WORK IN PROGRESS

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

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We estimate a three-country DSGE model to analyze the causes of Germany's substantial and persistent current account surplus, since the creation of the Euro, and its effect on the rest of Europe. The most important factors driving the surge in the German surplus were the convergence of Euro Area interest rates brought about by Monetary Union, German labor market reforms, and strong world demand for German exports. The key shocks that drove the rise in German net exports had a positive effect on real activity in the rest of the Euro Area.

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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 or close to balance--but after the advent of EMU, 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 Southern Europe stopped abruptly, but the overall German CA surplus bounced back rapidly and reached record levels (about 6% of domestic GDP in 2012), due inter alia to a strong rise in the surplus vis-à-vis Asia. 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 and beyond (see Lane (2012) and Chen, Milesi-Ferretti and Tressel (2012) for discussions of capital flows in the Euro Area).

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 reliable quantitative dynamic general equilibrium model that captures the relevant shocks, and their transmission to the macroeconomy. This paper will thus study the drivers of the German CA using an *estimated* state-of-the art dynamic general equilibrium model of a multi-county world (see in't Veld, Raciborski, Ratto and Roeger (2011) and Kollmann, Ratto, Roeger and in't Veld (2013)). Specifically, our model features three 'countries': Germany, the Rest of the Euro Area, and the Rest of the World. 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.

We use the model as a laboratory for quantifying the key drivers and transmission mechanisms that explain the German CA and its effect on intra-Euro Area external imbalances and real activity in the rest of the Euro Area. This allows us to shed light on a series of widely debated hypotheses.

We devote particular attention to the following key shocks: (i) an increase in financial integration among EMU members, brought about by the launch of the Euro (1999) led to the convergence of German and REA interest rates; (ii) far-reaching labor market reforms and wage restraint in Germany; (iii) strong growth in emerging economies which boosted demand for German exports. Our estimates suggest that these shocks were the main causes of rise in the German external surplus, after the launch of the Euro. The key shocks that drove the rise in German net exports had a positive effect on real activity in the rest of the Euro Area.

Our model disaggregates the household sector into patient savers and impatient, collateral-constrained borrowers. This allows us to analyze the evolution of household debt in a coherent fashion—we show that this variable provides important clues for explaining the German CA. Specifically, the evolution of German household debt shows a pattern that differs markedly from that observed in other EA countries (leveling off in Germany vs. continuous increase in the REA). We show that the evolution of German household debt reflects both a tightening of credit to households, and a change in saving behavior due to a fall in households' rate of time preference.

Accounting for the underlying sources of the German surplus also allows us to discuss its possible future evolution. We present a scenario analysis based on possible evolutions of risk premia within the EA (persistently high risk premia in Southern EA countries), labour market reforms (leveling off of labour market shocks in DE) and external demand developments (continued high demand from emerging economies and the US).

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.

Fernandez-Villaverde et al. (2013), Reis (2013) and in't Veld et al. (2013) highlight the role of the interest rate convergence for the capital inflows into European periphery economies—these papers focus on the effect of those capital inflows on the recipient countries. By contrast, the present paper focuses on a major surplus country. (See European Commission (2012) for a detailed discussion of intra-EU current account imbalances.)

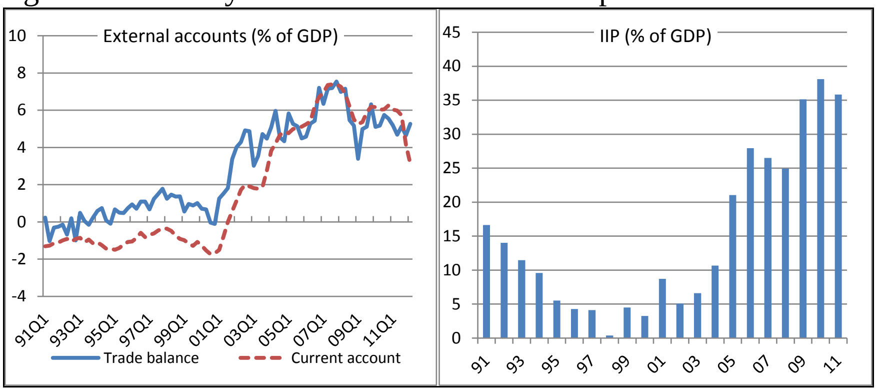
Section 2 describes macroeconomic conditions in Germany and her trading partners in the REA and in the ROW, since 1991, and discusses key hypotheses about the determinants of the German current account. Section 3 provides a brief overview of key model relationships that allow to evaluate these hypotheses. Section 4 presents the results.

2. Macroeconomic conditions and the German current account

This Section first describes key facts about the German external balance, and about macroeconomic conditions in Germany (DE), and the REA. It then discusses prominent hypotheses about the drivers of the German external surplus.

Our empirical analysis focuses on the period 1991-2012, i.e. on ther period since German Reunification (3.10.1990). The German trade balance, the current account and the international investment position (IIP) over this period are plotted in Figure 1. After close-to-balance positions in the 1990s, the trade balance has been in persistent surplus since 2000. The trade surplus and the current account peaked at 7% of GDP in 2007 before declining in the global recession 2008-9 and stabilized around 5%-6% thereafter; this has led to a substantial accumulation of net foreign assets.

Figure 1: Germany's external accounts and IIP position



Source: Eurostat

2.1. Saving, investment and the German external balance

The current account balance equals the difference between gross saving (S) and investment (I): CA=S-I, and thus CA/Y=S/Y-I/Y, where Y is GDP. Figure 2 (Panel (b)) plots German (gross) national saving and investment, expressed as a % of GDP. All ratios of National Accounts variables shown in Figure 2 and discussed in the following paragraphs are ratios of nominal variables.

The German national 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 the saving and investment rates explains the sharp increase in the German current account in the early 2000s.

Figure 2 disaggregates national saving and investment into private sector and government saving and investment (see Panels (c) and (d)); private S & I are further disaggregated into household, and corporate S & I (Panels (e) and (f)); finally corporate S & I is broken down into S & I by non-financial corporations and by financial corporations Panel (g)). Note that private saving and investment account for the lion share of national saving—private S and I, hence closely tracks national S and I. Figure 2 also plots the ratio of housing investment to GDP, and the ratio of non-housing investment to GDP.

Strikingly, all of the disaggregated investment series has a downward trend (relative to GDP). Household and corporate saving both rose, as a ratio of GDP, around the year 2000. Government saving (i.e. the primary government surplus) did not have a marked trend, but underwent noticeable fluctuations--government saving rose in the 5 years before the financial crisis, fell sharply during the crisis, and then rose again in 2010.

Table 1 reports mean saving and investment rates for the period 1991-2000 (Col. (1)), when the German CA balance was substantially negative, and for the 2002-2012 period (Col. (2)) characterized by a sizable positive CA balance. Also shown is the change in mean, across the two sub-periods (Col. (3)).

The national saving rate was higher in 2002-2012 than in 1991-2000, by 1.94 ppt, while the investment rate was lower, by 4.42 ppt. About 2/3 of the rise in mean CA/Y rate between the two sub-periods was thus driven by the fall in the investment ratio. The mean private saving rate rose by 1.94 ppt—that rise is largely driven by a rise in the corporate saving rats, while the mean household saving rate was slightly lower in 2002-2012 than in 1991-2000. By contrast, the drop in the mean investment ratio (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. Thus, both types of investment contributed noticeably to the reduction in the total I/Y ratio. The sizable reduction in housing investment is noteworthy, as 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 housing investment/GDP ratio amounts to 25% of the mean ratio in 1991-2000.

Figure 2 also provides a decomposition of the net exports/GDP ratio into a component driven by the private and government consumption ratio, (Y-C-G)/Y, and the investment ratio (note that NX/Y=(Y-C-G)/Y-I/Y). The private plus government consumption ratio has, essentially, been trend-less during the sample period (see Panel (2.l)). The mean ratio of net exports to GDP rose by 4.82ppt, across sub-periods. The main driver of that rise was a fall in the I/Y ratio (-4.42 ppt), where Y is GDP.

The private consumption ratio (C/Y) only showed minor fluctuations (around a mean value of 58%) 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. As shown below, the German real interest rate rose by almost 2ppt in 2007, and then fell to very low (negative) values during the financial crisis. The interest rate hike before the crisis too may help to explain the sudden drop in the C/Y ratio. The rise of the C/Y ratio during the 2009 is largely due to the sharp contraction of GDP during 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 rise to more than 20% during the 2009 recession.

Accordingly, the only larger fluctuation of the German next exports rate (NY/Y) occurred immediately before and after the financial crisis: that ration rose by 3.8 ppt in 2006 (from 22.7% in 2006q1 to 26.5% in 2007q1), and then fell to about 21% during the sharp 2009 output contraction. However, in 2010 the NX/Y ratio reverted to values close to the 23% sample mean.

The swings of the consumption ratio during the sample period largely reflect fluctuations in purchases of non-durables services and services. Panel (n) of Figure 2 decomposes NX/Y into (Y-Cnds-G)/Y and (I+Cdur)/Y (where Cnds: nondurables + services spending by private households; Cdur: durable consumption spending). (Y-Cnds-G)/Y is markedly smoother than (Y-C-G)/Y; the rise in German NX/Y is thus, essentially, driven by a drop in the ratios of investment and durable goods purchases, since 2003.

In conclusion, German mean (Y-C-G)/Y is basically trendless, while S/Y has slightly risen during the sample period. Note that S=GNP-C-G. Hence, the rise in the German national saving ratio across the two sub-periods is (almost) entirely driven by the rise in GNP-GDP=net transfers and incomes received from the rest of the world. Panel (a) of Figure 1 plots the ratio of German net transfers and net incomes from the rest of the world to German GDP. That ratio has risen by 1.54 ppt across the sub-periods 1991-2000 and 2002-2012. [1]

Saving and investment and external balance fluctuations at business cycle frequencies

While the decadal rise in the German CA is largely driven by the fall in the investment rate, the high-frequency fluctuations of the CA are to a greater extent driven by fluctuations in the saving rate. Table 2 reports the standard deviations and correlations of the German saving and investment rate, and of the current account (expressed as a ratio of GDP). These moments are computed for levels of these variables, and for detrended, first-differenced and HP filtered series. In level terms, the investment rate is more volatile than the saving rate, and more strongly correlated (in absolute terms) with the current account than the saving rate. However, at business cycle frequencies (i.e. once low frequency components have removed), the saving rate is a more important driver of the current account than the investment rate. The detrended saving rate is more volatile than the investment rate, and more strongly correlated with the current account. During the 1991-2012 period, the saving and investment rates are negatively correlated in levels, while the detrended component are positively correlated.

Table 3 documents the contributions of the consumption ratio (C+G)/Y and of the investment ratio I/Y to cyclical fluctuations of the trade balance ratio (NX/Y=(Y-C-G)/Y-I/Y). The detrended (C+G)/Y ratio is roughly as volatile as the investment ratio, and markedly less volatile than the saving ratio. This underscores the key role of external transfers and incomes as drivers of high frequency movements of the German saving ratio, during the period 1991-2012.

Regional structure of the German external balance

The German current account and trade balance with the REA and the ROW both contributed by roughly equal amounts to the strong rise in the aggregate CA and TB between the launch of the Euro and 2007. Since the financial/sovereign debt crises, the German CA and TB

[1] Note that the net T&I measure used in the Figure 2 and Table 1 is based on National Accounts data, and thus it does NOT include valuation changes on foreign assets and liabilities (due to exchange rate changes, or asset price changes). Germany experienced sizable negative external valuation losses, during the financial crisis (2007-08), and the sovereign debt crisis that erupted in 2010. The cumulated valuation losses between 2007 and 2011 represent about 20% of annual German GDP (see Figure 4), and outweigh hence the (increase) in the net transfers & incomes from abroad recorded by NIPA. Hence, the National Accounts S measure overstates 'true' saving since the onset of the financial crisis.

balances with the REA have fallen markedly (by more than 2ppt of GDP), but this was off-set by a rise in the CA and TB balances with the ROW (see Figure 4, Panels (4.c) and (4.d)).

2.2. Output, interest rates, exchange rates

Figure 4 plots year-on-year (YoY) growth rates of real GDP in Germany, the REA and the ROW. Output growth is highly positively correlated across these three countries/region; the correlation of the German growth rate with REA and ROW growth rates was 0.69 and 0.49, respectively—thus German GDP growth is more closely synchronized with REA GDP than with ROW GDP.

German GDP grew less than REA GDP in each year, between 1995-2005 (during this period the mean German and REA GDP growth rates were 1.26% and 2.42%, respectively). The gap between REA and German growth rates was especially sizable in 2002-2005. 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.

A well-known empirical regularity is that, for most 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 Tables 2 and 3, this regularity holds for Germany too. The strong growth of the German current account and net exports after the introduction of the Euro is consistent with that countercyclical pattern (given the weak growth of relative German output, during that period).

Other important facts about macroeconomic conditions in Germany and her trade partners are documented in Figure 5. The creation of the Euro eliminated exchange rate risk, and reduced financial transaction costs, across member countries. In addition, the financial integration among EU member countries was also stimulated by changes in regulations that greatly facilitated cross-border financial transactions, such as the Markets in Financial Instruments Directive', MiFID, of 2004. This led to a convergence of nominal interest rates between Germany and the rest of the Euro Area. The short term (risk free) nominal interest on government debt was lower in German than in the REA prior to the launch of the Euro; see Panel (5.a) (mean spread: -2.3% p.a. in 1991-1995). The DE-REA interest rate differential rose continually between the end of 1995 and the introduction of the Euro, when it (essentially) vanished;[2] since the eruption of the sovereign debt crisis (2010), a positive spread between German and REA short government debt rates has emerged again.

The nominal (effective) exchange rates of the DM and the Euro underwent a persistent depreciation until 2001 against the USD; this was followed by a sizable appreciation, by more about 70%, until 2008. Since the beginning of the financial crisis, the Euro-USD exchange rate has fluctuated widely, around a slight downward trend (Panel (5.d)). Since the creation of the Euro, the EA-ROW nominal interest rate differential has been relatively small (between -2% and 2% p.a.).[3] Due to the persistent appreciation of the Euro between the creation of the Euro and 2008, the return on Euro risk-free debt has hence been markedly higher than the return on US T-bills.

2.3. Hypotheses about the German external surplus

The debate on the determinants of Germany's external surplus has advanced a number of hypotheses, which are not mutually exclusive. We here mention several prominent hypotheses, before providing a statistical evaluation of these (and other) hypotheses using our estimated model.

[2] The convergence of interest rates began after the Madrid European Council of December 1995 had set the date of the launch of the Euro (1.1.1999), and defined the practical steps for the transition to the new currency.

[3] Our measure of the ROW short term risk-less interest rate is the US Federal Funds rate.

