure 2 shows the contributions of private consumption (C), government consumption (G) and investment to the dynamics of net exports: \(NX=(Y-C-G)-I\). The ratio of private plus government consumption to GDP has, essentially, been trend-less during the sample period.\(^6\) The mean ratio of net exports to GDP rose by 4.82ppt across the sub-periods 1991-2000 and 2002-2012. The main driver of that rise was the fall in the investment rate. National saving is defined by \(S=\text{GNP-}C-G\). The facts that \(S/Y\) rose after 2002, while \((Y-C-G)/Y\) has (essentially) been trendless, shows that the rise in \(S/Y\) has largely been driven by the rise in GNP-GDP=net transfers and incomes received from the rest of the world.

Besides representing a declining share in GDP, investment has also been low in terms of real growth. Figures 6.a and 6.b plot volume series of GDP (Y), private consumption (C), government purchases (G) and investment (I) for Germany and the REA (compared to the base year 1995). German private consumption growth in real terms has been lower than real GDP growth since the mid-2000s. More strikingly, however, real investment demand has almost had a flat trend between 1995 and 2012, experiencing mainly temporary ups and downs.

Figure 4 also plots the CA balance and net exports for the REA and for the aggregate Euro Area (EA) (these balances are reported in \% of EA GDP). 'REA' is the EA less Germany. The REA CA balance was positive in the mid-1990s (about 1\% of EA GDP), and then fell steadily until the financial crisis. Since 2009 the REA CA has been improving continually, reaching a positive value in 2012.\(^7\) The German CA surplus is highly positively correlated with the REA CA deficit. Nevertheless, the REA CA is not a perfect mirror image of the German CA: in particular, the reduction in the REA CA balance began in 1998, while the German CA only began to rise in 2001. After the financial crisis, the German CA remained at a high level, while the REA CA balance fell sharply. The EA as a whole has mostly had a small positive CA balance since the mid-1990s (average balance since 1995: 0.5\% of EA GDP), but note the sizable EA surplus at the end of the sample (due to the simultaneous German and REA surpluses).

Figure 5 plots the bilateral CA (and bilateral net exports) of Germany vis-à-vis the REA and the ROW (all other countries of the world, including the rest of the EU). The German bilateral balances with the REA and the ROW both contributed by roughly equal amounts to the strong rise in the German external surplus after the launch of the Euro. Since the financial/sovereign debt crises, the German CA and trade balances with the REA have fallen markedly (by more than 2ppt of German GDP), but this was off-set by a rise in the CA and trade balances with the ROW. The bilateral CA surplus of Germany vis-à-vis the REA was highly positively correlated with the total REA CA deficit; however, the rise in capital flows from Germany to the REA only account for about one third of the sharp increases of the REA CA deficit between the 1990s and 2008.\(^8\)

\(^6\) The private consumption ratio (C/Y) only showed minor fluctuations until 2005; the consumption ratio then dropped by about 3 ppt in 2006-2007, before rising by more than 3 ppt in 2009. The sharp fall in the C/Y ratio in 2006-2007 occurred shortly after the 'Hartz' labor market reforms (2003-2005) that led to a permanent 15\% cut in the unemployment benefit ratio (ratio of benefit to wage) in 2005 (see below); the fall in the C/Y ratio might thus, partly, be due to the cut in benefits. The rise of the C/Y ratio in 2009 was largely due to the sharp contraction of GDP in that year. The ratio of government consumption to GDP, G/Y, too has been relatively stable since 1991. Note, however, the gradual fall in the G/Y ratio by about 1.75 ppt between late 2003 and the onset of financial crisis, followed by a sharp rise during the 2009 recession.

\(^7\) The REA trade balance closely tracks the path of the REA CA, but exceeds the CA, as the REA has a negative net income and transfers balance (of close to 1\% of EA GDP, on average).

\(^8\) The REA CA deficit rose from about -1\% of EA GDP in 1995-1999 to 2.3\% in 2008. During the same time span, the bilateral CA of Germany vis-à-vis the REA rose from -0.1\% of EA GDP to about 1\%. Thus, the rise in
Output and exports
Figure 6.c 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 was highly synchronized across these countries/region; however, German GDP growth is more closely synchronized with REA GDP than with ROW GDP. (Correlation of German GDP growth with REA and ROW growth: 0.69 and 0.49, respectively, in 1995-2012.)

German GDP grew less than REA GDP between 1995-2005. The gap between REA and German growth rates was especially sizable in 2002-2005. In that period Germany was sometimes referred to as the ‘laggard of Europe’ (Sinn, 2003). During that period, ROW growth too was markedly higher than REA and DE growth. Since 2006, German GDP has grown faster than REA GDP, except during the Great Recession of 2009.

Figures 7.e and 7.f plot trade-weighted GDP in the REA and the ROW as a proxy for German export demand. German net exports have been driven mainly by strong demand growth in the ROW (especially in emerging countries): the ROW share in German exports has increased steadily since about 2000, whereas the REA share has fallen. Real effective depreciation vis-à-vis the REA (see below) too has been supportive in translating higher foreign demand into higher demand for German exports. 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).

Labor market reforms
As a response to stagnant real activity in the early 2000s, the German government implemented a far-reaching labor market deregulation in 2003-05, also known as the ‘Hartz’ reforms. These reforms led to a reduction in unemployment benefits, but also included a host of other measures, such as a re-organization of labor placement and job training schemes to improve job matching. 9 Figure 8.d plots the average unemployment benefit ratio (ratio of unemployment benefit to wage rate) in Germany. The benefit ratio fell permanently in 2004-2005, from 62% to 53%. The German labor market reforms arguably weakened the bargaining power of German labor union. Union density (fraction of wage earners who are union members) fell steadily from 29% in 1995 to 18% in 2011 (OECD Labor Force Statistics (2013)). These developments most likely contributed to the very low growth of wages and of unit labor cost in Germany and also help to explain low German inflation (see below). These factors raised the competitiveness of German exporters, relative to the rest of the Euro Area.

The creation of the Euro: REA-DE interest rate convergence
The creation of the Euro eliminated exchange rate risk, and reduced financial transaction costs across member countries. 10 The date of the launch of the Euro (1.1.1999) was irrevocably set at the December 1995 Madrid European Council. Before 1995, the short term net capital flows (+1.1 ppt of EA GDP) accounts for roughly 1/3 of the rise in overall net capital flows to the REA (+3.3 ppt of EA GDP).

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10 Shortly after the launch of the Euro, EU financial integration was further stimulated by important regulatory changes that facilitated cross-border financial transactions, such as the ‘Markets in Financial Instruments Directive’, MiFID, of 2004.
(risk free) nominal interest on government debt was markedly higher in the REA than in Germany; see Figure 6.e (mean REA-DE 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-DE nominal interest rate spread was (essentially) zero when the Euro was launched at the beginning of 1999. Between 1999 and the outbreak of the global financial crisis in the second half of 2008, the interest rate spread remained very small; a positive spread between REA and German short government debt rates emerged again after the eruption of the sovereign debt crisis (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 7.a). It has been argued that Germany entered EMU at an overvalued exchange rate—and that hence low wage and price growth were needed to re-establish German competitiveness (internal devaluation) after the launch of the Euro.¹¹

This view is supported by OECD estimates of the Purchasing Power Parity (PPP) exchange rate between Germany and the Euro Area (OECD (2013)). As shown in Figure 7.d, the German nominal exchange rate was about 10% overvalued, relative to the OECD PPP benchmark in 1999; the gap between the nominal exchange rate and the PPP benchmark then fell gradually between 1999 and 2005. The real exchange rate of Germany plotted in Figure 7.c also provides support for German exchange rate overvaluation against the REA, at the start of EMU. 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 DE-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 inflation differentials inside the Euro Area: between 1999 and 2008 inflation has been markedly lower in Germany than in the REA (see Figure 6.f): the average annual growth rate of the GDP deflator was 0.75% in Germany, and 2.49% in the REA.¹² As a result of nominal interest rate convergence, the lower German inflation rate implied that the German real interest rate was higher than the REA real interest during the first 10 years of the Euro (Figures 6.g and 6.h).

The nominal (effective) exchange rates of Germany against the ROW depreciated much more strongly than the DE-REA exchange rate, between 1995 and 2001; the DE-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.

**Wages and unit labor cost**

Nominal wage growth has been markedly lower in Germany than in the aggregate EA during most of the Euro-era (see Figure 8.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 frequently negative during part of this period. As a result of these developments, the German labor share

¹¹ See, e.g., Louanges (2005) and Carton and Hervé (2012).

¹² The financial crisis led to a rise in German inflation, and to a sharp reduction in REA inflation; in 2009-2012 the average German [REA] inflation rate was 1.22% [1.00%]. Consumer price inflation shows a similar pattern: the 1999-2008 average PCE inflation rate was 1.26% in Germany and 2.45% in the REA; the corresponding rates for 2009-2012 were 1.41% and 1.46%, respectively.
(share of wage income in GDP) fell steadily, from 57% in the early 1990s to 49% in 2008. Nominal unit labor 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. By contrast, nominal ULC rose steadily in the REA, between 1995 and 2008, but has been constant since then.