Financial integration and interest rate convergence

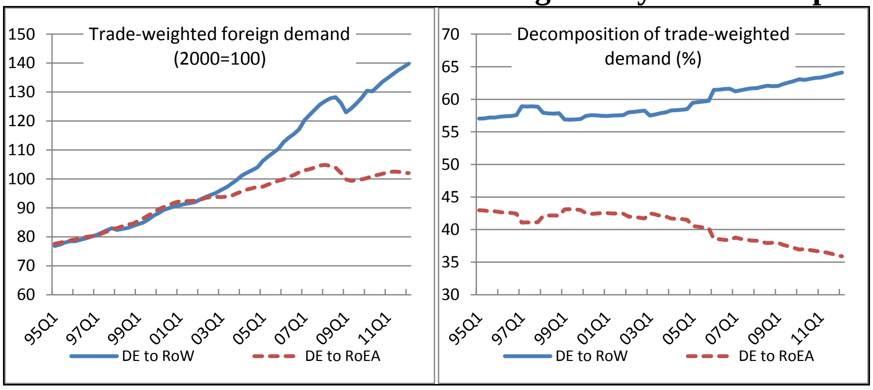
According to one prominent hypothesis, the elimination of the (negative) interest rate differential between Germany and the REA triggered a massive capital outflow from Germany and that weakened domestic German investment; see, e.g., Sinn, 2010. The capital outflow may thus have contributed to the low real GDP growth, in the immediate aftermath of the launch of the Euro—the negative consequences for domestic activity may have been amplified by labour market rigidities (Sinn, 2006). In closely related analyses, in't Veld et al. (2013), Reis (2013), Villaverde et al. (2013) argue that the capital inflows experienced by Eurozone periphery countries were largely driven by interest rate convergence.[4]

Expanding world demand

The second hypothesis argues that Germany's external surplus was driven by strong demand from emerging economies for goods for which Germany has a comparative advantage—especially investment goods. Strong growth in emerging economies may have added to intra-EMU balances by increasing competition for exports from the EMU periphery (e.g., Chen et al., 2012).

The Figure below plots trade-weighted GDP in the REA and the ROW as a proxy for German export demand. The Figure suggests that German exports have been driven mainly by strong demand growth in the ROW: the ROW share in German exports has increased steadily since about 2000, whereas the REA share has fallen.

Rest of Euro Area and Rest of world GDP weighted by German export shares



Labor market reforms and wage restraint

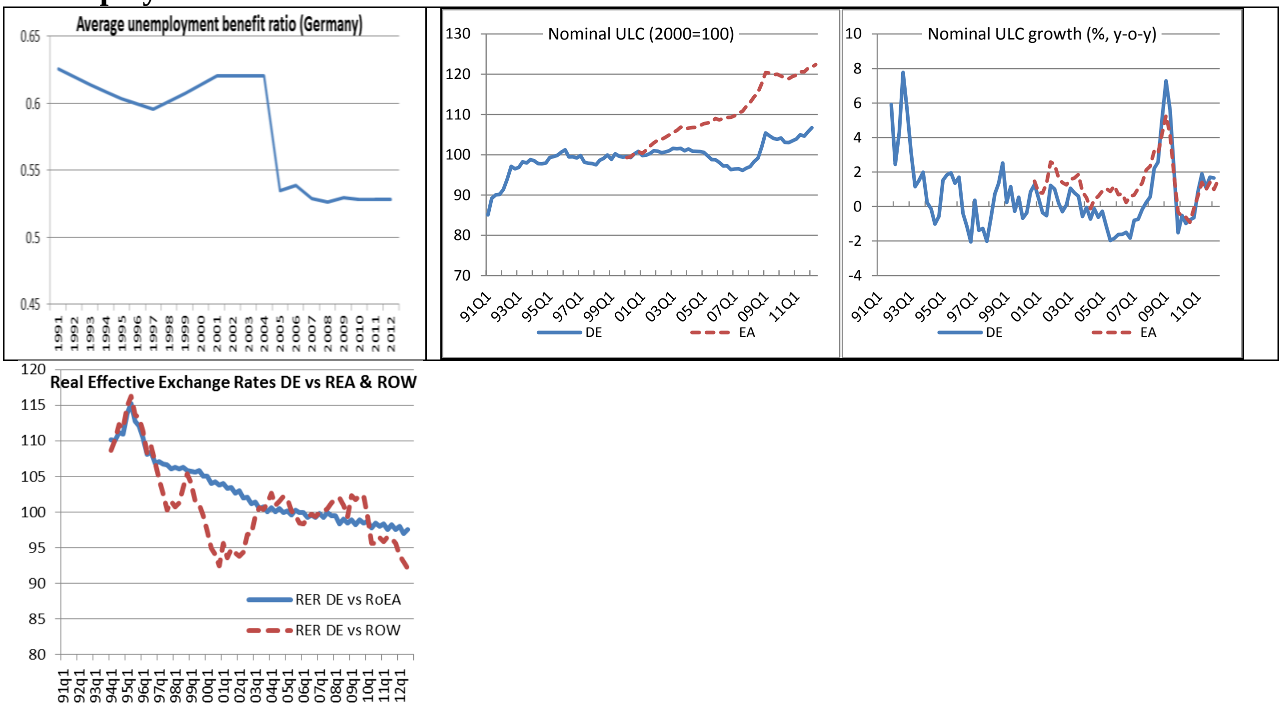
In 2003-2005, a major labor market deregulation took place in Germany--the so called 'Hartz reforms'. These reforms entailed a reduction in unemployment benefits, and also included a host of other measures, such as a re-organization of labor placement and job training schemes to improve job matching. [5] The Figure below plots the average unemployment benefit ratio (ratio of unemployment benefit to wage rate) in Germany. The replacement rate fell permanently in 2004-2005, from 62% to 53%. The labor market reforms arguably weakened the bargaining power of labor union. Union density (fraction of wage earners who are union

[4] Notice that the 'financial markets hypothesis' does not claim that Germany suffered from greater financial integration, in income terms. To the contrary it argues that because of capital market restrictions prior to EMU there was a home bias of German savings driving down the return on capital. Capital outflows from Germany associated with EMU, while reducing German GDP increases German GNP (see CESifo 2003).

[5] See Fahr and Sunde (2009). The model here does not capture changes in matching efficiency. The estimates of the macroeconomic effect of benefit changes discussed below reflect hence the combined effect of matching efficiency and benefit changes on employment and output. See, e.g. Jacobi and Kluve (2007) for an overview of the Hartz reforms, and Krause and Uhlig (2012) and Krebs and Scheffel (2012) for recent quantitative assessment.

members) fell steadily from 29% in 1995 to 18% in 2011 (OECD Labor Force Statistics (2013)). These developments dampened the growth of wages, and thus raised the competitiveness of German exporters, relative to the rest of the Euro Area. As shown in the Figure below, nominal unit labor cost (ULC) has, essentially, stayed constant between the mid-1990s and the Hartz reforms—after the reforms, UCL fell (before rising slightly above its pre 2005 level). By contrast ULC rose strongly steadily in the Euro Area, after the creation of the Euro (+20% between 2000 and 2012). Due to the low wage growth, and low inflation, Germany has experienced a steady real devaluation against the rest of the Euro Area, during the sample period.

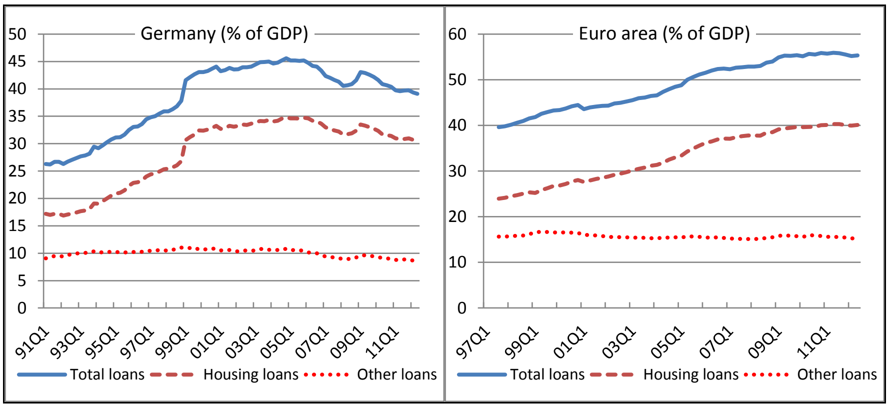
Unemployment benefit ratio and nominal unit labour costs



Increase in household savings

Other hypotheses focus on the rise in saving, as a driver of the external surplus. It has been argued that reform of the German labor market increased income uncertainty for households, which may have raised precautionary saving. Also, pension reforms enacted in 2001 and 2004 increased the importance of private saving for retirement (e.g., Boersch-Supan et al., 2001; Deutsche Bundesbank, 2011; Huefner and Koske, 2010). As shown in the Figure below, total loans received by German households grew strongly during the 1990s; loan growth has been much more muted (or even negative) since the creation of the Euro. By contrast, household debt continued to expand after the creation of the Euro (until the financial crisis).

Private household debt



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. A Not-for-Publication Appendix (to be posted on the website of the journal) provides a detailed description of the model, and of the econometric methodology.[6]

Our model builds on the EU Commission's Quest III model (in't Veld, Ratto and Roeger (2008)), 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 et al. (2005), Smets and Wouters (2007), Ratto et al. (2009), Kollmann et al. (2013), Jacob 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 key features of macroeconomic fluctuations in a range of countries.

Our model assumes three countries: Germany, an aggregate of 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.

The German bloc of the model is rather detailed, while the REA and ROW blocs are more stylized. The German bloc assumes credit constrained households, housing and a construction sector, and a government that finances purchases and transfers using distorting taxes and by issuing debt; German firms/households export and import from the REA and ROW, and borrow/lend in an international bond market. 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. In total, 40 exogenous variables are assumed. Other recent estimated DSGE models likewise assume many shocks, as it appears that many shocks are needed to capture the key dynamic properties of macroeconomic and financial data (e.g., Smets and Wouters (2007)). 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 the different hypotheses about the causes of German external surplus, data on a relatively large number of variables have to be used—we use data on a 36 macroeconomic and financial variables for Germany, the REA and the ROW (see the Appendix).

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[6] We solve the model by linearizing it around a deterministic steady state. The linearized model is estimated using Bayesian methods.

Changes in international financial market integration
To capture the effect of changes in international financial integration on the current account, we assume that the interest rate parity conditions that link German, REA and ROW risk-free one-period nominal interest rates are disturbed by exogenous shocks (as, e.g., in McCallum (1994); Kollmann (2002)):

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

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

where i_{t+1}^{DE}, i_{t+1}^{REA} and i_{t+1}^{ROW} are the nominal interest rates on one-period German, REA and ROW government debt, respectively. i_{t+1}^{EA} is the average risk-free interest rate, in the Euro Area, defined as a weighted average of i_{t+1}^{DE} and i_{t+1}^{REA}:

$$i_{t+1}^{EA} = s i_{t+1}^{DE} + (1-s) i_{t+1}^{REA}, \quad (3)$$

where s=0.275 is the steady state share of German GDP in by EA GDP. $e_t^{j,k}$ 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 ROW currency is a weighted average of the rates of depreciation of DE and REA currencies against the ROW, with weights *s* and 1-*s*, respectively:

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

Since the introduction of the Euro $e_{t+1}^{DE,REA}$ has been constant, and $\Delta \ln e_{t+1}^{EA,ROW} = \Delta \ln e_{t+1}^{DE,ROW} = \Delta \ln e_{t+1}^{REA,ROW}$ holds. Our empirical measure of i_{t+1}^{ROW} is the US federal funds rate; we take USD exchange rates as measures of $e_{t+1}^{DE,ROW}$ and $e_{t+1}^{REA,ROW}$.

$\rho_t^{DE,REA}$ and $\rho_t^{EA,ROW}$ are stationary disturbances that drive wedges between the returns on German, REA and ROW bonds; 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 $\rho_t^{DE,REA}$ and $\rho_t^{EA,ROW}$ as 'risk premia'. We treat the 'risk premia' are exogenous, following much of the open economy DSGE literature (e.g., Kollmann (2002, 2005)). All exogenous variables are assumed to follow autoregressive processes.

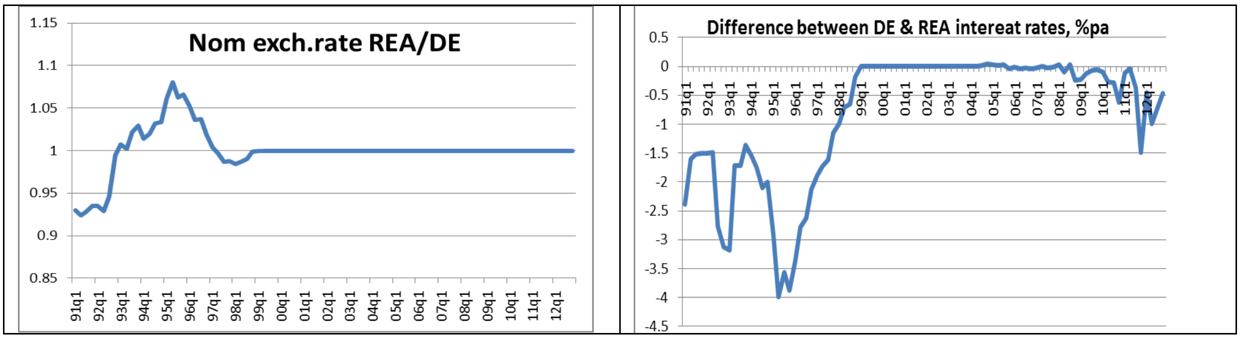
(1)-(4) imply that the following interest parity conditions hold between Germany and the rest of the world, and between REA and ROW:

$$i_{t+1}^{DE} = i_{t+1}^{ROW} + E_t \Delta \ln e_{t+1}^{DE,ROW} + \rho_t^{DE,ROW}, \text{ with } \rho_t^{DE,ROW} \equiv \rho_t^{EA,ROW} + (1-s)\rho_t^{DE,REA}; \quad (5)$$

$$i_{t+1}^{REA} = i_{t+1}^{ROW} + E_t \Delta \ln e_{t+1}^{EA,ROW} + \rho_t^{REA,ROW}, \text{ with } \rho_t^{REA,ROW} \equiv \rho_t^{EA,ROW} - s \cdot \rho_t^{DE,REA}. \quad (6)$$

Monetary policy in the Euro Area is described by an interest rate rule. Specifically, we assume that the EA average nominal interest rate i_{t+1}^{EA} is set according to an augmented Taylor rule: i_{t+1}^{EA} is function of the lagged interest rate, of the year-on-year Euro Area CPI inflation rate, and of the year-on-year growth rate of Euro Area real GDP, and of a random disturbance. Between 1995q1 (start of estimation sample) and the introduction of the Euro, the bilateral REA/DE exchange rate showed very muted fluctuations. We assume that agents believed the exchange rate to follow a random walk during that transition period, i.e. that $E_t \Delta \ln e_{t+1}^{DE,REA} = 0$. This assumption allows to construct a time series for the DE-REA risk premium: $\rho_t^{DE,REA} = i_{t+1}^{DE} - i_{t+1}^{REA}$. The DE-REA risk premium was about -3% in 1995q1; it converged almost monotonically to zero during the phase that preceded the launch of the Euro. The premium then stayed very close to (or at) zero until the sovereign debt crisis of

2010-11, when the premium became negative again. We feed the DE-REA risk-premium into our model, to assess the effect of the convergence of DE and REA interest rate on macroeconomic variables and the German external balance.



The left panel plots the bilateral (effective) exchange rate between the REA and Germany (the exchange rate after the introduction of the Euro is normalized at unity).

External demand conditions and trade shocks

The model assumes that 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 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 and to the foreign price level 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-ups) of exporters. We refer to those shocks as 'trade shocks'.

Labor market reforms and wage restraint

In our model, the government pays unemployment benefits to unemployed workers.[7] 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 (plotted above) in our 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. We refer to these union market power shocks as 'wage restraint shocks'.

Household saving and financial conditions shocks

The model assumes two types of German households that have different rates of time preference. Both households provide labor services to goods producing firms, and they accumulate housing capital—worker welfare depends in their consumption, hours worked and stock of housing capital (all households are owner-occupiers). In equilibrium, the more patient household holds financial assets (government debt, foreign bonds), and she owns the goods producing sector, and the construction sector. The other (impatient) worker borrows from the patient household, using her housing capital as collateral.[8] We assume that the

[7] Those benefits are equivalent to a subsidy for leisure.

[8] This structure (with patient and impatient household) builds on Iacoviello (2005) and Iacoviello and Neri (2010).

collateral constraint binds in all periods. To capture the rise in household saving and the fall in household investment (housing), 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—we refer to those LTV shocks as 'household financing conditions' shocks.

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., Fischer (2002, 2004)), and by TFP shocks. In addition, we assume shocks to the required rate of return on capital: the rental rate equals the risk free rate plus an exogenous risk premium; we refer to that shock as a shock to 'firm financing conditions'.

Fiscal policy
The government purchases domestically produced and imported intermediates that are used for government consumption, and for investment in public capital; the government also pays unemployment benefits 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.

4. Results

We now describe shock decompositions of hey historical time series, implied by the estimated model. To explain the key mechanisms operating in the model, we also present impulse responses to selected shocks. All model properties are evaluated at posterior estimates (modes) of the model parameters. [9]

4.1. 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. We separately show the contributions of shocks to: (1) production and investment technology; (2) firms' financing conditions; (3) household savings; (4) household financing conditions; (5) external demand; (6) the DE-REA bond risk premium ('DE rpreme'); (7) the EA-ROW bond risk premium ('EA rpreme'); (8) union market power ('wage restraint'); (9) benefit generosity; (10) Euro Area monetary policy; (11) German fiscal policy. These shocks capture the bulk of the variation in the data on German real activity and external balance.

Figure 6 shows historical decompositions of the following German macroeconomic variables that are expressed in nominal terms, and normalized by nominal German GDP: (a) the trade balance, (b) private investment; (c) GDP minus private and government consumption; (d) private consumption; (e) government consumption. We also report shock decompositions of year-on-year growth rates of real GDP (Panel f), real investment (g) and real consumption (h); as well as the decomposition of nominal unit labor cost (Panel i).

[9] Estimated model parameters and other detailed estimation results are reported in the 'Not for Publication' Appendix.

Decomposing the trade balance

The historical decomposition shows that three shocks had a major **positive** effect on the German trade balance surplus: (i) the rise in the German-REA risk premium (DE rpreme), between 1995 and 1999 (convergence of German and REA interest rates); (ii) positive external demand shocks, due to strong ROW and REA growth in 2004-08; (iii) the 2003-05 labor market reforms, captured in our model by the reduced generosity of unemployment benefits.

The **convergence of German and REA interest rates** had a persistent positive effect on German net exports that lasted until the financial crisis (when the German interest rate again began to fall below the REA rate)—see the yellow bars labeled 'DE rpreme' in Panel (a) of Figure (6). Interest rate convergence lowered German domestic productive investment and consumption, and raised German saving (relative to GDP). Interest rate convergence also had a delayed negative effect on German government consumption (as the convergence lowered German GDP). The positive effect on the saving rate is stronger than the negative effect on the investment rate. The impact of interest rate convergence on the trade balance operated thus mainly through the reduction in domestic demand and activity, which via lower factor demand also translates into a reduction in labour costs. In this respect, the trade surplus is a sign of weakness of th German economy, rather than a sign of strength.

The DE-REA risk-premium shock in isolation accounts for an increase in the German net exports/GDP ratio by about 3.9 percentage point (ppt) in the early 2000s. The decompositions of the GDP, investment and consumption growth rates show that the DE-REA risk premium shock had a very small negative effect on output growth, in the period prior to the launch of EMU; the effect on consumption and investment growth was more pronounced, but likewise concentrated on the pre-EMU period. The persistent effect on the German consumption and investment ratios (and on the trade balance/GDP ratio) is due to a long-lasting negative level shift in the path of GDP and investment, induced by the negative responses of growth rates in the early years of the sample.

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 the demand for German exports and contributed to export growth and the rising share of exports to GDP. 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 unit labour costs. Hence the effect of strong world demand is mitigated by its impact on German trade competitiveness. Strong domestic activity has also increased the demand for imports from the REA, so that growth spillovers to the REA were positive.

The **cuts in unemployment benefits** introduced during the 'Hartz' labor market reforms raised German GDP, but lowered private consumption, according to the model estimates. Note that the benefit generosity shocks contributed noticeably to the marked 2006-2007 fall in the consumption/GDP ratio. According to the historical decomposition, the labor market reforms raised household labor supply, but only had a negligible effect on physical investment. Nevertheless, the reforms contributed to a decline in unit labour costs, and thus increased German price competitiveness. Labour market reforms have also increased domestic employment and household income. Spillovers of German labor market reforms to REA real activity were positive.

Other, more modest, factors that contributed to the surge in the German trade balance surplus included shocks to household financing conditions, and household saving shocks. The estimated model shows a softening of financing constraints during the 1990s and a moderate tightening in the 2000s. Both episodes show up in as first reducing and then increasing the trade surplus.

Exogenous shifts in household savings appear more important than a tightening of household financing conditions for the widening of the trade surplus. The shock to household savings has negatively contributed to GDP and labour cost growth, with a negative impact on import demand and some positive impact on exports given the competitiveness gain. The transmission trough domestic demand is similar to the impact of EMU-related interest rate convergence. Growth spillovers to the REA were negative due to the competitiveness gains and the dampening impact on import demand.

The contribution of firms financing conditions to net exports varies across the sample period. The contribution has been positive in periods of elevated financing costs and, hence, weak domestic investment, and negative in times of lower financing costs and stronger domestic investment demand. 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.

The shocks discussed so far (mainly) had a positive effect on German net exports. Our estimates show that there also existed forces that had a noticeable countervailing (but weaker) negative effect on net exports. In particular, the strong and persistent appreciation of the EUR against the USD after the launch of the Euro dampened considerably the rise in net exports. (The model, essentially, explains the Euro appreciation as a response to shocks to the EA-ROW UIP risk premium; see brown bars labeled 'EA rpreme'.)

Finally, the contribution of fiscal policy to the trade surplus is estimated to be minor. Figure 6 shows a negative contribution during the recession 2008-9, when fiscal stimulus measures supported domestic demand.

4.2. Impulse response functions

This Section discusses the transmission mechanisms of three of the key shocks that affected the German trade balance during the sample period: DE vs. REA risk premium shock; a shock to benefit generosity; a shock to external demand for German goods. As shown below, all three shocks induce a positive comovement between German net exports and real GDP in the REA.

Figures 7-9 show impulse responses of the following variables: German GDP, private consumption and investment; the ratio of German next exports to nominal GDP; German, REA and ROW nominal interest rates; REA and ROW GDP. Interest rate responses are expressed in basis points, the response of the trade balance/GDP ratio is in percentage points, while responses of the remaining variables are shown as % deviations from unshocked paths.

4.2.1. Shock to the DE vs. REA risk premium

Figure 7 shows responses to an unanticipated 1 standard deviation innovation to the risk-premium $\rho_t^{DE,REA}$ (wedge between German and REA nominal interest rates); see (1). The risk-premium follows an AR(1) process with autocorrelation 0.98. Thus, the innovation leads to a persistent rise in the risk-premium. This triggers a persistent rise in the German nominal interest rate, and a persistent fall in the REA nominal interest rate. Due to price stickiness, the German real interest rate rises as well, while the REA real interest rate falls. This induces a sharp and persistent fall in German investment, and a more muted fall in German aggregate consumption. German imports fall, hence. German net exports rise persistently. German GDP falls too, but less than investment. The fall in the REA interest rate boosts REA absorption and REA output.

4.2.2. Positive shock to unemployment benefit replacement rate

Figure 8 shows responses to a permanent 1ppt rise in the German unemployment benefit replacement rate. This triggers a rise in aggregate German consumption, as the higher transfer payment from the government raises the consumption of credit constrained German households. The shock lowers the labor supply of German households, which triggers a fall in German GDP. According to the estimated monetary policy rule, the ECB responds to a fall in EA GDP by lowering the nominal interest rate. As a fall in German GDP has a noticeable negative effect on EA aggregate GDP, a rise in the German benefit replacement ratio leads, hence, to a reduction in the nominal interest rate. This explains why German investment rises, in the first few periods after the shock; in the long term, however, German investment falls below its unshocked path, as the (permanent) reduction in German labor employment entails a permanent reduction in the German capital stock. The fall in German GDP, the rise in German consumption, and the (transitory) rise in German investment imply that German net exports fall. The reduction in German GDP lowers German demand for imports from REA and ROW, and thus REA and ROW GDP fall likewise.

4.2.3. Positive shock to aggregate demand in the rest of the world

Figure 9 shows responses to a 1 standard deviation ROW taste shock that raises the ROW marginal utility of consumption. According to the model estimates, the ROW taste parameter has an autocorrelation of 0.57. Therefore, the taste shock raises ROW aggregate spending—which leads to a rise in ROW demand for German and REA products. This demand shock raises German and REA output. The ECB responds to this by raising the Euro interest rate, which lowers German consumption and investment. German net exports increase, hence.

5. Scenarios for the German external balance

The estimated model can also be used to estimate the future evolution of the German external balance. We now present a scenario analysis based on possible evolutions of risk premia within the EA (persistently high risk premia in Southern EA countries), labour market reforms (leveling off of labour market shocks in DE) and external demand developments (continued high demand from emerging economies and the US).
[TO BE COMPLETED]

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, and the rest of the world. We used that model to analyze the causes of Germany's substantial and persistent current account surplus, and its effect on the rest of the Euro Area. According to our estimates, the most important factors driving the surge in the German surplus after the introduction of the Euro were the convergence of Euro Area interest rates brought about by Monetary Union, German labor market reforms, and strong world demand for German exports. The key shocks that drove the rise in German net exports also had a positive effect on real activity in the rest of the Euro Area.

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Table 1. German current account, net exports and demand components, in % of German GDP (means over sub-periods)

	Mean, 1991-2000	Mean, 2002-2012	Percentage point difference between mean 2002-2012 & mean 1991-2000
	(1)	(2)	(3)
CA	-1.09	5.27	6.36
NX	0.51	5.32	4.82
Net transfers & income	-1.60	-0.06	1.54
National S	21.23	23.17	1.94
Private S	20.52	22.82	2.30
Households S	11.47	11.41	-0.06
Corporations S	9.05	11.41	2.36
NFC S	8.42	10.44	2.01
FINC S	1.12	1.11	-0.01
Government S	0.70	0.35	-0.35
National I	22.32	17.90	-4.42
Private I	20.07	16.32	-3.75
Households I	8.19	5.99	-2.20
Corporations I	11.88	10.33	-1.55
NFC S	11.25	10.12	-1.13
FINC S	0.60	0.29	-0.31
Government I	2.24	1.58	-0.66
C	57.93	57.76	-0.17
Housing I	7.21	5.42	-1.78
Non-housing I	15.10	12.48	-2.62
G	19.25	19.01	-0.23
CA wrt REA	-0.20	2.76	2.97
CA wrt ROW	-0.89	2.51	3.39
NX wrt REA	0.11	2.58	2.47
NX wrt ROW	0.40	2.74	2.35

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 2. Decomposing fluctuations in the German current account, annual data

	Std(s)	Std(i)	Std(ca)	C(s,i)	C(s,ca)	C(i,ca)	$\frac{V(s)}{V(ca)}$	$\frac{V(i)}{V(ca)}$	$\frac{-2Cov(s,i)}{V(ca)}$	Corr between ca & Y^{DE}	$\frac{Y^{DE}}{Y^{REA}}$	$\frac{Y^{DE}}{Y^{ROW}}$
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
(a) 1991-2012												
Level	1.87	2.35	3.45	-0.33	0.77	-0.86	0.29	0.46	0.24	---	---	---
dtrendL	1.56	1.06	1.48	0.41	0.76	-0.28	1.11	0.51	-0.62	-0.13	-0.28	-0.59
fdiff	1.23	1.08	0.99	0.64	0.54	-0.29	1.56	1.20	-1.76	-0.00	-0.21	-0.23
HP	1.32	0.99	1.30	0.40	0.71	-0.36	1.04	0.58	-0.62	-0.07	-0.55	-0.56
(b) 1960-1990												
Level	2.25	3.26	2.10	0.77	-0.12	-0.73	1.15	2.40	-2.55	---	---	---
dtrendL	1.84	1.48	1.35	0.69	0.61	-0.15	1.88	1.21	-2.00	-0.18	0.03	-0.95
fdiff	1.27	1.36	1.08	0.66	0.34	-0.48	1.37	1.58	-1.95	-0.36	-0.36	-0.51
HP	1.45	1.37	1.17	0.65	0.47	-0.36	1.52	1.35	-1.87	-0.18	0.14	-0.40
(c) 1960-2012												
Level	2.45	3.51	2.80	0.61	0.11	-0.72	0.76	1.57	-1.34	---	---	---
dtrendL	2.03	1.75	2.24	0.30	0.67	-0.50	0.82	0.61	-0.43	-0.30	-0.29	-0.71
fdiff	1.28	1.29	1.27	0.51	0.49	-0.49	1.02	1.03	-1.05	-0.29	-0.50	-0.50
HP	1.51	1.34	1.59	0.38	0.63	-0.43	0.90	0.71	-0.61	-0.35	-0.48	-0.73

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^i : 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.