Demographics and pension reforms
One prominent candidate for increased German saving rates is population ageing. Empirical analysis by the IMF (2013) provides evidence for a strong positive impact of projected ageing speed on the CA position.\(^\text{13}\) The number of births was high during the 1930s, but fell sharply during World War II; the number of birth then rose steadily between 1945 and the early 1960s, and then fell sharply (Figure 9.a). This has led to a rapid rise in the number of pensioners, during the period 1995-2012 (due to retirement of the cohorts born in the 1930s). The old-age dependency ratio, defined as the number of people aged 65 and above, relative to the working-age population (15-64 years), has increased by 10 percentage points between the mid-1990s and 2012. Projections (German Council of Economic Advisors (2011)) point to a still more dramatic increase by around 20 percentage points within the next 20 years, due to the retirement of the post-war ‘baby boom’ cohorts (Figure 9.b). The expected increase in the old-age dependency rate over 10-30 year horizons at a given point in time (Figure 9.c) is another way to visualise these ageing projections. Importantly, the speed of population ageing is higher in Germany than in most other major economies (German Council of Economic Advisors (2011)). Higher future dependency rates 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 out of current income.

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 (Fig. 9.d). 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 (e.g., Boersch-Supan et al., 2001; Deutsche Bundesbank, 2011; Huefner and Koske, 2010). It has also been argued that reform of the German labor market increased income uncertainty for households, which may have raised precautionary saving.

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. The Appendix provides a complete description of the model and of the econometric methodology.\(^\text{14}\)

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 (e.g., Christiano, Eichenbaum and Evans (2005), Smets and Wouters (2007), Ratto, Roeger and in’t Veld (2009), Kollmann, Roeger and in’t Veld (2012), Kollmann, Ratto, Roeger and in’t Veld (2013), Kollmann (2013), Jacob

\(^{13}\) The IMF analysis uses a sample of 49 countries over the period 1986-2010 and finds that a 1 percentage-point increase in the old age dependency ratio relative to the country average tends to increase the CA balance by 0.2 percentage points.

\(^{14}\) We solve the model by linearizing it around a deterministic steady state; the linearized model is estimated with Bayesian methods, using DYNARE (Adjemian et al. (2011)).
and Peersman (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.

Our model assumes three countries: Germany, the REA and the ROW. We estimated the model using quarterly macroeconomic and financial data for Germany, REA and the ROW during the period 1995q1-2012q4. (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 Euro was highly likely; the date of the launch of the Euro was officially announced in December 1995, as mentioned above).

The German bloc of the model is rather detailed, while the REA and ROW blocs are more stylized. The German bloc 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 labor services to goods producing firms, and they accumulate housing capital—worker welfare depends on their consumption, hours worked and stock of housing capital (all households are owner-occupiers). 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 the discount rate used by German firms 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 shortcut 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 labor 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 data dynamics.

The German bloc also assumes a government that finances purchases and transfers using distorting taxes and by issuing debt.

The model assumes exogenous shocks to preferences, technologies and policy variables that alter demand and supply conditions in markets for goods, labor, production capital, housing, and financial assets. All exogenous variables follow independent univariate autoregressive processes. In total, 40 exogenous variables 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 36 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:

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15 This structure (with patient and impatient households and exogenous loan-to-value shocks) builds on Iacoviello (2005) and Iacoviello and Neri (2010).
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 (1999-2012), the policy rate is taken to be a weighted average of $i_{t+1}^{DE}$ and of the REA short-term government bond rate, $i_{t+1}^{REA}$:

$$i_{t+1}^{EA} = s_{t+1}^{DE} + (1-s_{t+1}^{REA}),$$ (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 function of the lagged policy rate, of the year-on-year Euro Area CPI inflation rate, of the year-on-year growth rate of Euro Area real GDP, and of a random disturbance.16

Interest rate spreads

We assume that the uncovered interest rate parity conditions that link German, REA and ROW interest rates (denoted by $i_{t+1}^{DE}$, $i_{t+1}^{REA}$ and $i_{t+1}^{ROW}$ respectively) are disturbed by exogenous shocks (e.g. McCallum (1994), Kollmann (2002)):

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

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

where $e_{t+1}^{jk}$ is the nominal (effective) exchange between countries $j$ and $k$, defined as 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):

$$\Delta \ln e_{t+1}^{REAROW} = s \Delta \ln e_{t+1}^{READOE} + (1-s) \Delta \ln e_{t+1}^{REAROW}. $$ (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 DE 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’.17

Since the introduction of the Euro, $e_{t+1}^{READE}$ has been constant; thus $\Delta \ln e_{t+1}^{READOE}$ holds after the launch of the Euro. Between 1995q1 (start of estimation sample) and the introduction of the Euro (1.1.1999), the bilateral REA/DE exchange rate only showed muted fluctuations (see Figure 7.a). We assume that agents believed the REA/DE exchange rate to follow a random walk during the 1995-1998 transition period, i.e. that $E_t \Delta \ln e_{t+1}^{READE} = 0$. This assumption allows to construct a time series for the DE-REA risk premium: $\rho_t^{REA,DE} = i_{t+1}^{REA} - i_{t+1}^{DE}$ (see Figure 6.h). We feed the REA-DE risk-premium into our model to assess the effect of the convergence of REA and DE interest rates on macroeconomic variables and the German external balance. Our empirical measure of the

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16 We thus assume that before the launch of the Euro (1995-98), the Bundesbank set monetary policy for all countries in the (future) Euro Area. For simplicity, 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.

17 It follows from (1)-(4) that the following interest parity conditions hold between Germany and the ROW (and between REA and ROW): $i_{t+1}^{DE} = i_{t+1}^{ROW} + E_t \Delta \ln e_{t+1}^{REAROW} + \rho_t^{DE,ROW}$ and $i_{t+1}^{REA} = i_{t+1}^{ROW} + E_t \Delta \ln e_{t+1}^{REAROW} + \rho_t^{REA,ROW}$, with $\rho_t^{DE,ROW} = \rho_t^{EA,ROW} = -(1-s)\rho_t^{REA,DE}$ and $\rho_t^{REA,ROW} = \rho_t^{EA,ROW} + s \rho_t^{REA,DE}$. 

10
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. Capital accumulation is affected by shocks to investment efficiency (e.g., Fisher (2006)), and by shocks to total factor productivity (TFP). As discussed above, we also assume an exogenous wedge between the marginal product of German productive capital and the German risk-free interest rate.

**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**

In the model, German private and government 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/technology shocks that shift the desired combination between domestic and imported intermediates, and shocks to the market power (mark-up) of exporters.

**Labor 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 ‘Hartz’ labor market reforms (see discussion above) by treating the unemployment benefits ratio as a time-varying exogenous variable. We feed the historical benefits ratio (Figure 8.d) into the model. We assume that wages are set by a labor union that acts like a monopolist in the labor market. To capture the (low) wage growth in Germany, we assume that 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) is time varying.

**Household 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 ‘household 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 a fixed number of infinitely-lived 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 labor, 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 ‘rr’ is an exogenous parameter, the ‘pension replacement rate’. We use the empirical replacement rate (Figure 9.d) 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 (0.7). German households exhibit stronger consumption habit persistence (habit parameter: 0.8) than REA and ROW households (habit parameters: 0.57 and 0.55, respectively). German households have an intertemporal substitution elasticity below unity (0.6). The German (Frisch) labor supply elasticity is 0.4. 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. The substitution elasticity between domestic and imported products is high (3.0) in Germany, close to unity (1.1) in the REA and below unity (0.7) 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.

4.1. Impulse response functions
We now discuss dynamic responses to the shocks that matter most for the German external balance. We begin by discussing shocks to German aggregate supply (shocks to German TFP and to German unemployment benefits), and then discuss German aggregate demand shocks (saving shocks), a shock to the REA risk premium, and an external (ROW) demand shock.

Positive German aggregate supply shocks: TFP increase and labor market reform
Figure 10.a shows dynamic responses to a permanent rise in German TFP. In the short-run, price stickiness and capital and labor 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; the consumption ratio falls, hence. On impact, the German labor 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. The shocks 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 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

18 Despite the modest degree of nominal wage stickiness, the impulse responses show that the real wage rate exhibits substantial sluggish adjustment to shocks.
19 Other detailed estimation results are reported in the Appendix.
fall in German productive investment. The sluggish rise in German absorption and the improvement in German price competitiveness (fall in the price of the relative German/REA output price) implies that German net exports rise persistently. The rise in German net exports leads to a persistent fall in REA net exports, which helps to understand why REA GDP too falls persistently—but 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 robust 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). 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 would then fall (e.g. Obstfeld and Rogoff (1996)). As mentioned above, estimated consumption habit persistence is markedly weaker for REA and ROW household—our model estimates suggest that positive REA and ROW productivity shocks lower the net exports of these countries. \(^{20}\)

Figure 10.b reports dynamic responses to a German labor market reform—captured here by an exogenous permanent reduction in the German unemployment benefit rate (unemployment benefit divided by wage income per employee). The benefits cut raises German labor 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 after two years (due to the increase in GDP which raises the consumption of saver households). However, consumption again adjusts sluggishly to the rise in GDP, and the German consumption/GDP ratio falls. 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 labor 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. (The model also assumes another type of German aggregate supply shock, namely a shock to investment efficiency; see, e.g., Justiniano, Primiceri and Tambalotti (2008). The effects of that shock on domestic output and net exports are similar to the responses to TFP and benefits shocks.)

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: high net exports, low inflation (relative to the REA) and a high saving rate.

**Negative German aggregate demand shocks**

Figure 10.c shows dynamic responses to a positive German saving shock, namely a persistent fall in the subjective rate of time preference. The shock triggers a long-lasting reduction in

\(^{20}\) An additional factor explaining why German net exports are pro-cyclical, while REA net exports are counter-cyclical in response to domestic TFP shocks is that the German shock triggers a weaker fall in the EA policy rate, as Germany accounts for a smaller share of the aggregate EA economy. Hence, EA monetary policy provides a weaker stimulus to aggregate demand, after a positive German TFP shock.
German aggregate consumption; the resulting increase in the marginal utility of consumption raises households’ (desired) labor 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 demand—i.e. GDP and employment fall initially, before rising above their unshocked path (due to the increased labor supply). German investment falls on impact, but then increases, as the rise in household saving lowers the German real interest rate (due to a fall in the German inflation rate). REA net exports and REA GDP are negatively affected by the German saving increase, due to the fall in German demand for REA goods.

Other negative German aggregate demand shocks have similar effects. E.g., a fall in the German pension replacement rate likewise raises German saving, it lowers German GDP and increases German net exports. Discretionary cuts in government purchases, and tax increases (a fiscal consolidation) also lower German aggregate demand, and thus lead to a fall in domestic GDP and prices, while raising net exports.21

Negative German aggregate demand shocks too are, thus, consistent with key features of the German macro data—namely high net exports, and low inflation.

Fall in spread between REA bonds and German bonds
Figure 10.d shows dynamic responses to a persistent fall in the REA-DE bond spread, \( \rho_{t}^{REA,DE} = t_{t+1}^{REA} - t_{t+1}^{DE} \). 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 (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 more gradual fall in German consumption. However, German GDP rises due to strong REA demand, and thus 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 1996-1998 (phase before Euro launch, during which the REA-DE 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 offset the effect of the spread shock on German net exports.

Positive shock to ROW aggregate demand
Finally, Figure 10.e shows responses to a rise in ROW aggregate demand triggered by a persistent rise in the ROW subjective discount rate. The shock raises ROW GDP and ROW absorption, which increases demand for German and REA exports and GDP, and leads to higher inflation in the Euro Area. This triggers a rise in the EA policy rate, which reduces German investment by increasing financing costs. 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 shocks to historical time series. Figures 11.a-11.c show historical decompositions of the following German macroeconomic variables: net exports (divided by nominal GDP), year-on-year GDP growth, and inflation (GDP deflator). Figures 12.a-12.b show decompositions of the REA trade balance (divided by REA nominal GDP).

21 Detailed dynamic responses to shocks to the pension replacement ratio and to fiscal shocks are available on request. The historical decompositions of net exports discussed below show that these shocks had a smaller role for the German saving-investment gap than rate-of-time preference shocks.
and of the REA 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). 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 exogenous shocks originating in Germany: (1) TFP and investment efficiency (see red bars labeled ‘technology’); (2) firm investment wedge (‘firm financing conditions’); (3) household loan-to-value ratio (‘household financing conditions’); (4) subjective rate of time preference, number or retirees and pension replacement rate (‘household saving’); (5) unemployment benefit generosity; (6) fiscal policy; (7) union power (‘labour market shocks’).

In addition, we show the contribution of disturbances to: (1) REA-German interest rate spread (‘Risk premium shock’); (2) transfers by Germany to the REA and the ROW (net contribution to EU budget; migrant remittances), referred to as ‘transfer account shocks’; (3) external demand and trade shocks.

Figures 12.a and 12.b (of REA net exports and GDP growth) also show the contributions of REA aggregate demand shocks and of REA aggregate supply shocks.

The remaining shocks are markedly less important drivers of German real activity and of German net exports, and are hence combined into a category labeled ‘other shocks’.

The historical decomposition shows that the following shocks had a noticeable positive effect on the German trade balance, at varying times, during the sample period: (i) positive German aggregate supply 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 labor 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 aggregate supply shocks had a persistent negative effect on the German investment rate, according to the estimated model, and boosted the German trade balance by up to 1.5% of GDP during the early 2000s, i.e. during the phase during which the trade balance rose sharply. The positive contribution of aggregate supply shocks became gradually weaker after 2004. (During the 2009 financial crisis, TFP and investment efficiency fell noticeably in Germany—and thus domestic aggregate supply shocks made a negative contribution to the German trade balance after the crisis.) Aggregate supply shocks are 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 have a noticeable effect on German inflation: positive supply shocks in the first half of the sample period had a

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22 In the model, the steady state of German and REA net exports is set at 0; the steady state year-on-year growth rates of German and REA GDP is 1.08%, and steady state annual inflation is 2%.

23 In the historical decomposition of German variables, ‘external demand and trade shocks’ refers to aggregate demand and supply shocks originating in the REA and in the ROW. In the decompositions of REA net exports and REA GDP growth, ‘external demand and trade shocks’ pertains to ROW aggregate demand and supply shocks only.

24 Also included in ‘other shocks’ are the dynamic effects of initial conditions, i.e. of predetermined states in the first period of the sample (‘base trajectory’).
pronounced negative effect on inflation. Negative TFP 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 net exports between the late 1990s and the mid-2000s (see dark yellow bars labeled ‘Risk premium shocks’ in Figure 11.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 11.d), 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 was completed when the Euro was launched on 1.1.1999. This explains why the impact of interest rate convergence on the German trade balance was strongest between 1999 and 2002 (accounting for about +1% of the trade balance/GDP ratio). However, during that time German net exports were still very small—net exports actually fell slightly between 1998 and 2001. The timing of interest rate convergence does thus not match the sharp rise in German net exports (the latter occurred several years after convergence). According to our estimates, interest rate convergence had a small positive effect on German GDP (due to stronger REA demand for German exports), unit labor cost and inflation.

As might be expected, the convergence of REA interest rates to German levels made a markedly stronger negative contribution to the REA trade balance—interest rate convergence contributed especially to the sharp fall in REA net exports that occurred in 1998-2001. Interest rate convergence also contributed noticeably to the 1997-1999 boom in REA activity.

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 CA balance, but only by a modest amount. Also, as pointed out above, the timing of interest rate convergence does not match the surge of German net exports. In closely related analyses, ‘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 noticeably more for the REA trade balance than for German net exports, 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 ‘t Veld et al. (2013), Reis (2013) and Fernández-Villaverde, Garicano and Santos (2013).)

The historical decomposition shows that strong world demand in the 2000s, too, has contributed to Germany’s trade surplus. Indeed, high world demand has increased German exports. The positive external demand shocks prior to the financial crisis essentially crowded out German consumption spending, but only had a very weak and short-lived (negative) effect on investment. At the same time, stronger demand has increased German inflation. Hence the effect of strong world demand is mitigated by its impact on German trade competitiveness.

The cuts in unemployment benefits introduced during the ‘Hartz’ labor market reforms raised German GDP, but lowered private consumption, according to the model estimates. According to the historical decomposition, the labor market reforms raised
household labor supply, but only had a negligible effect on the German investment rate. Nevertheless, the reforms contributed to a decline in unit labour costs, and thus increased German price competitiveness. Spillovers of German labor market reforms to REA real activity were weak, but positive; the reforms made a negative contribution to REA net exports.

Positive shocks to the German saving rate account for an increasingly more important share of the German trade balance surplus after 2003. In the model, these savings shocks represent the observed fall in the pension replacement ratio (Figure 9.d), as well as exogenous (negative) shocks to German households’ subjective discount rate. The latter can be viewed as reduced-form shocks reflecting households’ heightened awareness/concerns about population ageing. 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 above). Note that we do not feed changes in German demographic variables predicted beyond the sample period into the model—this might be a useful avenue for future research. Note also that German saving shocks contributed to low German inflation (as those shocks depressed aggregate demand in Germany). German saving shocks have negatively contributed to German GDP and labour cost growth, with a negative impact on import demand and some positive impact on exports given the competitiveness gain. The effects of German saving shocks on REA GDP were negative due to German competitiveness gains and the fall in German import demand (triggered by the saving shock).

The contribution of shocks to German firm financing conditions to net exports varies across the sample period. The contribution has been positive in periods of elevated financing costs (aftermath of dot-com bubble and of global financial crisis) and, hence, weak domestic investment, and negative in times of lower financing costs and stronger investment demand (as shortly before the financial crisis). The fluctuation in firms financing costs in the estimated model does, hence, not explain the persistent trade balance improvement. By contrast, adverse shocks to firm financing conditions were key drivers of the fall in the German investment rate.