Rows with the 'Level' label in the left-most column: all statistics computed using linearly detrended series; 'fdiff': first differenced series; 'HP': HP filtered series (smoothing parameter: 400)

Table 3. Decomposing fluctuations in German next exports, annual data

	Std(ŝ)	Std(i)	Std(nx)	C(ŝ,i)	C(ŝ,nx)	C(i,nx)	$\frac{V(\hat{s})}{V(nx)}$	$\frac{V(i)}{V(nx)}$	$\frac{-2Cov(\hat{s},i)}{V(nx)}$	Corr between nx & Y^{DE}	Corr between nx & $\frac{Y^{DE}}{Y^{REA}}$	Corr between nx & $\frac{Y^{DE}}{Y^{ROW}}$
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
(a) 1991-2012												
Level	1.09	2.35	2.53	0.06	0.38	-0.90	0.19	0.86	-0.05	---	---	---
dtrendL	1.07	1.06	1.00	0.56	0.48	-0.46	1.15	1.12	-1.25	0.11	-0.54	-0.10
fdiff	1.28	1.08	0.89	0.73	0.55	-0.16	2.09	1.49	-2.58	0.25	-0.02	0.10
HP	1.03	0.99	0.92	0.59	0.49	-0.42	1.26	1.16	-1.41	0.08	-0.52	-0.24
(b) 1960-1990												
Level	2.94	3.26	1.51	0.89	0.03	-0.43	3.77	4.63	-7.41	---	---	---
dtrendL	1.86	1.48	1.38	0.68	0.62	-0.15	1.82	1.15	-1.98	-0.41	-0.32	-0.88
fdiff	1.11	1.36	1.01	0.68	0.18	-0.59	1.21	1.80	-2.02	-0.38	-0.22	-0.06
HP	1.25	1.37	1.06	0.67	0.31	-0.49	1.38	1.66	-2.04	-0.28	-0.08	-0.18
(c) 1960-2012												
Level	2.93	3.51	1.99	0.82	0.02	-0.55	2.17	3.12	-4.29	---	---	---
dtrendL	1.89	1.75	1.82	0.50	0.56	-0.44	1.07	0.92	-0.99	-0.47	-0.47	-0.69
fdiff	1.25	1.29	1.27	0.50	0.48	-0.52	0.97	1.02	-0.99	-0.23	-0.43	-0.33
HP	1.28	1.34	1.42	0.41	0.51	-0.57	0.81	0.84	-0.69	-0.40	-0.56	-0.66

Note— **ŝ**=(GDP-C-G)/GDP; i=I/GDP, nx=(Y-C-G-I)/GDP, where C,I,G,GDP are private consumption, government consumption, gross investment and GDP, in nominal terms, respectively. Y^i: 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 nx, motivated by the fact that $V(nx) = V(\hat{s}) + V(i) - 2Cov(\hat{s}, i)$, and thus: $1 = V(\hat{s})/V(nx) + V(i)/V(nx) - 2Cov(\hat{s}, i)/V(nx)$.
Cols. (10)-(11) show correlations between nx 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.

Rows with the 'Level' label in the left-most column: all statistics computed using linearly detrended series; 'fdiff': first differenced series; 'HP': HP filtered series (smoothing parameter: 400)

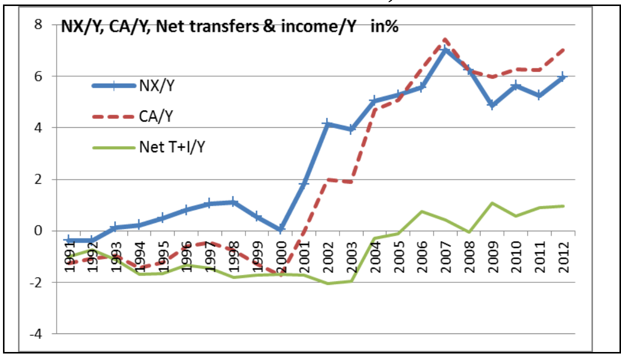
Table 4. YoY GDP growth and current accounts (means over sub-periods)

	Mean, 1991-2000	Mean, 2002-2012	Percentage point difference between mean 2002-2012 & mean 1991-2000
	(1)	(2)	(3)
(a) YoY growth rates, %			
DE	1.84	1.07	-0.77
REA	3.04	0.91	-2.13
ROW	3.03	2.50	-0.53
(b) Current account balances, in % of world GDP			
USA	-0.521	-1.141	-0.620
Euro Area	0.117	0.115	-0.002
Germany	-0.081	0.304	0.385
Rest of Euro Area	0.186	-0.189	-0.375
Japan	0.381	0.299	-0.082
Other Advanced Economies	0.149	0.267	0.118
CIS	0.024	0.136	0.112
Developing Asia	0.002	0.382	0.380
China	0.043	0.349	0.306
Middle East & North Africa	-0.025	0.369	0.395
Latin America & Caribbean	-0.169	-0.022	0.147

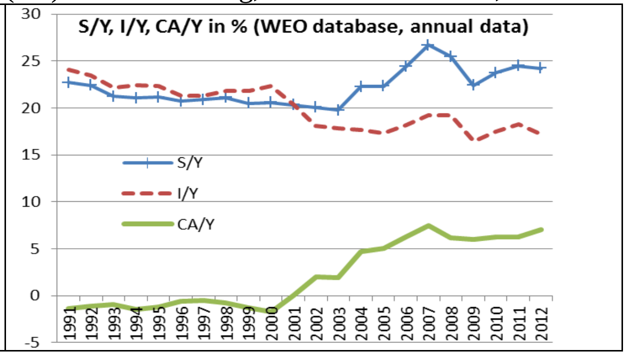
Note—The mean growth rate of REA and ROW GDP in Col. 1 is computed for 1996-2000. The mean current account balance for the Euro Area and the Rest of the Euro Area in Col. 1 is computed for 1997-2000. Source: IMF WEO database (April 2013).

Figure 2:The German current account, saving and investment

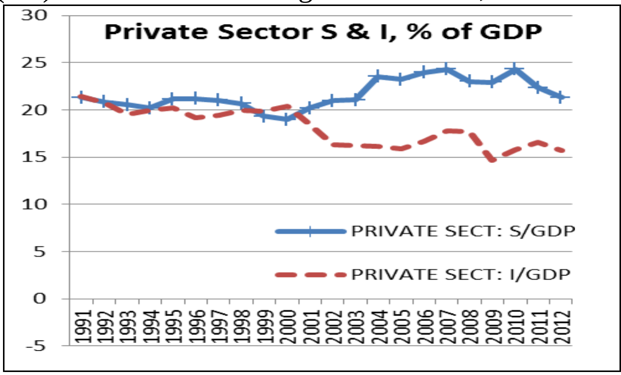
(2.a) Current Account, net exports, net transfers and incomes from rest of world, % of GDP



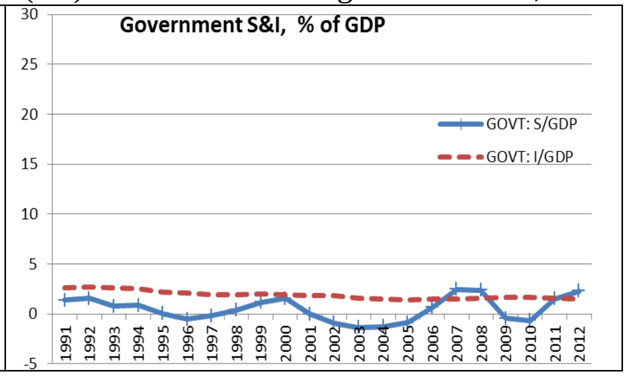
(2.b) National saving, investment and CA, % of GDP



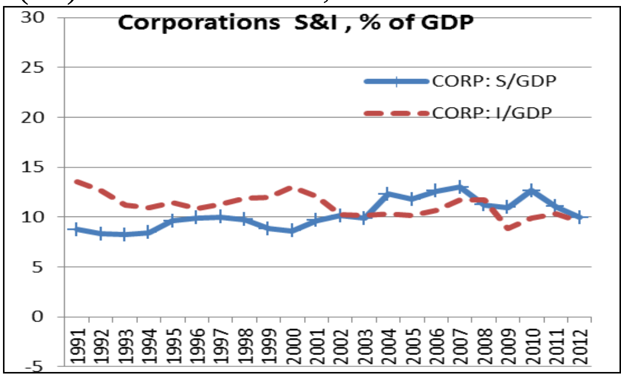
(2.c) Private sector: saving & investment, % of GDP



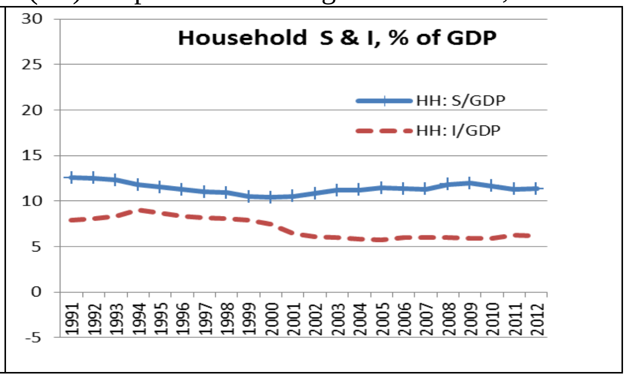
(2.d) Government: saving & investment, % of GDP



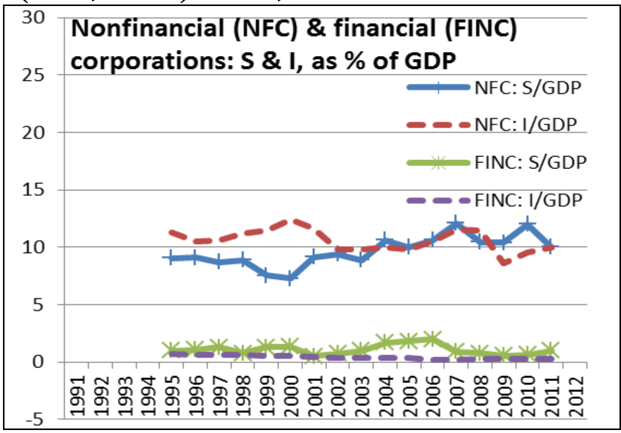
(2.e) Households: S & I, % of GDP



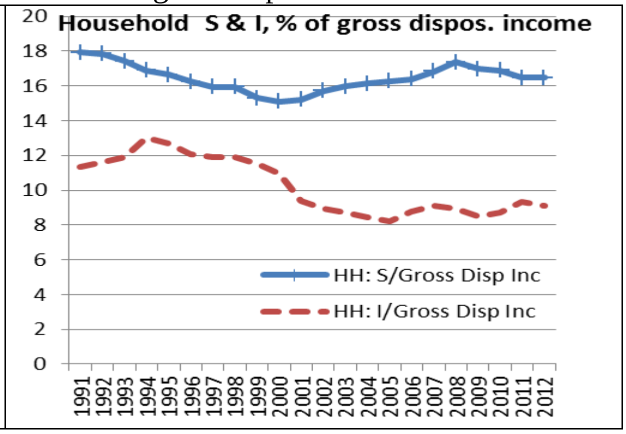
(2.f) Corporations: saving & investment, % of GDP



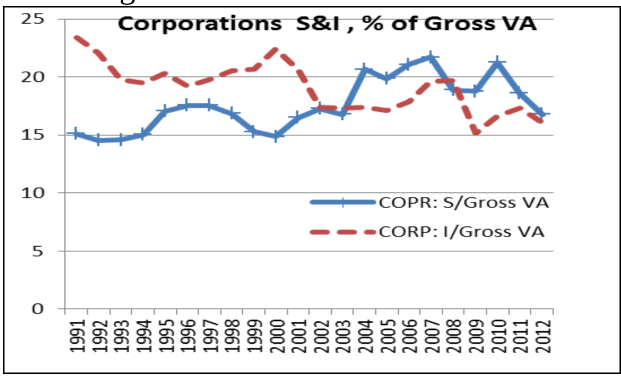
(2.g) Non-financial and financial corporations (NFC, FINC): S & I, % of GDP



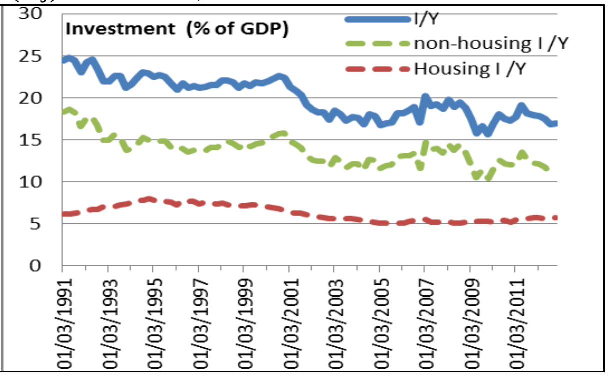
(2.h) Households: saving & investment, as % of gross disposable income



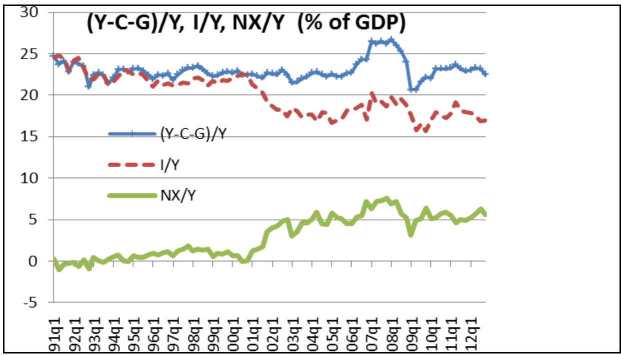
(2.i) Corporations: saving & investment, as % of gross value added