Finally, the contribution of German fiscal policy to the German trade surplus is estimated to be minor.

The major shocks increasing German net exports tend to reduce REA net exports (see Figure 12.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 both adverse income and competitiveness effects on Germany’s REA trading partners. In recent years, German labor market reforms, too, has 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 tended to raise 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 additional 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. 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.

25 Boersch-Supan et al. (2003) feed predicted long-term demographic trends into a multi-country OLG model (with a 50 year individual horizon) and generate sizable German current account surpluses from ageing (and noticeable current account increases in responses to German pension reforms).
of 2012. After the financial crisis, the REA experienced a noticeable reduction in TFP—and that adverse supply shock, too, has contributed to the marked improvement in the REA trade balance, after the crisis. (As discussed above, a REA TFP increase [reduction] reduces [raises] REA net exports.) Another factor that has tended to improve REA net exports since the crisis has been the fact that the REA-German interest rate spread became positive again (Figure 6.g).

As shown in Figure 12.a, ROW external demand fluctuations have tended to boost REA net exports, especially during the years 2001-2006 (during this period ROW GDP growth noticeably exceeded REA and DE growth). External REA transfers (mainly to the ROW), too, have tended to raise REA net exports, throughout most of the sample period.

REA GDP was largely driven by domestic aggregate supply and demand shocks. While shocks originating in Germany had a noticeable effect on REA net exports, the spillovers of German shocks to REA GDP are relatively weak. However, 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, while 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 crisis is to a large degree driven by adverse REA aggregate demand shocks. Labor 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).

5. Scenarios for the German external balance

Although uncertainty about future shocks makes it impossible to fully anticipate the further evolution of the German trade balance, we can characterize the likely impact of current drivers in the years to come. The contribution of German saving shocks to the trade balance has peaked at the end of the last decade and is slowly diminishing. One factor for this result is the rising share of pensioners, which reduces the aggregate savings rate. 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. Nevertheless this effect could be offset by pension reform measures which reduce the pay-as-you-go pillar. 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 net exports is that German residential investment is likely to pick up in the near term, given low interest rates in Germany. Although the tradable content of construction is low, this will raise non-housing consumption and hence reduce the trade balance, due to the complementarity between housing and non-housing consumption. The previous discussion has focused on the reduction of benefit replacement rates as a key element of the ‘Hartz’ labor 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 trade balance. The model suggests that the positive effect of permanent labour market reform on German net exports is only temporary, since employment and associated wage increases stimulate domestic demand (private consumption). According to the model estimates, the trade balance increase reaches its maximum around 7 years after the reform. After that, the trade surplus declines in response to growing domestic demand. This implies that the contribution of past labour market reforms to the trade balance surplus is likely to decline in future years. The contribution of fiscal policy shocks for the German trade balance has been modest, but
positive in recent years given the surplus in the primary government balance. The future trade balance contribution of fiscal policy will depend on the evolution of the primary balance in coming years. Given 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.

6. Conclusion
We have developed a three-country DSGE model and estimated that model using quarterly 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 surge in the German surplus after the launch of the Euro were strong world demand for German exports, German labor market reforms, and positive shocks to the German saving rate that depressed domestic demand. The key shocks that drove the rise in German net exports only had a modest effect on real activity in the REA, but these shocks had a marked negative effect on REA net exports. Given that some of the key driving shocks are likely to have a persistent but not a permanent positive impact on the trade balance, the German current account surplus is likely to gradually become smaller in coming years. This is particularly the case for the labour market reform shock, whose effect on German competitiveness gains are likely to be eroded in the medium/long run due to higher German wage growth. More uncertain are the prospects of the savings shock. The pure demographic component will reduce savings gradually, while other factors may raise precautionary saving.
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Table 1. Current accounts of major economies, in % of world GDP

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<td>USA</td>
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<td>CIS</td>
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<td>0.136</td>
<td>0.112</td>
</tr>
<tr>
<td>Developing Asia</td>
<td>0.002</td>
<td>0.382</td>
<td>0.380</td>
</tr>
<tr>
<td>China</td>
<td>0.043</td>
<td>0.349</td>
<td>0.306</td>
</tr>
<tr>
<td>Middle East &amp; North Africa</td>
<td>-0.025</td>
<td>0.369</td>
<td>0.395</td>
</tr>
<tr>
<td>Latin America &amp; Caribbean</td>
<td>-0.169</td>
<td>-0.022</td>
<td>0.147</td>
</tr>
</tbody>
</table>

Table 2. German current account, net exports and demand components, in % of German GDP (means over sub-periods)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>CA</td>
<td>-1.09</td>
<td>5.27</td>
<td>6.36</td>
</tr>
<tr>
<td>NX</td>
<td>0.51</td>
<td>5.32</td>
<td>4.82</td>
</tr>
<tr>
<td>Net transfers &amp; income</td>
<td>-1.60</td>
<td>-0.06</td>
<td>1.54</td>
</tr>
<tr>
<td>National S</td>
<td>21.23</td>
<td>23.17</td>
<td>1.94</td>
</tr>
<tr>
<td>Private S</td>
<td>20.52</td>
<td>22.82</td>
<td>2.30</td>
</tr>
<tr>
<td>Households S</td>
<td>11.47</td>
<td>11.41</td>
<td>-0.06</td>
</tr>
<tr>
<td>Corporations S</td>
<td>9.05</td>
<td>11.41</td>
<td>2.36</td>
</tr>
<tr>
<td>NFC S</td>
<td>8.42</td>
<td>10.44</td>
<td>2.01</td>
</tr>
<tr>
<td>FINC S</td>
<td>1.12</td>
<td>1.11</td>
<td>-0.01</td>
</tr>
<tr>
<td>Government S</td>
<td>0.70</td>
<td>0.35</td>
<td>-0.35</td>
</tr>
<tr>
<td>National I</td>
<td>22.32</td>
<td>17.90</td>
<td>-4.42</td>
</tr>
<tr>
<td>Private I</td>
<td>20.07</td>
<td>16.32</td>
<td>-3.75</td>
</tr>
<tr>
<td>Households I</td>
<td>8.19</td>
<td>5.99</td>
<td>-2.20</td>
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<tr>
<td>Corporations I</td>
<td>11.88</td>
<td>10.33</td>
<td>-1.55</td>
</tr>
<tr>
<td>NFC S</td>
<td>11.25</td>
<td>10.12</td>
<td>-1.13</td>
</tr>
<tr>
<td>FINC S</td>
<td>0.60</td>
<td>0.29</td>
<td>-0.31</td>
</tr>
<tr>
<td>Government I</td>
<td>2.24</td>
<td>1.58</td>
<td>-0.66</td>
</tr>
<tr>
<td>C</td>
<td>57.93</td>
<td>57.76</td>
<td>-0.17</td>
</tr>
<tr>
<td>Housing I</td>
<td>7.21</td>
<td>5.42</td>
<td>-1.78</td>
</tr>
<tr>
<td>Non-housing I</td>
<td>15.10</td>
<td>12.48</td>
<td>-2.62</td>
</tr>
<tr>
<td>G</td>
<td>19.25</td>
<td>19.01</td>
<td>-0.23</td>
</tr>
<tr>
<td>CA wrt REA</td>
<td>-0.20</td>
<td>2.76</td>
<td>2.97</td>
</tr>
<tr>
<td>CA wrt ROW</td>
<td>-0.89</td>
<td>2.51</td>
<td>3.39</td>
</tr>
<tr>
<td>NX wrt REA</td>
<td>0.11</td>
<td>2.58</td>
<td>2.47</td>
</tr>
<tr>
<td>NX wrt ROW</td>
<td>0.40</td>
<td>2.74</td>
<td>2.35</td>
</tr>
</tbody>
</table>

Note—NFC: non-financial corporations; FINC: financial corporations
Means are computed for 1995-2000 (Col. 1) and 2002-2011 (Col. 2), and the Col. 3 is the difference between mean values for 2002-2011 and 1995-2000.
**Table 3. Decomposing fluctuations in the German current account, annual data, 1991-2012**

<table>
<thead>
<tr>
<th>Filter</th>
<th>Std(s)</th>
<th>Std(i)</th>
<th>Std(ca)</th>
<th>C(s,i)</th>
<th>C(s,ca)</th>
<th>C(i,ca)</th>
<th>V(s)</th>
<th>V(i)</th>
<th>V(ca)</th>
<th>-2Cov(s,i)</th>
<th>V(ca)</th>
<th>Corr between ca &amp;...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>1.87</td>
<td>2.35</td>
<td>3.45</td>
<td>-0.33</td>
<td>0.77</td>
<td>-0.86</td>
<td>0.29</td>
<td>0.46</td>
<td>0.24</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>dtrendL</td>
<td>1.56</td>
<td>1.06</td>
<td>1.48</td>
<td>0.41</td>
<td>0.76</td>
<td>-0.28</td>
<td>1.11</td>
<td>0.51</td>
<td>-0.62</td>
<td>-0.13</td>
<td>-0.28</td>
<td>-0.59</td>
</tr>
<tr>
<td>fdiff</td>
<td>1.23</td>
<td>1.08</td>
<td>0.99</td>
<td>0.64</td>
<td>0.54</td>
<td>-0.29</td>
<td>1.56</td>
<td>1.20</td>
<td>-1.76</td>
<td>-0.00</td>
<td>-0.21</td>
<td>-0.23</td>
</tr>
<tr>
<td>HP</td>
<td>1.32</td>
<td>0.99</td>
<td>1.30</td>
<td>0.40</td>
<td>0.71</td>
<td>-0.36</td>
<td>1.04</td>
<td>0.58</td>
<td>-0.62</td>
<td>-0.07</td>
<td>-0.55</td>
<td>-0.56</td>
</tr>
</tbody>
</table>

Note—s=S/GDP; i=I/GDP; ca=CA/GDP, where S,I,CA,GDP are gross national saving, gross investment, the current account and GDP, in nominal terms. \( Y' \): real GDP in region i=DE,REA,ROW (DE: Germany; REA: rest of Euro Area; ROW: world economy less Euro Area).

Std(x), V(x): standard deviation and variance of ‘x’; C(x,y): correlation between x and y. Cov(x,y): covariance. Cols. (7)-(9) report (co)variances of s and i, normalized by the variance of ca, motivated by the fact that \( V(ca) = V(s) + V(i) - 2Cov(s,i) \), and thus: \( 1 = V(s)V(ca) + V(i)V(ca) - 2Cov(s,i)V(ca) \).

Cols. (10)-(11) show correlations between ca and logged German GDP, and the logged ratios of German GDP to GDP in the rest of the EA, and in the rest of the world.

The row labeled ‘Raw’ shows statistics computed with undetrended series; ‘dtrendL’: all series linearly detrended; ‘fdiff’: all series first differenced; ‘HP’: all series HP filtered (smoothing parameter: 400)
Figure 1: The German current account, net exports saving 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 sector: saving & investment, % of GDP

(1.e) Government: saving & investment, % of GDP

(1.f) Households: S & I, % of GDP

(1.g) Corporations: saving & investment, % of GDP

(1.h) Housing and non-housing investment, % of GDP
Figure 2: Decomposing net exports
(2.a) Net export, Y-C-G-I, % of GDP
(2.b) Private & Government consumption, % of GDP

Figure 3: CAAs of US, Germany and China
Figure 4. German, REA and EA external balances (in % of EA GDP)
(4.a) CA surplus of Germany, REA and ROW
(4.b) NX of Germany, REA and ROW

Figure 5. German bilateral external balances, in % of EA GDP
(5.a) German CA surplus with REA, ROW
(5.b) German NX to REA and ROW
(5.c) German CA surplus with REA & REA CA deficit
(5.d) German Net Exports to REA & REA Net Imports
Figure 6: GDP, interest rates, inflation

(6.a) Germany: real GDP and domestic demand

(6.b) REA: real GDP and domestic demand

(6.c) YoY GDP growth rates (DE, REA, ROW)

(6.d) Demeaned log GDP


(6.f) YoY growth of GDP deflator, %

(6.g) Real interest rates: DE, REA, % p.a.

(6.h) Germany-REA nominal & real interest rate differentials, % p.a.
Figure 7: Exchange rates and export markets

(7.a) Nominal effect. exchange rates: DE vs. REA
(7.b) Nominal exchange rates: DE & REA vs. ROW

Rise: DE appreciation; exch. rate 1999-2012 normalized at 1
Rise: DE (REA) appreciation

(7.c) Real exchange rates: DE-REA; DE-ROW
(7.d) Nominal exchange rate and PPP DE-REA

Rise: DE appreciation
Rise: DE appreciation. Source OECD.

(7.e) Export market growth
(7.f) Export market share
Figure 8: Wages, unit labor costs, unemployment benefits
(8.a) Nominal compensation per employee, % p.a. growth  (8.b) Real compensation per employee, % p.a. growth

(8.c) Nominal unit labor cost, DE & EA (2005=100)  (8.d) Average unemployment benefit ratio, Germany

Figure 9: Demographics and pensions: Germany
(9.a) Age distribution in 1995 and 2010, in %  (9.b) Germany, dependency ration, in %
(9.c) Germany: Ageing Speed  (9.d) Germany, average pension replacement rate, in %
Figure 10.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 10.b 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 10.c  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 10.d Fall in REA-DE 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 10.e 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 11. Historical decompositions of German macroeconomic variables

11.a. German net exports divided by nominal GDP

11.b. German GDP, year-on-year growth rate

11.c. Historical decomposition: 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 exogenous shocks originating in Germany are plotted: (1) TFP and investment efficiency (bars labeled ‘technology’); (2) firm investment wedge (‘firm financing conditions’); (3) household loan-to-value ratio (‘household financing conditions’); (4) subjective rate of time preference, number or retirees and pension replacement rate (‘household saving’); (5) unemployment benefit generosity; (6) fiscal policy; (7) union power (‘labour market shocks’). In addition, we show the contribution of disturbances to: (1) REA-German interest rate spread (‘Risk premium shock’); (2) transfers by Germany to the REA and the ROW (net contribution to EU budget; migrant remittances), referred to as ‘transfer account shocks’; (3) ‘external demand and trade shocks’ (aggregate demand and supply shocks originating on the REA and the ROW). The remaining shocks combined into a category labeled ‘other shocks’.
Figure 12. Historical decompositions of REA macroeconomic variables

12.a REA net exports divided by nominal GDP

12.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 the following exogenous shocks originating in Germany are plotted: (1) TFP and investment efficiency (bars labeled ‘technology’); (2) firm investment wedge (‘firm financing conditions’); (3) household loan-to-value ratio (‘household financing conditions’); (4) subjective rate of time preference, number or retirees and pension replacement rate (‘household saving’); (5) unemployment benefit generosity; (6) fiscal policy; (7) union power (‘labour market shocks’). In addition, we show the contribution of disturbances to: (1) REA-German interest rate spread (‘Risk premium shock’); (2) transfers by Germany to the REA and the ROW (net contribution to EU budget; migrant remittances), referred to as ‘transfer account shocks’; (3) ‘external demand and trade shocks’ (aggregate demand and supply shocks originating in the ROW). The remaining shocks combined into a category labeled ‘other shocks’.
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 $K^j_t$, employment $L^j_t$ and public infrastructure $K^G_t$ as inputs and the TFP scaling factor $A_t$:

$$\begin{align*}
Y^j_t &= A_t (ucap^j_t K^j_t)^{1-\alpha} (U^j_t L^j_t)^{\gamma} (K^G_t)^{\gamma \alpha},
\end{align*}$$

Employment at the firm level $L^j_t$ is itself a constant-elasticity-of-substitution (CES) aggregate of labour supplied by individual households $i$:

$$\begin{align*}
L^j_t &= \left( \int_0^1 L_i^j \frac{\theta-1}{\theta} \, di \right)^{\frac{\theta}{\theta-1}}.
\end{align*}$$

The parameter $\theta > 1$ determines the degree of substitutability between different types of labour. Firms also decide about the degree of capacity utilization ($ucap^j_t$). There is an economy-wide labour-augmenting productivity shock $u^Y_t$ that follows a random walk process with drift.

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

$$\begin{align*}
Y_t &= \left( \int_0^1 Y^j_t \frac{\eta-1}{\eta} \, dj \right)^{\frac{\eta}{\eta-1}}.
\end{align*}$$

\(^1\) Lower cases denote logarithms, i.e. $z_t = \ln Z_t$. Lower cases are also used for ratios and rates. In particular, we define $p^j_t = P^j_t / P_t$ as the relative price of good $j$ w. r. t. the GDP deflator. Domestic variables are without 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.
where $\eta$ determines the degree of substitutability between the varieties $j$, which determines the steady-state price mark-up of final goods and gives the demand function for individual varieties $Y_i^j = (p_i^j)^{-\eta} Y_t$.

The objective of the firm is to maximize profits $Pr_j$:

$$Pr_j = p_i^j Y_i^j - w_i L_i^j - \epsilon^K p_i^j K_i^j - (adj^p(P_{t-1}^j) + adj^L(L_{t-1}^j) + adj^{ucap}(ucap_{t-1}^j)),$$

where $\epsilon^K = \epsilon^C + \epsilon^{rpk}$ is the rental rate of capital, which equals the borrowing rate of Ricardian consumers ($i^C$) plus an equity premium ($r_{pk}$) and a stochastic shock to the perceived investment risk ($u_{t-1}^{pk}$). Given the identical technologies in the production of consumption and investment goods (see below), the unit price of capital installment equals the consumer price index ($p_i^C$).