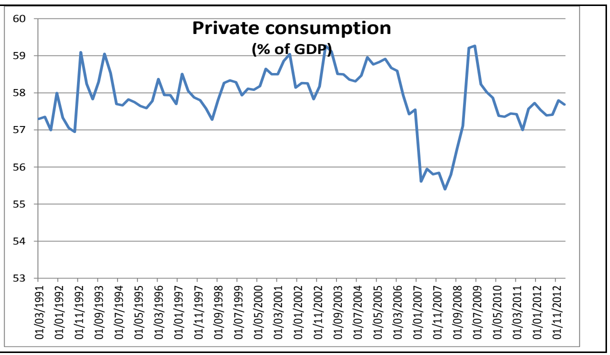
(2.j) Investment, % of GDP



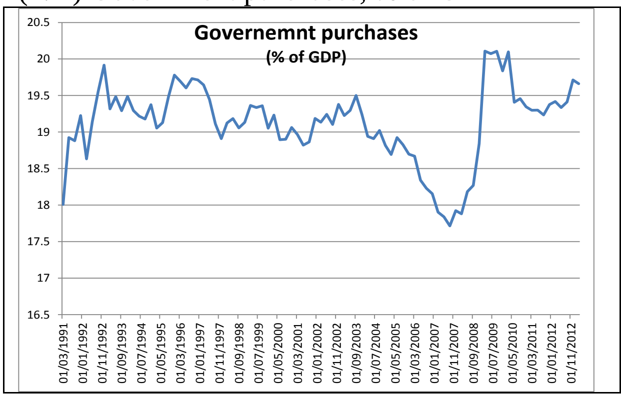
(2.k) Net export, Y-C-G, I, % of GDP



(2.l) Private consumption, % of GDP



(2.m) Government purchases, % of GDP



(2.n) NX decomp. based on non-dur+serv. consumption

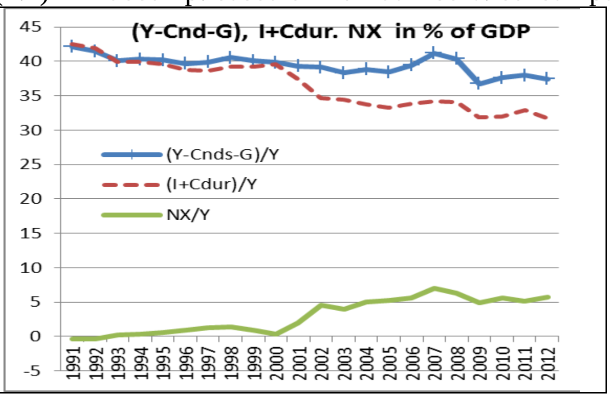
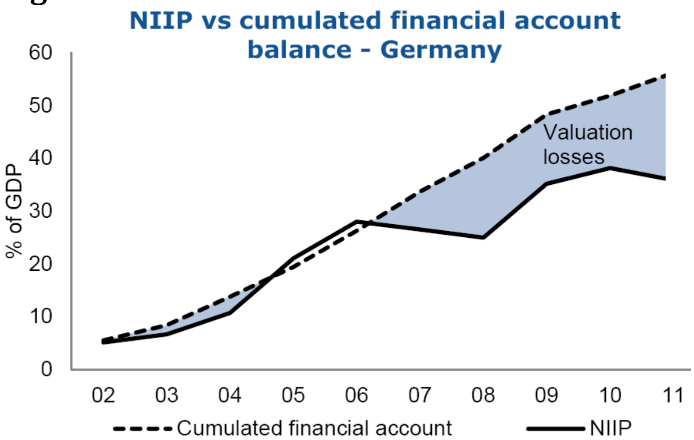


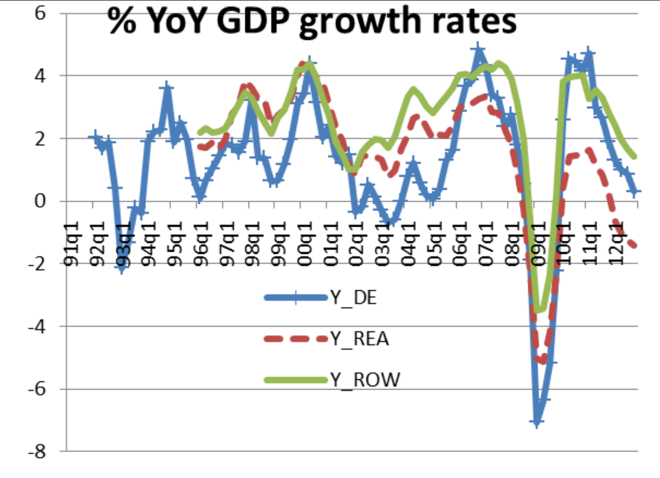
Figure 3: German external valuation losses



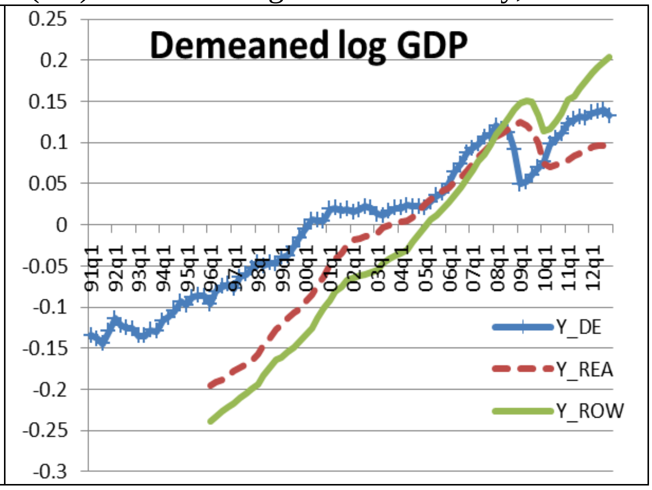
Source: European Commission (2012), p.41

Figure 4: GDP in Germany (DE), the Rest of the Euro Area (REA) and the Rest of the World (ROW); Regional structure of DE CA/TB

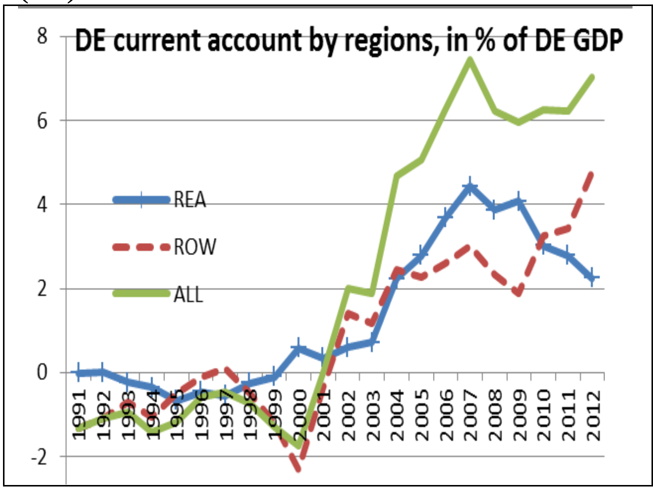
(4.a) YoY GDP in Germany, REA and ROW



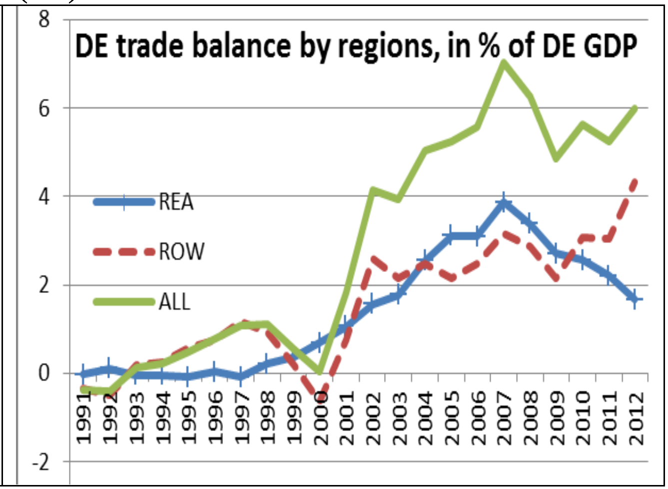
(4.b) Demeaned log GDP in Germany, REA & ROW



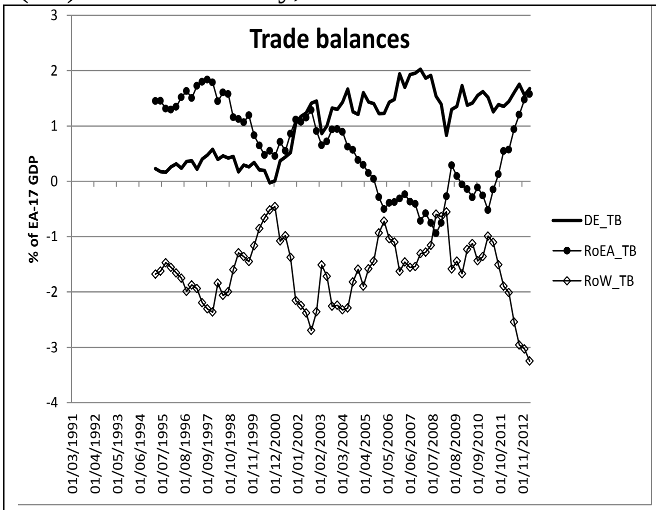
(4.c) German CA with REA and ROW



(4.d) German NX with REA and ROW



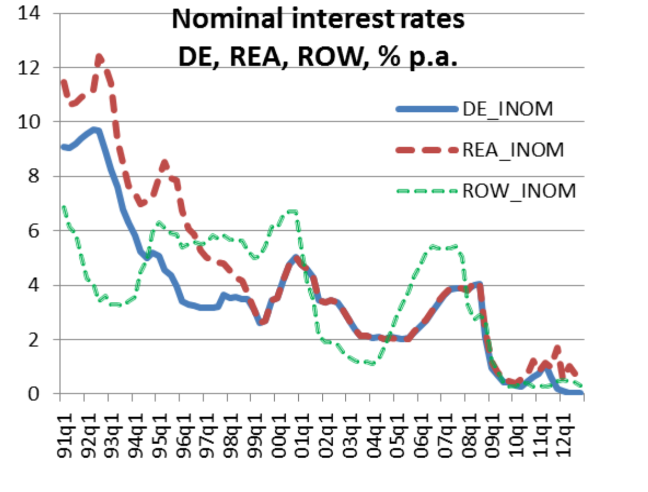
(4.e) NX of Germany, REA and ROW



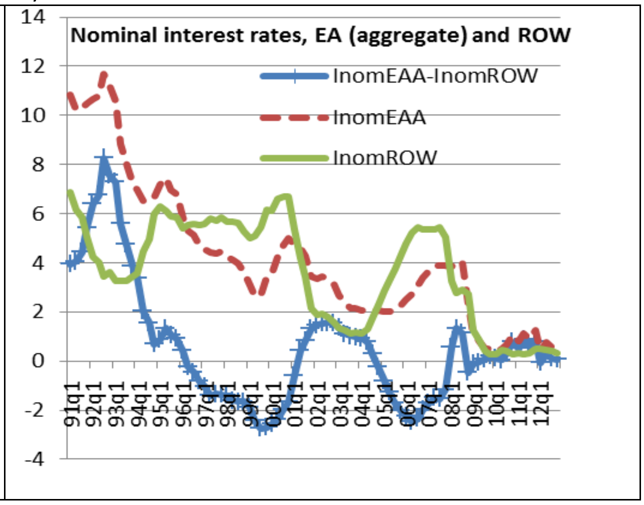
Note: trade balances are shown as % of EA-17 GDP.
RoEA: Euro Area less Germany; RoW: rest of world
RoW_TB/EA_Y=-DE_TB/EA_Y-RoEA_TB/EA_Y

Figure 5: Interest rates and exchange rates

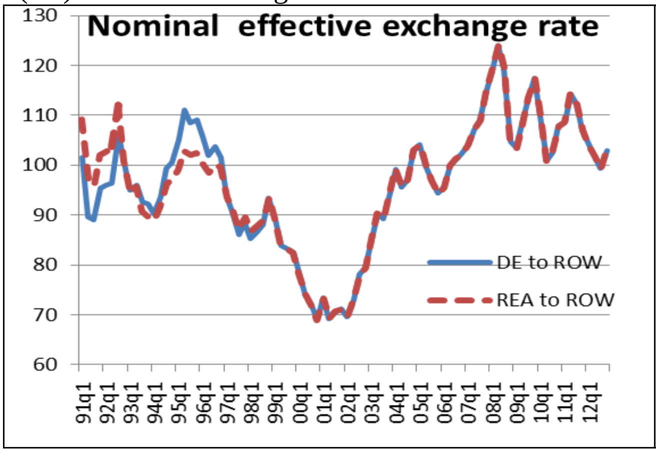
(5.a) Nominal interest rates: DE, REA, ROW