The firms face technological and regulatory constraints that restrict the price setting, employment and capacity utilization decisions. Price adjustment costs $adj^{pr}$ can derive from the internal organization of the firm or specific customer-firm relationships. Costs of adjusting employment $adj^l$ have a strong job-specific component (e.g., training costs), but higher employment adjustment costs may also arise in heavily regulated labour markets with search frictions. Costs associated with the utilization of capital $adj^{ucap}$ can result from higher maintenance costs associated with a more intensive use of capital equipment. The following convex functional forms are chosen:

$$adj^p(L_{t-1}^j) = 0.5 \gamma_L \Delta L_{t-1}^j w_i,$$

(5) $$adj^L(P_{t-1}^j) = 0.5 \gamma_P (P_{t-1}^j / P_{t-1}^j - 1)^2 P_{r-1}^j.$$

(6) $$adj^{ucap}(ucap_{t-1}^j) = p_i^C K_i^j \left( \gamma_{ucap,1} (ucap_{t-1}^j - 1) + \gamma_{ucap,2} (ucap_{t-1}^j - 1)^2 \right).$$

In each period of time, firm $j$ determines the demand for labour, the demand for capital services, capacity utilization and product prices optimally given the production technology, adjustment costs and the demand function for firm output. The first-order conditions for the demand for capital and labour, capacity utilization and pricing are:

(7) $$w_i (1 + u_{t-1}^C) = \epsilon_{i}^C \alpha Y_i^j / L_i^j - \gamma_{i} \Delta L_{i-1} w_j + \gamma_{i} / (1 + r_i^C) E_i (\Delta L_{i-1} w_{i+1}).$$

(8) $$\epsilon_{i}^C (1 - \alpha) Y_i^j / (p_i^C K_i^j) = \left( \gamma_{ucap,1} + 2 \gamma_{ucap,2} (ucap_{t-1}^j - 1) \right) u_{t-1}^{cap}.$$

where $\beta^C$ is the discount factor of Ricardian households that own the firms, $\delta^K$ is the rate of capital depreciation, $t_i^C$ is the tax on corporate revenue, $w_j$ is the real wage, $\epsilon_{i}^C$ is the inverse of the price mark-up, $sf_p$ is the degree of forward-looking behavior among price setters in forming inflation expectations and $r_i^C = \epsilon_i^C - E_{i} \pi_{i+1}$ is the real interest rate as the short-term nominal rate minus expected GDP price inflation.

A.1.2. Residential construction

Monopolistically competitive firms $h$ in the residential construction sector use new land $J^L_t$ sold by (Ricardian) households and final goods $J^{Com}_t$ to produce new houses with a CES technology:

(10) $$J^H_t = \left( \frac{1}{s_t^{\sigma_{-1}}} J^L_t \sigma_{-1}^{\sigma_{-1}} + \frac{1}{(1 - s_t^{\sigma_{-1}}) \sigma_{C} \sigma_{-1}} J^{Com}_t \sigma_{C} \sigma_{-1} \right) \sigma_{-1}^{\sigma_{-1}}.$$ 

The firms in the residential construction sector are monopolistically competitive and face quadratic adjustment costs for house prices $P_{r-1}^H$:

(11) $$adj^{pr}(P_{r-1}^H) = 0.5 \gamma_{pr} (P_{r-1}^H / P_{r-1}^H - 1)^2 P_{r-1}^H.$$
The first-order conditions for the pricing of construction services, and houses are:

\[
\begin{align*}
(12) & \quad p_{t}^{\text{Con}} = 1 + u_{t}^{\text{Con}} + \gamma_{p_{t}^{\text{Con}}} \left( \beta^e (sfpl t E + \pi_{t+1}^{\text{Con}}) (1 - sfpl t) + \pi_{t+1}^{\text{Con}} - \pi_{t}^{\text{Con}} \right) \\
(13) & \quad e_{t}^{L} = 1 - \gamma_{p_{t}} \left( \beta^e (sfpl t E + \pi_{t+1}^{\text{Con}}) (1 - sfpl t) + \pi_{t+1}^{\text{Con}} - \pi_{t}^{\text{Con}} \right) \\
(14) & \quad E_{t} (e_{t}^{L} + p_{t}^{L}) + (e_{t}^{L} / p_{t}^{L}) = 1 + \delta - g^{L} \\
(15) & \quad p_{t}^{H} = \left( 1 + \gamma_{p_{t}} \left( \beta^e (sfpl t E + \pi_{t+1}^{\text{Con}}) (1 - sfpl t) + \pi_{t+1}^{\text{Con}} - \pi_{t}^{\text{Con}} \right) \right) \left( s_{t} (p_{t}^{L})^{1-\sigma_{t}} + (1 - s_{t}) (p_{t}^{\text{Con}})^{1-\sigma_{t}} \right)^{(1-\sigma_{t})},
\end{align*}
\]

where the equilibrium return on land equals the Ricardian interest rate plus a risk premium

\[ i_{t}^{r} = i_{t}^{r} + \rho_{t}^{pl} + u_{t}^{pl}, \quad \gamma_{p_{t}^{pl}}, \quad \gamma_{p_{t}} \text{ and } \gamma_{p_{t}} \text{ are construction, land and house price adjustment costs, sfpl, sfpl and sfph are the degrees of forward-looking behavior in the formation of construction service, land and house price expectations, } e_{t}^{L} \text{ is the mark-up on land prices and } g^{L} \text{ the exogenous growth of land supply. 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 \( J_{i}^{\text{Imp}} \), then real output of the investment goods sector is produced by the following linear production function:

\[
(16) \quad J_{i} = J_{i}^{\text{Imp}} U_{t}^{i}
\]

where \( U_{t}^{i} \) is a technology shock specific to the production technology for investment goods that follows a random walk \( U_{t}^{i} = U_{t-1}^{i} + \epsilon_{t}^{U_{t}^{i}} \).

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 remaining fraction \( 1 - s^{r} \) of the households 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 \( (C^{i}_{t}) \) and housing services \( (H^{i}_{t}) \) plus separable utility from leisure \( (1 - L^{i}_{t}) \).

We also allow for habit persistence in consumption \( (h^{r}) \) and leisure \( (h^{L}) \). The temporal utility for household \( i \) is given by:

\[
(17) \quad U(C^{i}_{t}, H^{i}_{t}, 1 - L^{i}_{t}) = \left[ \left( \frac{C^{i}_{t} - h^{r} C^{i}_{t-1}}{1 - h^{c}} \right)^{\frac{\sigma_{u} - 1}{\sigma_{u}}} + \left( s^{r}_{t} \right)^{\frac{1}{\sigma_{u}}} \left( \frac{H^{i}_{t}}{\sigma_{a}} \right)^{\frac{\sigma_{a} - 1}{\sigma_{a}}} \right] + \epsilon^{U} g (1 - PENS_{t} - L^{i}_{t} - h^{L} \Delta L^{i}_{t})^{1-\kappa}.
\]

where \( PENS_{t} \) is the exogenous population share of retired persons. Ricardian and credit-constrained households supply differentiated labour services \( L^{i}_{t} \) that are assumed to be equally distributed across both household types.

A.2.1 Ricardian households

Ricardian households have full access to financial markets. They hold domestic government bonds \( (B^{G}_{t}) \) and bonds issued by other domestic and foreign households \( (B^{r}_{t}, B^{f}_{t}) \), own the real capital \( (K_{t}) \) used in the final goods production sector, the stock of land \( (Land_{t}) \) that is still available for building new houses and part of the housing stock \( (H^{i}_{t}) \). In addition, Ricardian households keep bank deposits \( (D^{i}_{t}) \) with return \( \delta^{d,r} = \delta^{d} (C^{r} / D^{r})^{\sigma_{d}} \).
The Ricardian households receive labour income, returns to financial assets and deposits, rental income from lending capital to firms, the proceeds from selling land to the residential construction sector and the profit income from the firms owned by the household, i.e. Pr_i from final-goods producers, Pr_i^H from residential construction and Pr_i^B from banks. All domestic firms are owned by domestic Ricardian households. The government taxes labour income and consumption at rates t_i^W and t_i^C, respectively, and pays the lump-sum transfers TR_i. The discount factor β’ is subject to random shocks U_t adding exogenous changes to the intertemporal consumption path.

The Lagrangian of this maximization problem is given by:

\[\text{Max} \quad V_0 = E_0 \sum_{t=0}^{\infty} U_t^\beta \beta^{t}\beta^t \ U \left(C_t', 1-L_t', H_t' \right)\]

\[= - E_0 \sum_{t=0}^{\infty} \lambda_t^\beta \beta^t \left( \left(1+\xi_t^C \right) p_t^C C_t' + p_t^C I_t' + p_t^H (1+\xi_t^H) I_t^H' + B_t^G + B_t^r + D_t^r + rer B_t^e \right) + 0.5 \gamma_{i0} \Delta W^2 / W_{t-1} - \left(1-t_i^W - sxc_t \right) w_t L_t' - \left(1-t_i^H \right) j_{t+1}'^K + t_i^K \delta^K p_t^C K_{t+1} \]

\[-\left(1+\xi_t^B \right) B_t^G - \left(1+r_t^B \right) B_t^r - \left(1+r_t^d \right) D_t^r - \left(1+r_t \right) rer B_t^e - p_t^L J_t^L \]

\[= - \sum_{j=1}^{J_t} Pr_j - Pr_i^H - Pr_i^B - TR_j - BEN_j (1 - PENS_j - NPART_j - L_t') \]

(18)

The budget constraint in (18) is written in real terms with all prices expressed relative to the GDP deflator (P_t). The investment decisions w. r. t. physical capital and housing are subject to convex adjustment costs, which introduces a distinction between real investment expenditure (I_t, I_t^H') and physical investment (J_t, J_t^H'). Investment expenditure of Ricardian households including adjustment costs is given by:

\[I_t = J_t \left(1 + \frac{\gamma_k}{2} \left( \frac{J_{t-1}}{K_{t-1}} - \delta^K \right)^2 K_{t-1} \right) + \frac{\gamma_t}{2} \left( \Delta J_t \right)^2 \]

(19)

\[I_t^H = J_t^H \left(1 + \frac{\gamma_h}{2} \left( \frac{J_{t-1}}{H_{t-1}} - \delta^H \right)^2 H_{t-1} \right) + \frac{\gamma_h}{2} \left( \Delta J_t^H \right)^2 \]

(20)

The stock of capital per efficient unit evolves according to:

\[K_t = J_t + \left(1 - \delta^K - g_{POP} - g_{TFP} \right) K_{t-1}, \]

where \(g_{POP}\) and \(g_{TFP}\) are trend population growth and trend productivity growth. Analogously, the stock of housing owned by Ricardian households per efficiency unit is:

\[H_t^H = J_t^H + \left(1 - \delta^H - g_{POP} - g_{TFP} \right) H_{t-1}. \]

(21)

2 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.
When making consumption and investment decisions, Ricardian households face an interest rate \( i_t \) that depends on the aggregate net foreign asset (NFA) position \( B_t^F / (PY_t) \) relative to its target level \( bwy^T \) plus the stochastic country risk premium \( u_t^{spe} \):

\[
(23) \quad i_t = i_t^E - rpe\left( B_t^F / (PY_t) - bwy^T \right) + u_t^{spe}.
\]

The debt-elastic interest rate premium on domestic households induces stationarity in the NFA position (e.g., Schmitt-Grohé and Uribe, 2003). 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.

The maximization problem (18) gives standard first-order optimality conditions for consumption, housing and productive investment by the Ricardian household:

\[
(24) \quad U_t^\rho \beta_t^E E_t^u U_{c,t} / U_{c,t} = 1 / \left( 1 + i_t^c - E_t \pi_{t+1}^c \right)
\]

\[
(25) \quad U_{c,t} = (1 + \iota_t) p_t^\pi \lambda_t^c.
\]

\[
(26) \quad q_t^{H,c} = \left( p_t^c / U_{c,t} \right) \gamma H_t^c = \left( p_t^H / U_{H,t} \right) + \gamma H_t^c \left( 1 - \delta^H - (i_t^c - E_t \pi_{t+1}^c - u_t^{spe}) \right) E_t q_{t+1}^H).
\]

\[
(27) \quad q_t^{H,c} = 1 - \gamma K_t (J_t^{H,c} / H_{t+1} - \delta^H - g_{pop} - g_{TPP}) + \gamma J_t (\Delta J_t^{H,c} - \beta^H \gamma J_t E_t \Delta J_{t+1}^{H,c}).
\]

\[
(28) \quad q_t - 1 = \gamma_k (J_t / K_{t-1} - \delta^K - g_{pop} - g_{TPP}) + \gamma J_t (\Delta J_t - \beta^H \gamma J_t E_t \Delta J_{t+1}^{H,c}).
\]

A.2.2 Credit constrained households

Credit-constrained households differ from Ricardian households in two respects. First, they have a time preference \((\beta_t < \beta_t^c)\), and they face a collateral constraint on their borrowing. They borrow \( B_t^c \) exclusively from domestic Ricardian households. The Lagrangian of this maximization problem is given by:

\[
(29) \quad V_0^c = E_0 \sum_{t=0}^{\infty} \beta_t^c U_t^c (C_t^c, 1 - L_t, H_t).
\]

The collateral constraint determines the borrowing capacity of the credit-constrained households, where the loan-to-value ratio imposed by Ricardian lenders is subject to a stochastic shock \( \lambda_t^c = \lambda_t^c + u_t^c \). It increases the shadow price of borrowing as determined by the Lagrange multiplier \( \psi_t^c \) of the collateral constraint. The real interest rate on credit-constrained debt is \( r_t^c = i_t^c - E_t \pi_{t+1}^c \) with \( i_t^c = (1 - \delta) i_t^c + \delta s t^d, \) and \( s^d \) as 1 minus the capital requirement, whereas deposits \( D_t^c \) pay the return \( i_t^{d,c} = i_t^{d,c} - E_t \pi_{t+1}^c \) with \( i_t^{d,c} = i_t^{d,c} - o_t^{d,c} (C_t^c / D_t^c)^{\epsilon_t} \).

The investment decisions w. r. t. housing are subject to convex adjustment costs, which introduce a distinction between real investment expenditure \( (J_t^{H,c}) \) and physical investment \( (J_t^{H,c}) \). Residential investment including adjustment costs is given by:

\[
(30) \quad I_t^{H,c} = J_t^{H,c} + \left( 1 + \frac{\gamma H_t}{2} \left( J_t^{H,c} / H_{t+1} - \delta^H \right)^2 \right) H_{t+1} - \gamma J_t (\Delta J_t^{H,c} / H_{t+1}^{H,c}).
\]

The housing stock in efficiency units of credit-constrained households evolves as:

\[
(31) \quad H_t = I_t^{H,c} + (1 - \delta^H - g_{pop} - g_{TPP}) H_{t+1}.
\]

The first-order conditions for consumption and housing from the problem (29) are:

\[
(32) \quad (1 + i_t^c) p_t^c \lambda_t^c = U_{c,t}.
\]

44
\[ 1 - \beta' (1 + i_t^c - E, \pi_{t+1} - g^{POP} + g^{TFP}) \psi_t, \]

\[ (33) \]

\[ U_t^\beta = \frac{E_t^\pi + \beta' (1 + i_t^c - E, \pi_{t+1} - g^{POP} + g^{TFP}) \rho^{i,e} E_t \psi_{t+1}}{1 + g^{POP} + g^{TFP}} \]

\[ (34) \]

\[ q_t^{H,e} = 1 - \gamma_H \left( q_t^{H,e} / H^{c,e} - \delta^H + \gamma_H \Delta l^{H,e} \right) \]

\[ (35) \]

The non-fundamental shock to housing investment \( u_t^{nph} \) is constrained to be equal across household types.

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 the marginal utility of consumption times the real wage adjusted for a wage mark-up:

\[ \left( s U_{t+1}^{\epsilon,c} \right)^{1-\rho} \left( \left( 1 - t_{w_t} - s \pi_{t+1} - B_{t+1} \right) - \frac{1 - \beta^w}{\beta^w} \right) \left( \pi_{t+1} - s f w \pi_{t+1} \right) \]

\[ (36) \]

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:

\[ \text{adj}^H (W_t) = 0.5 \gamma_H (W_t / W_{t-1} - 1)^2 W_{t-1} \]

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 also allows for some degree of real wage inertia \( \rho^\nu \).

The unit labour costs in the economy are \( ULC_t = w_t I_t / Y_t \), which equals the wage share in total domestic income.

A.3 Trade and the current account

Aggregate imports and exports

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 \( Z^i \in \{ C^i, I^i, C^G, I^G \} \) be demand by an individual household, investment good producer or the government. Then their preferences are given by the utility function:

\[ Z^i = \left( s^d - u^M_t \right) \left( 1 / \gamma_u \right) \left( \sigma_u^{-1} \right) + (1 - s^d + u^M_t) \left( 1 / \gamma_u \right) \left( \sigma_u^{-1} \right) \left( \gamma_u / (\sigma_u - 1) \right) \]

\[ (38a) \]
where $Z^{di}$ and $Z^{fi}$ are indexes of demand across the continuum of differentiated goods produced in the domestic economy and abroad, respectively. The home bias parameter $s^d$ can be subject to random shocks $u^M_t$.

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

$$p_t^X = 1/(1-u_t^{PX} - \gamma_{px} \beta' (sfpxE, \pi_{t+1}^X + (1-sfpx)\pi_{t-1}^X - \pi_t^X)),$$

where $u_t^{PX}$ is a price setting shock, $\gamma_{px}$ quantifies price adjustment costs and $sfpx$ is the degree of forward-looking in expectations.

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

$$p_t^M / p_t^W = 1/(1-u_t^{PM} - \gamma_{pm} \beta' (sfpmE, \pi_{t+1}^M + (1-sfpm)\pi_{t-1}^M - \pi_t^M)),$$

where $u_t^{PM}$ is a price setting shock, $\gamma_{pm}$ quantifies price adjustment costs and $sfpm$ is the degree of forward-looking in expectations.