(5.b) Nominal interest rates: Euro Area and ROW

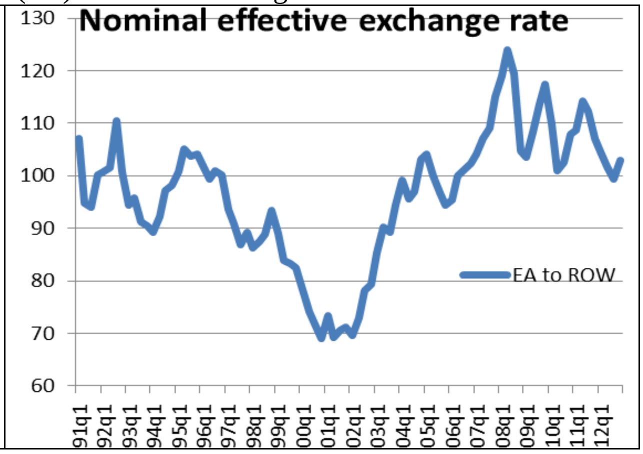


(5.c) Nominal exchange rate: DE and REA vs. REA



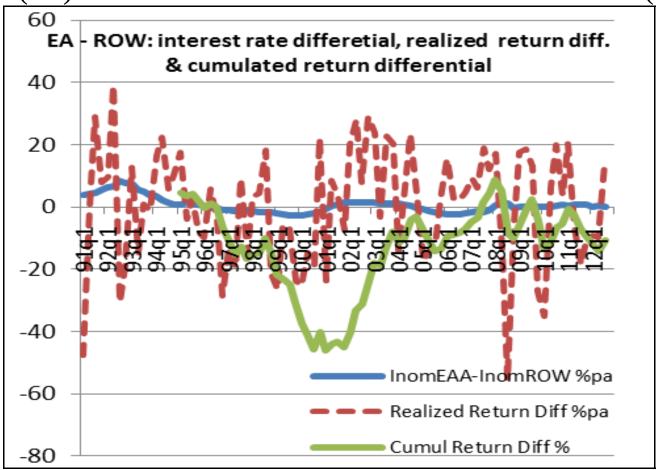
Rise: DE (REA) appreciation

(5.d) Nominal exchange rate: Euro Area vs. ROW



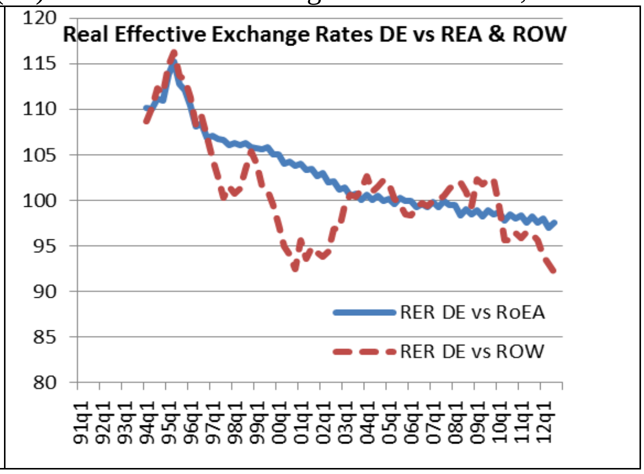
Rise: EA appreciation

(5.e) EA-ROW interest rate and return differential



Rise: DE appreciation

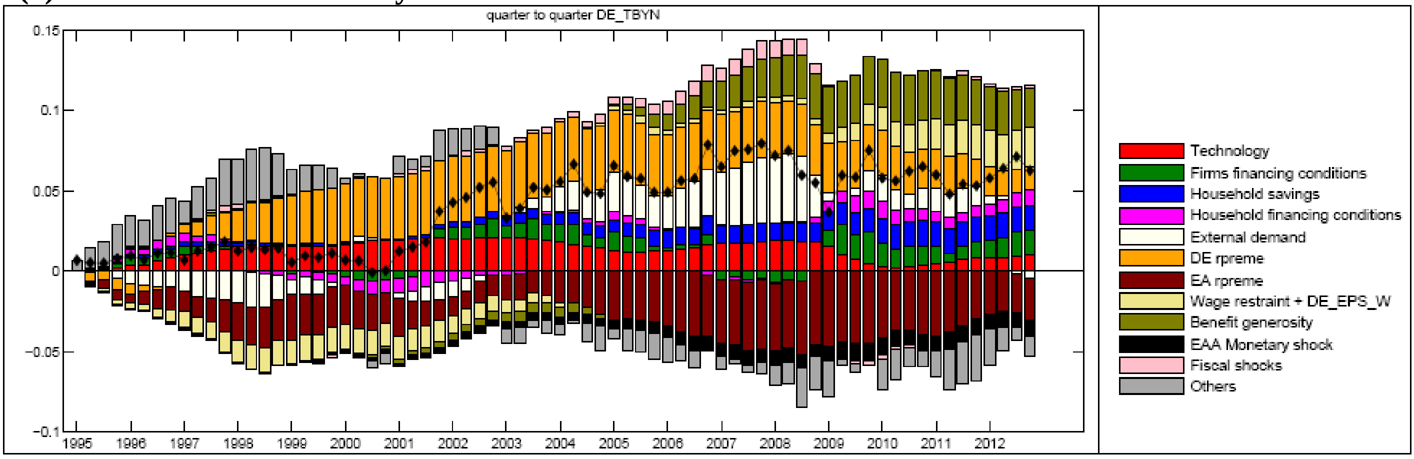
(5.f) Real effective exchange rates: DE-REA; DE-ROW



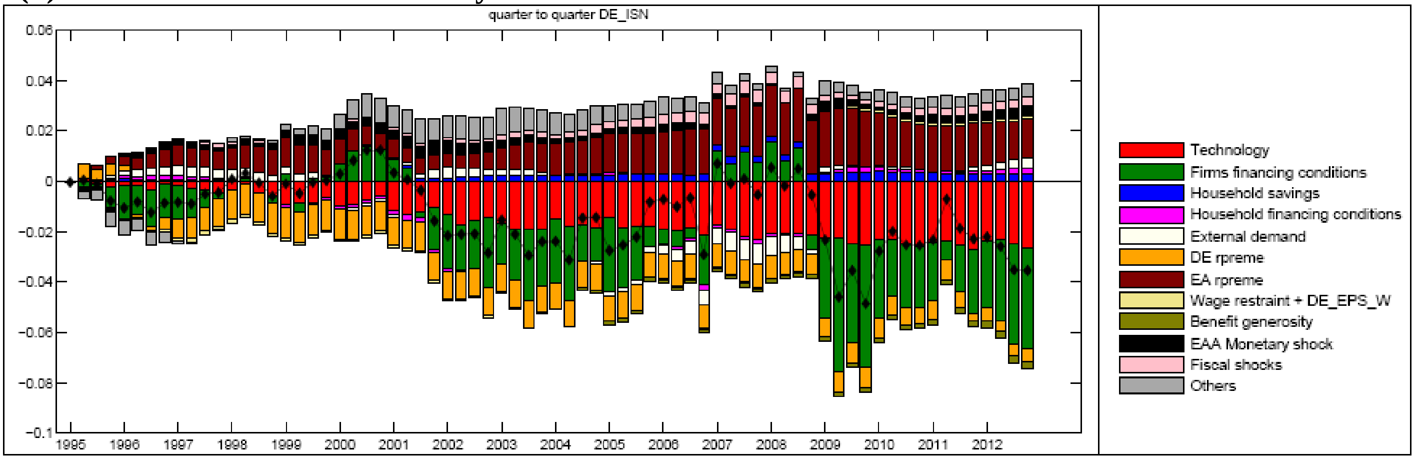
Rise: DE appreciation

Figure 6: Historical decompositions of German macroeconomic variables, 1995-2012

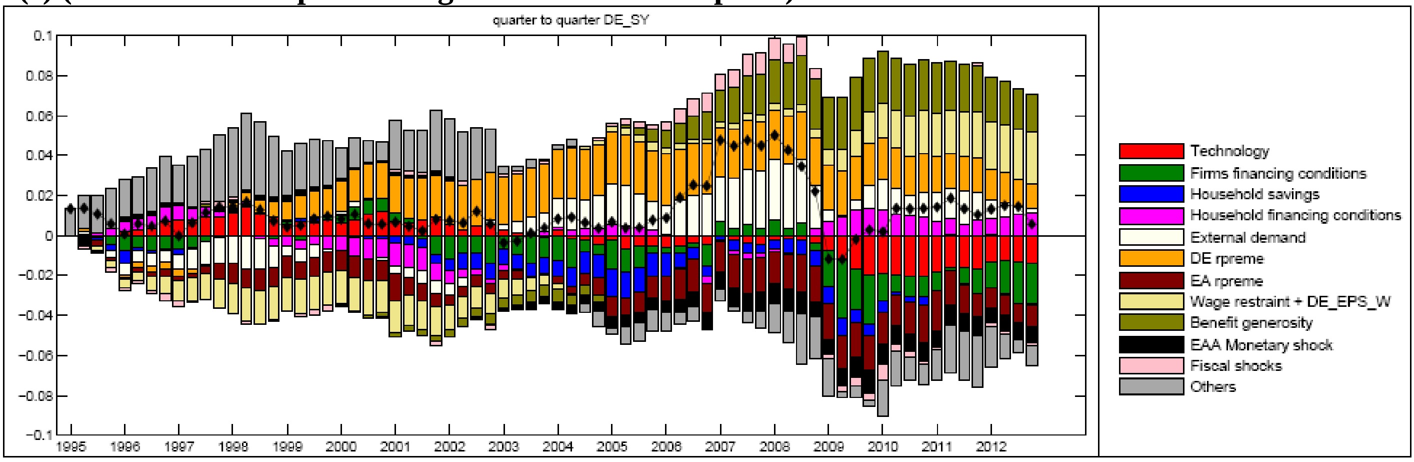
(a) Trade balance divided by nominal GDP



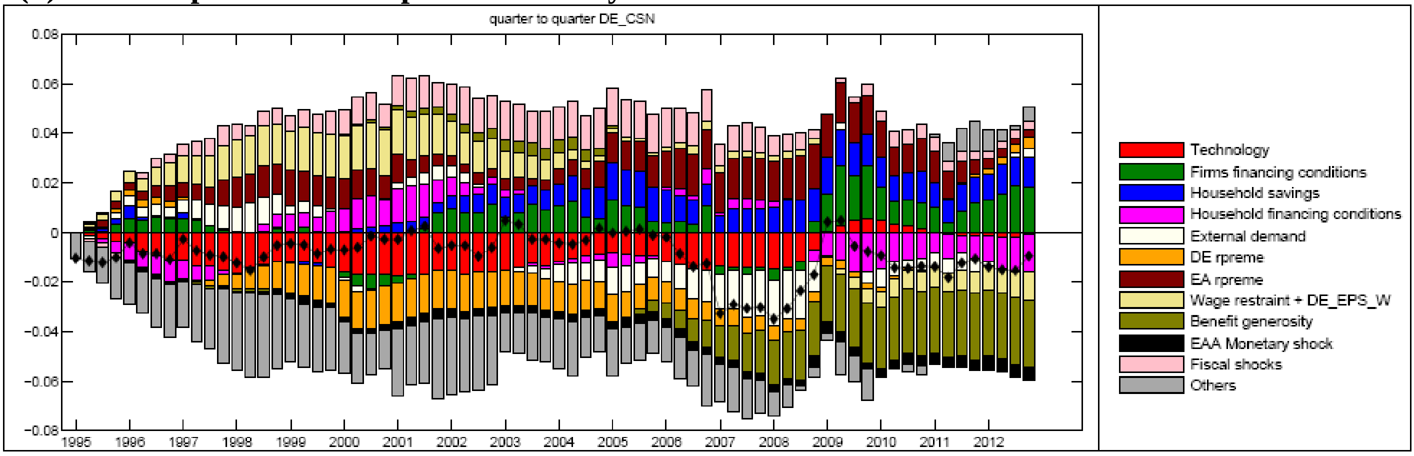
(b) Nominal investment divided by nominal GDP



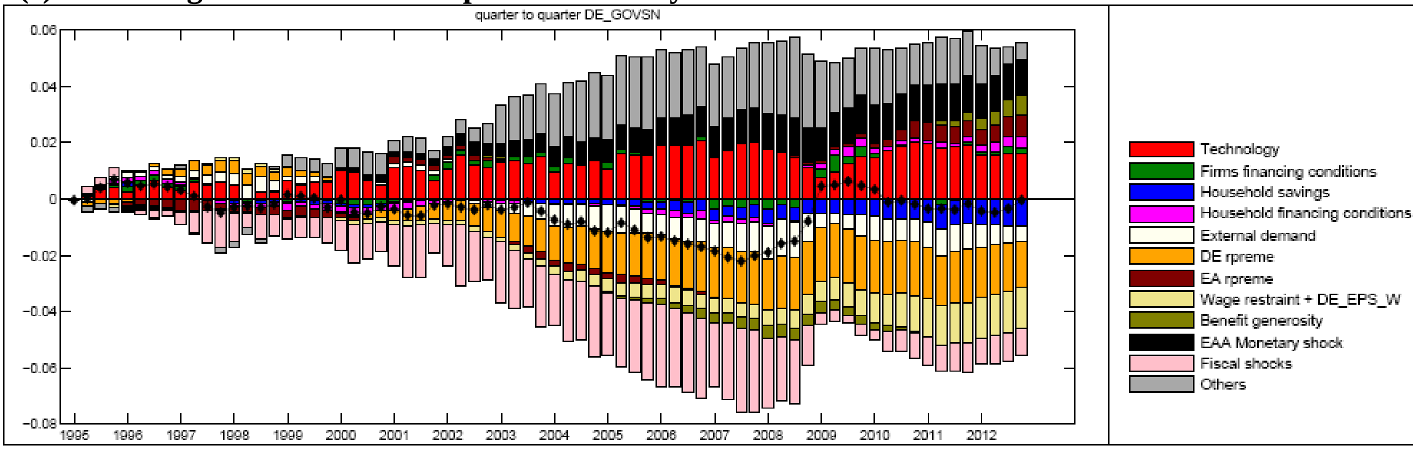
(c) (Nominal GDP – private & government consumption)/nominal GDP



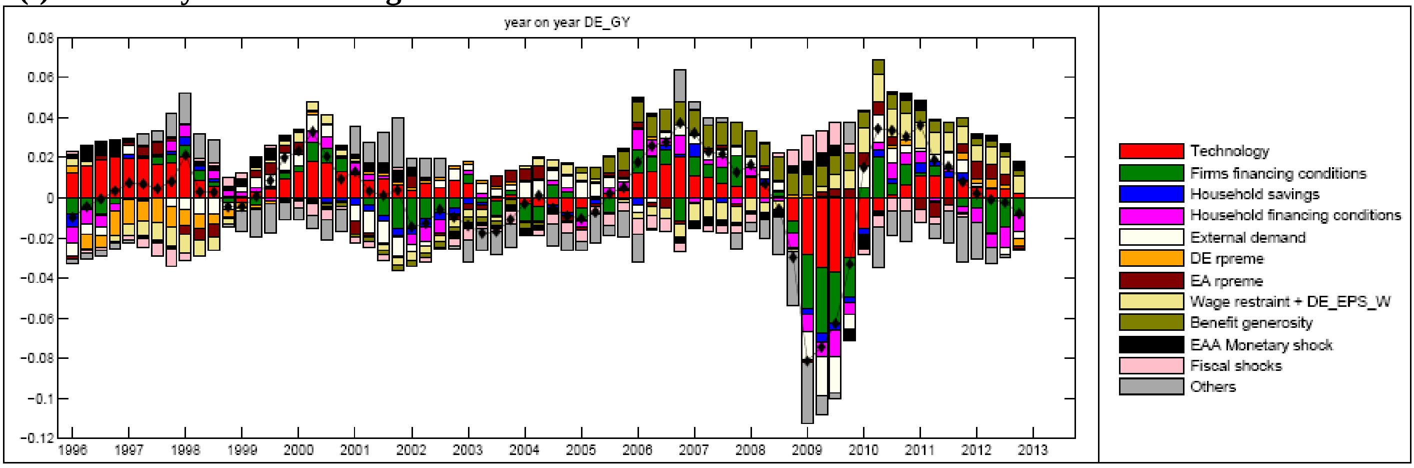
(d) Nominal private consumption divided by nominal GDP



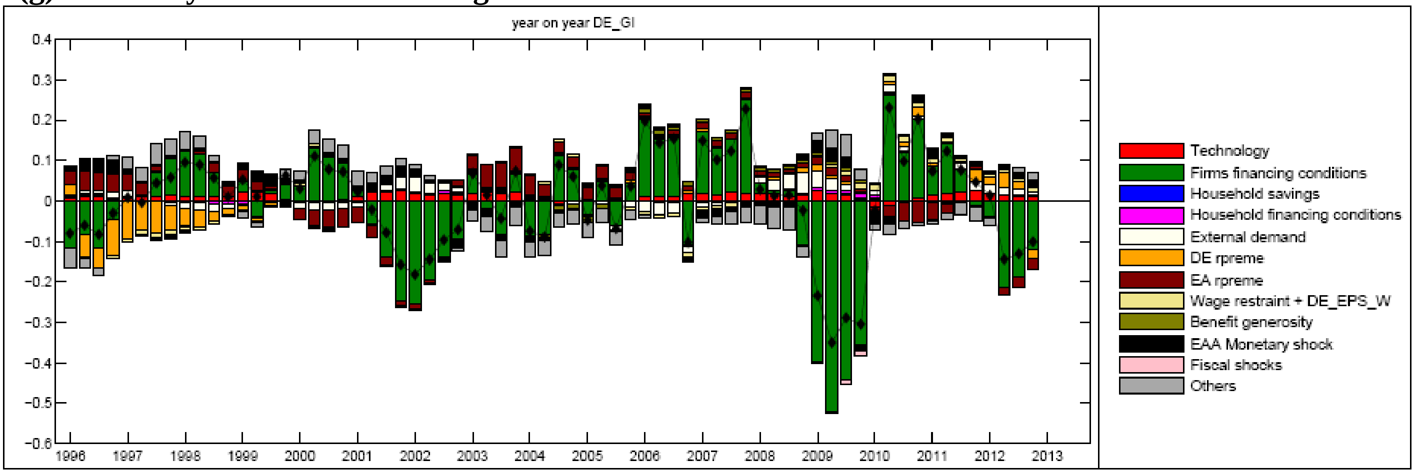
(e) Nominal government consumption divided by nominal GDP