The demand for exports allows for some inertia in demand adjustment ($X^\rho$) and is given by:

$$X_t = (1-s^d + u_t^X)\left(p_t^X / p_t^W\right)^{-\sigma_x} X_t^w (E, X_t^m X_t^s / X_t)^{\rho_x}$$

Similarly, import demand includes some inertia ($M^\rho$) and follows:

$$M_t = (1-s^d + u_t^M)\left(p_t^M / p_t^C\right)^{-\sigma_m} \left(C_t + I_t + \frac{p_t^G}{p_t^C} G_t + \frac{p_t^{Con}}{p_t^C} (I_t^{Con})\right) (E, M_t^m M_t^s / M_t)^{\rho_m}.$$

The trade balance $TBY_t \equiv (p_t^X X_t - p_t^M M_t) / Y_t$ is the value of net exports to GDP. Net exports together with net interest receipts and the exogenous balance of primary incomes and transfers ($TA_t$) determine the evolution of net foreign assets (NFA) denominated in domestic currency and efficiency units:

$$B_t^F = (1+i_{t-1} - g^{POP} - g^{TFP}) B_{t-1}^F + P_t^X X_t - P_t^M M_t + TA_t,$$

where $TA_t$ captures discrepancies between external flows and the stock of NFA due to, e.g., valuation effects.

**Bilateral Imports**

Households, firms and governments in country/region $i$ have preferences over imports from country/region $j$ given by

$$(38b) \quad Z^{fi} = \left(\sum_{j=1}^I (s^{f,i,j} + u_t^{f,i,j}) \theta^{\alpha-i} Z^{f,i,j} \right)^{\theta/(\theta-1)}$$

where $Z^{f,i,j}$ are indexes of demand across the continuum of differentiated goods produced in the $j$ exporting regions. The bilateral import share parameter $s^{f,i,j}$ can be subject to random shocks $u_t^{f,i,j}$.

The elasticity parameters $\sigma_M$ and $\theta$ determine the price elasticity of bilateral imports. In general we find that goods and services produced in Germany and the Rest of the EA are closer substitutes to each other, while goods produced in the Rest of the World are stronger complements to goods produced in the EA. This is reflected by $\theta^{DE} < 1$ and $\theta^{W} > 1$ and $\theta^{W} < 1$.

**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 for de-trended $C_t^G$ and $I_t^G$, i.e. after removing trend productivity and population growth from the variables in logarithms:
where both variables can react to the government deficit relative to the associated deficit target $def^T$. 

The transfer system consists of two parts, the benefit $BEN_t = b^U w_t$ paid to the unemployed members of the labour force $(1 - PENS_t - NPART_t - L_t)$ and other transfers $TR_t$, including transfers to pensioners $(PENS_t)$. Unemployment benefits and pensions are indexed to wages with replacement rates $Ub$ and $Rb$. Transfers may react to the debt-to-GDP ratio and the government deficit, where $Tb$ is the government debt target:

$$
tr_t = b^R w_t PENS_t - \tau^{TRB} \left( B^G_{t-1} / (Y_{t-1} P_{t-1}) - b^T \right) - \tau^{TRDEF} \left( \Delta B^G_t / (Y_t P_t) - def^T \right) + u^{TR}_t.
$$

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

$$
K^G_t = I^G_t + (1 - \delta^G - g^{POP} - g^{TFP}) K^G_{t-1}.
$$

The government revenue $R^G_t$ consists of taxes on consumption, labour and corporate income:

$$
R^G_t = t^G p^C_t C_t + t^C p^H_t H_t + (ssc_t + t^w_y) w_t L_t + t^K (Y_t - w_t L_t - \delta^K p^K_t K_t).
$$

We assume consumption and capital income taxes to follow a linear scheme, but use a progressive labour income tax schedule:

$$
t^w_t = \tau^w_t Y_t^t
$$

where $\tau^w_0$ measures the average tax rate and $\tau^w_t$ the degree of progressivity. A simple first-order Taylor expansion around the steady-state growth rate yields:

$$
t^w_t = \tau^w_0 + \tau^w_1 (\sum_{i=0}^{3} \Delta y_{t-i} - 4\Delta y)
$$

Government debt $(B_t)$ evolves according to:

$$
B^G_t = (1 + i^G_t - \pi_{t-1}) / (1 + g^{POP} + g^{TFP}) B^G_{t-1} + p^G_t C^G_t + p^H_t H_t + BEN_t (1 - PENS_t - NPART_t - L_t) + TR_t - R^G_t,
$$

where $i^G_t$ is the implicit interest rate that the government pays on its debt. This interest rate on government debt depends on the average maturity structure of sovereign debt, $1/(1 - \rho^G)$, and the policy rate augmented by a sovereign risk premium $rpb_t$ with a stochastic shock $u^{rpb}_t$:

$$
i^G_t = \rho^G i^G_{t-1} + (1 - \rho^G)(\bar{i}_{1}^{EA} + rpb_t + u^{rpb}_t).
$$

The systematic part of the sovereign risk premium $rpb_t$ depends on the level of government debt relative to its target level. The price level of government consumption may deviate from private consumer prices by a stochastic shock $P^{PG}_t$:

$$
P^{PG}_t = U^{PG}_t.
$$

Monetary policy is modeled via a Taylor rule, where the ECB sets the 3 month policy rate $i^{EA}_t$ in order target Euro Area inflation and real GDP growth. The policy rate adjusts sluggishly to deviations of inflation and GDP growth from their respective targets, and the policy rule is subject to random shocks

$$
i^{EA}_t = t^M_{lag} i^{EA}_{t-1} + (1 - t^M_{lag}) \left( \bar{\pi} + \pi_t^\tau + \pi_t^M (\pi_t^C - \pi_t^T) + \pi_t^M \sum_{i=0}^{3} \Delta y_{t-i} - 4\Delta y) / 4 \right) + u^M_t
$$

For the period before EMU 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 our 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 the following market clearing conditions hold for final domestic goods:

\[ Y_t^e = p_t^C (C_t + J_t) + p_t^{Con} (J_{t,Con}^{t,Con} + I_t^G) + p_t^{G} e_t^G + p_t^X X_t - p_t^M M_t \]

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 \( s' \) and \( 1 - s' \):

\[ C_t = s'C_{t}' + (1-s')C_{t}^c. \]

Similarly, total housing investment is defined as:

\[ J_t^H = s'J_t^{H} + (1-s')J_t^{H,c} \]

and equilibrium in the labour market is given by:

\[ L_t = s'L_t' + (1-s')L_t^c. \]

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

\[ B_t^c = s'/ (1-s')B_t^r. \]

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

\[ D_t = s'D_t' + (1-s')D_t^c. \]

The amount of deposits relative to the capital requirement determines the spread between \( i_t^r \) and \( i_t^{d,r} \):

\[ i_t^r - i_t^{d,r} = \alpha_g (D_t - s'(1-s')B_t^r) \]

Given import prices and domestic price setting, the CES aggregator (38) gives:

\[ p_t^C = U_p^{PC} \left( (s^d - u_t^M) + (1-s^d + u_t^M)(p_t^M)^{1-\sigma_u} \right)^{1/(1-\sigma_u)} \]

as the domestic price index of (private) consumption relative to the GDP deflator.

Models for RoW and REA

Rest of the world variables are denoted by a superscript R. In order to identify demand and supply shocks from the REA and the RoW we use highly aggregated DSGE models with aggregate demand modeled via an aggregate IS curve (note we do not distinguish between private and government demand).

\[ \frac{U_t^{R,\beta} U_t^{R,c} U_t^{R,t+1}}{U_t^{R,c,t}} = \frac{1}{1+\pi_t^{R,E} \pi_t^{R,c}} \]

Marginal utility of domestic demand \( U_{C,t}^R \) allows for habit persistence and \( U_t^{R,\beta} \) denotes a shock to the rate of time preference.

Firms set prices via a New Keynesian hybrid Phillips curve with inflation rising as output deviates from an exogenous stochastic trend \( y_t^{R,T} \)

\[ \pi_t^R = \beta^R (s f^R E_t \pi_{t+1}^R + (1-s f^R) \pi_t^R) + \gamma^R \left( y_t^R - y_t^{R,T} \right) + u_t^{R,\pi} \]

For the REA it is assumed that monetary policy is conducted by the ECB. For the RoW specify a Taylor rule where the RoW short term interest rate is determined by a Taylor rule targeting RoW inflation and GDP growth and there exchange rate flexibility.
B. Econometric methodology and parameter estimates
We calibrate selects parameters. The remaining parameters are estimated using Bayesian methods.

B.1. Calibrated parameters.
We calibrate the steady state ratio 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.

B.2. Parameter estimates
The model is estimated on quarterly data for the period 1991q1 to 2012q2 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. We run 4 Metropolis-Hastings chains of 100,000 draws to estimate the posterior distribution. Concerning the steady state calibration, parameters shown in Table 1 have been calibrated to match ratios of main economic aggregates (corporate investment, construction investment, government consumption and government investment) to GDP over the sample period. The following Tables report the priors of all estimated model parameters, as well as the corresponding posterior modes and standard deviations.
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