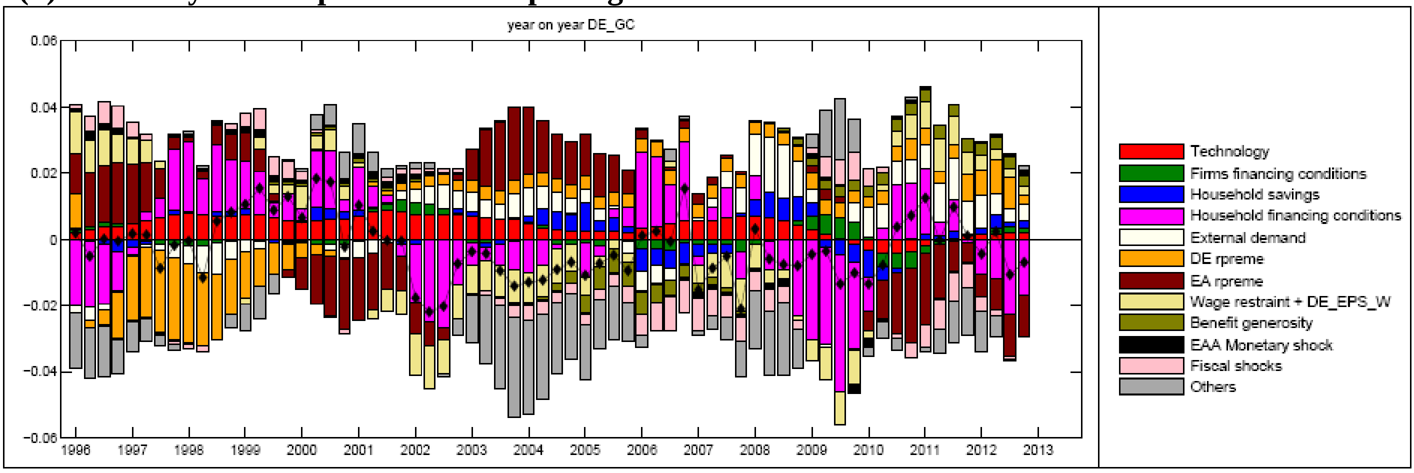
(f) Year-on-year real GDP growth rate



(g) Year-on-year real investment growth rate



(h) Year-on-year real private consumption growth rate



(i) Unit labor cost

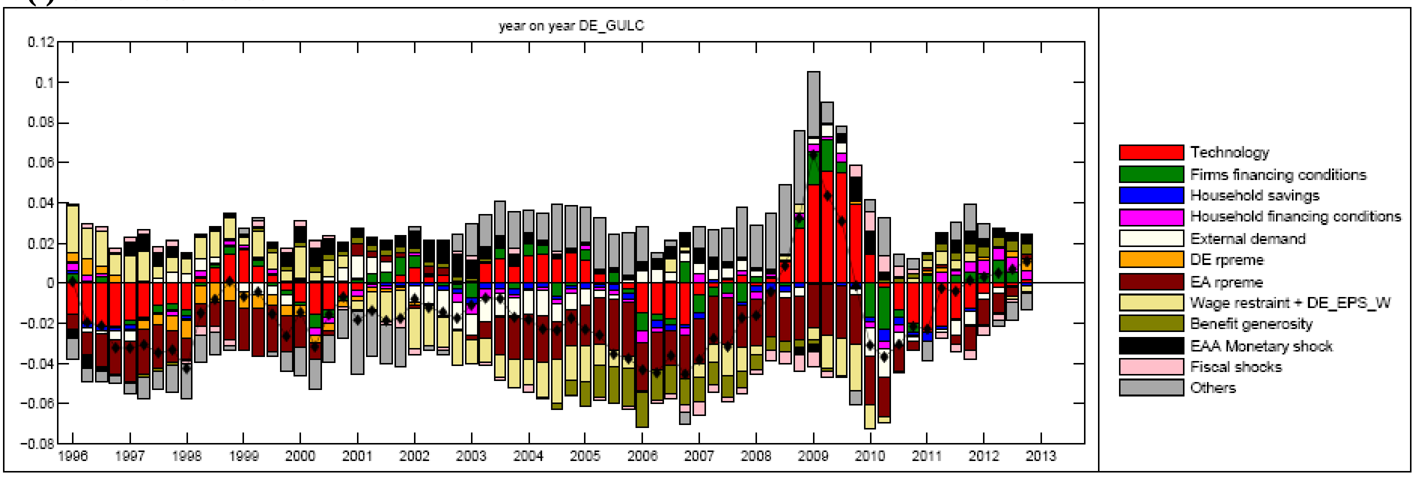


Figure 7. Dynamic responses to 1 std. innovation to risk-premium Germany vs. REA

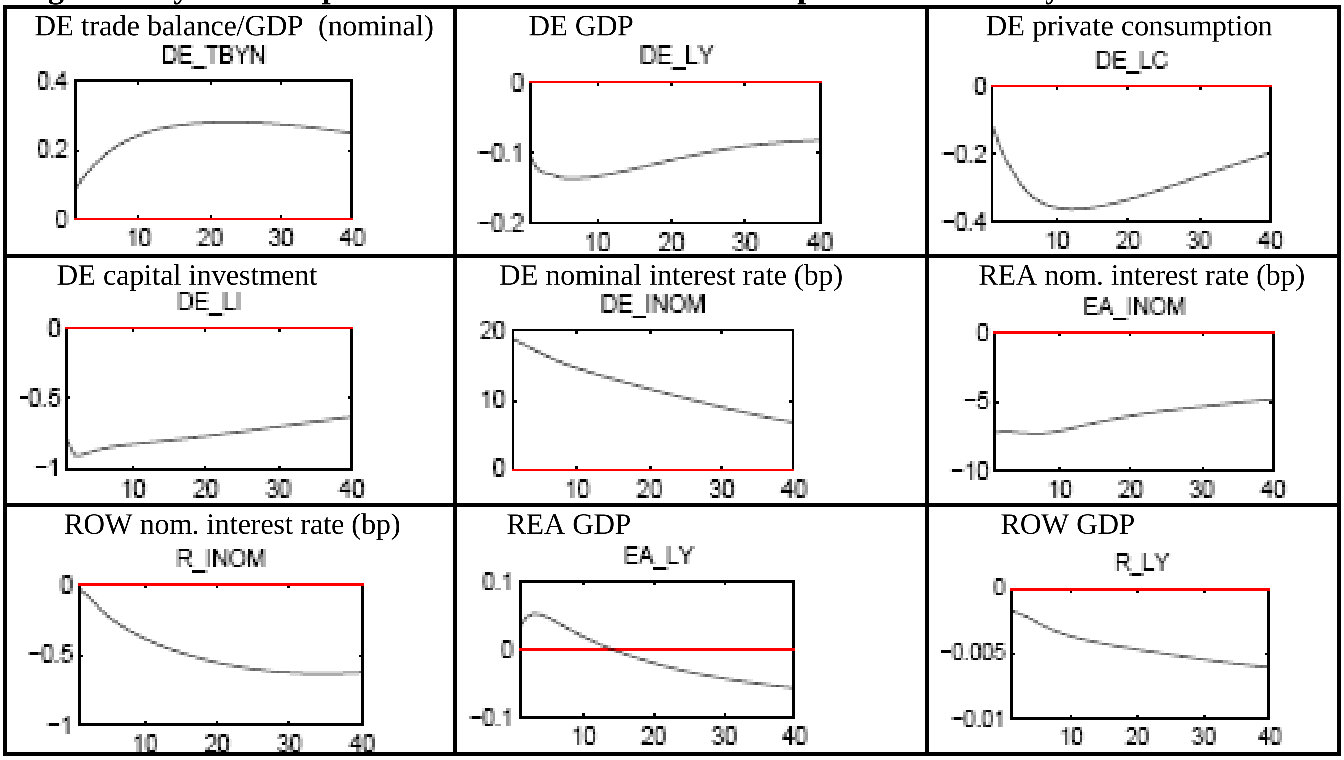


Figure 8. Dynamic responses to 1 ppt *rise* in German unemployment benefit replacement rate

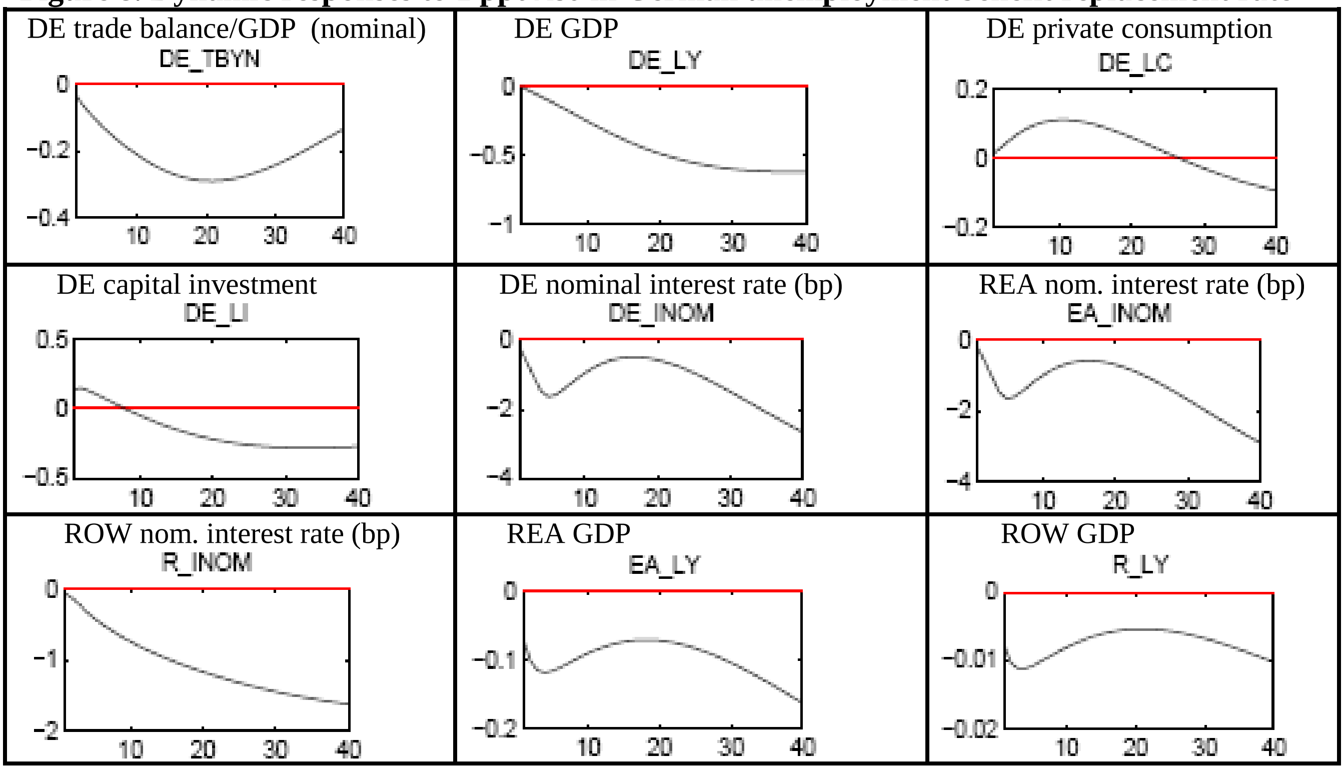
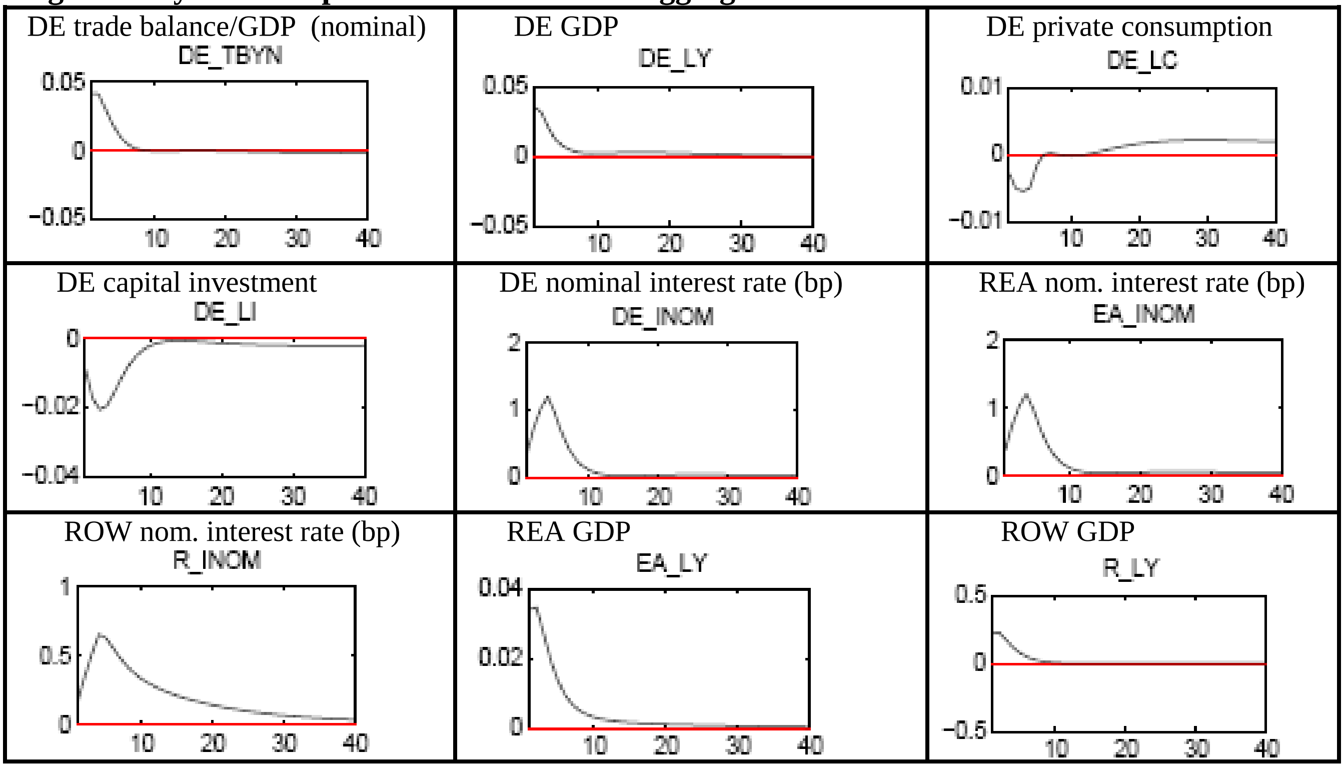
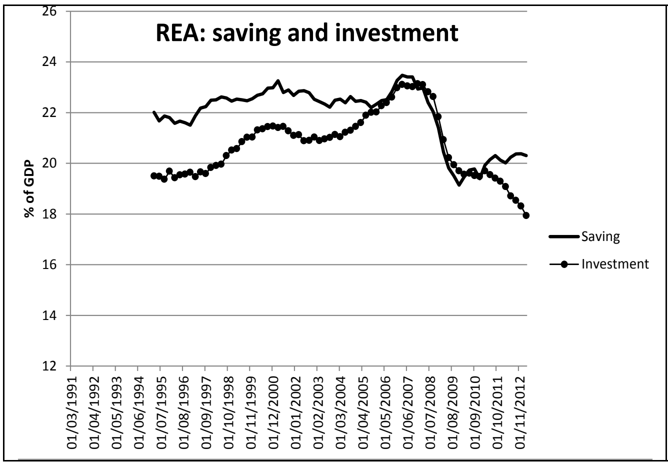
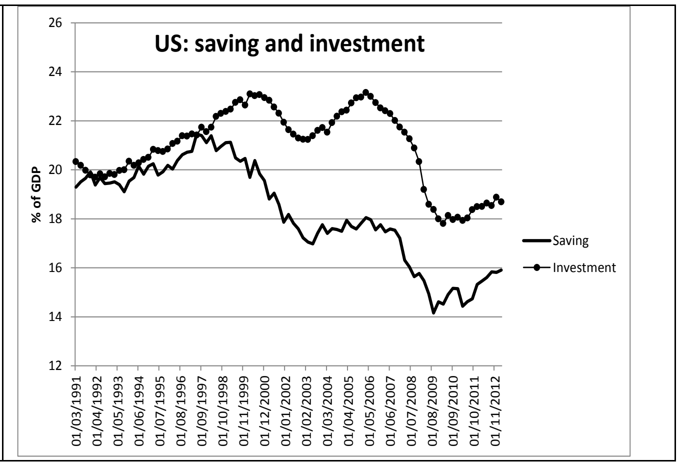


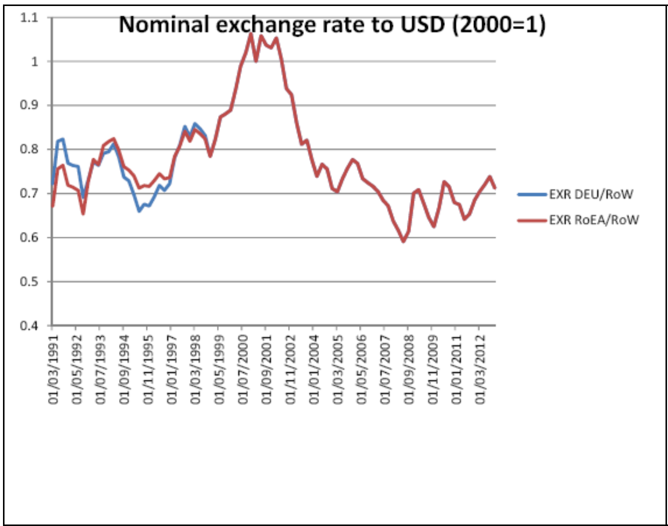
Figure 9. Dynamic responses to rest-of-world aggregate demand shock

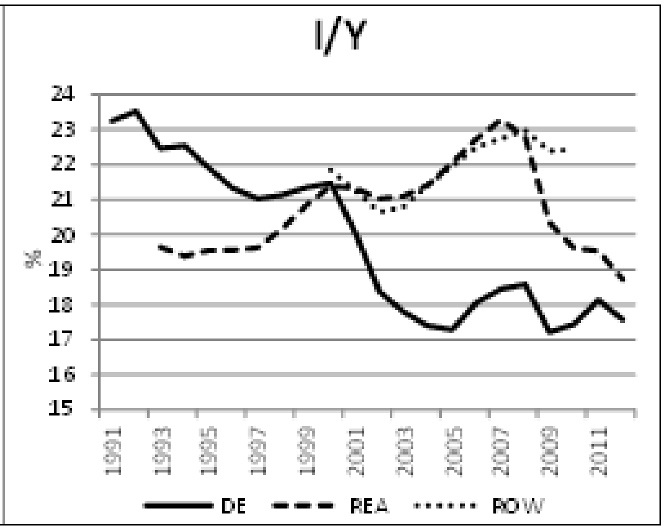


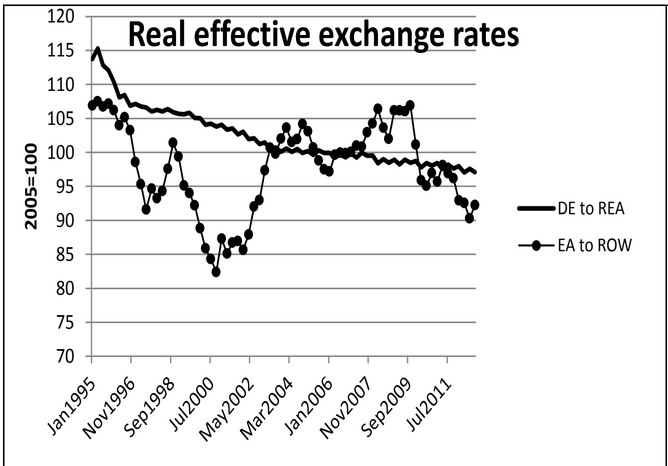
SUPPLEMENTAL PLOTS

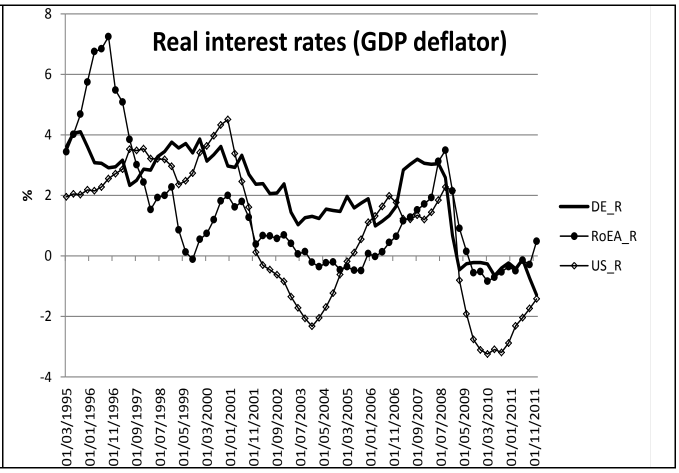




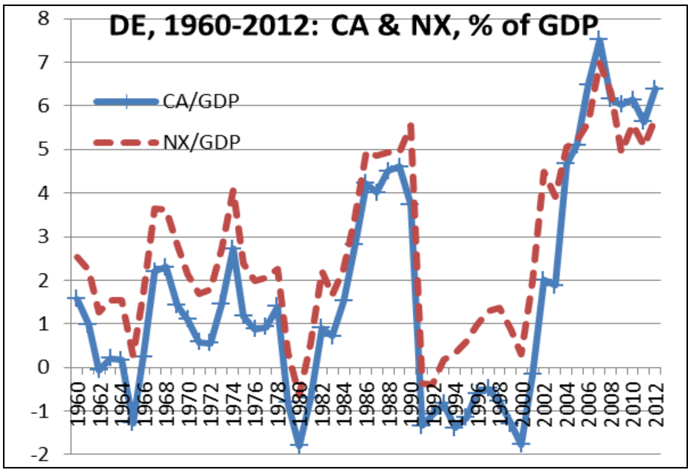


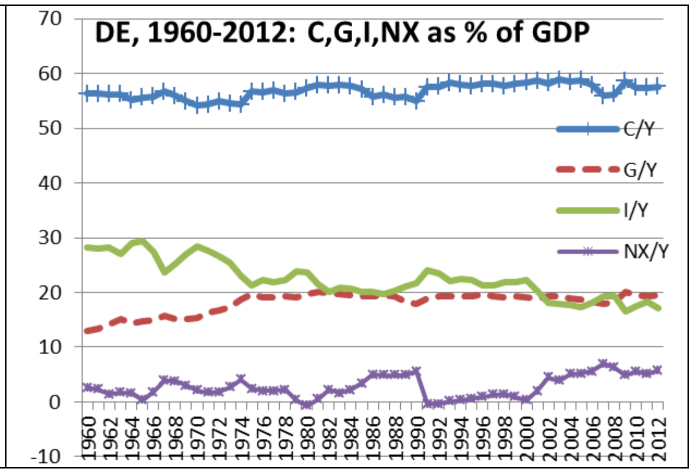


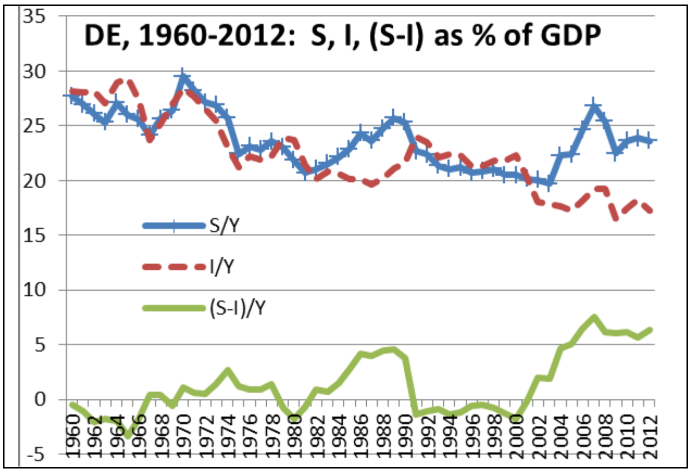


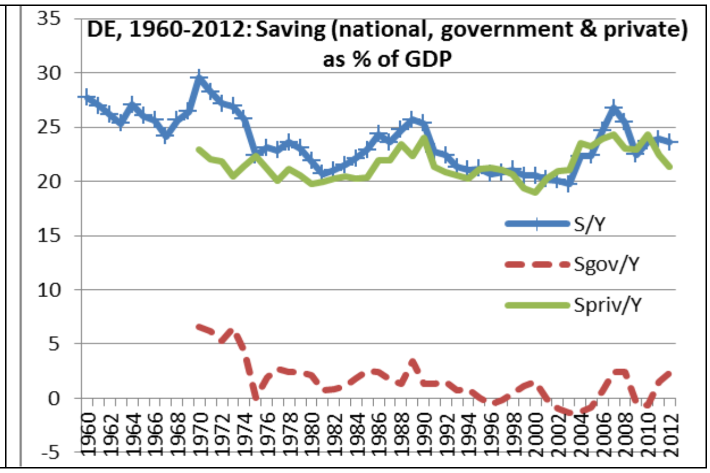


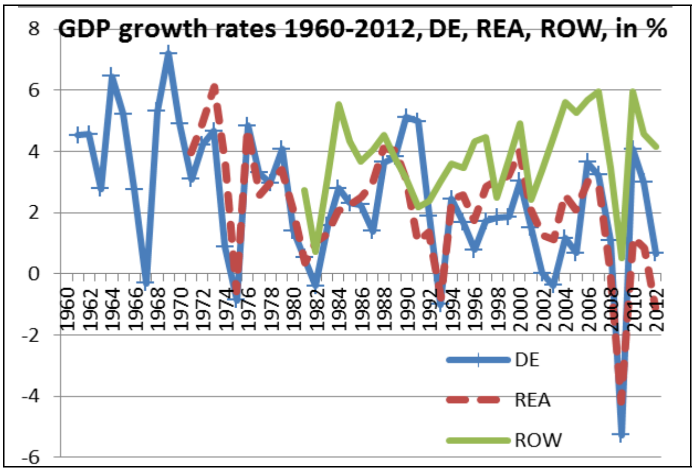
Long run data on DE CA, NX: 1960-2012 (AMECO)

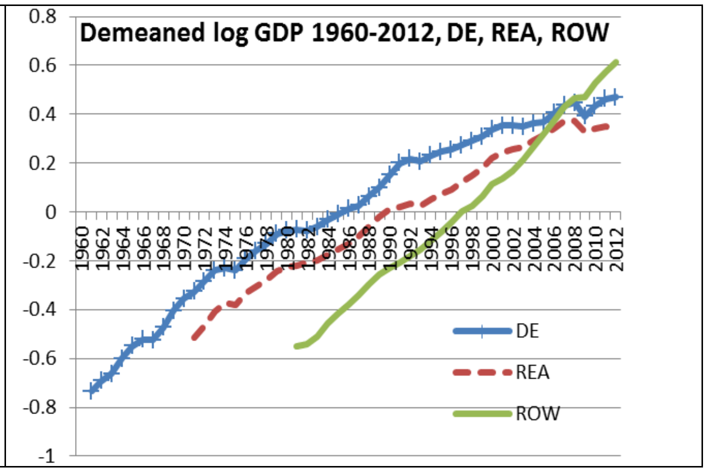


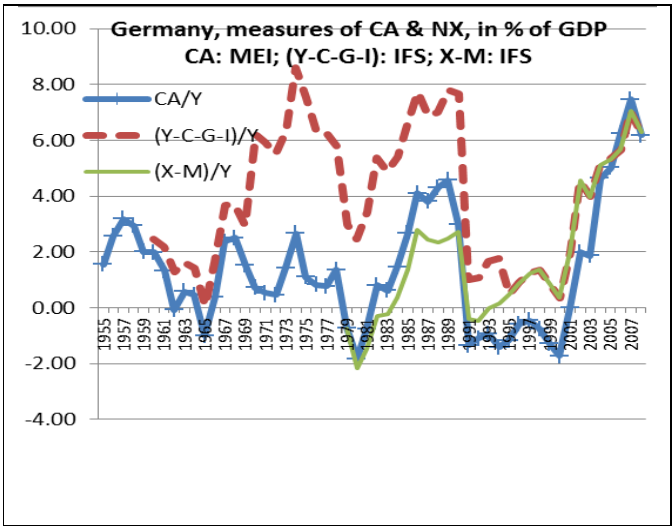


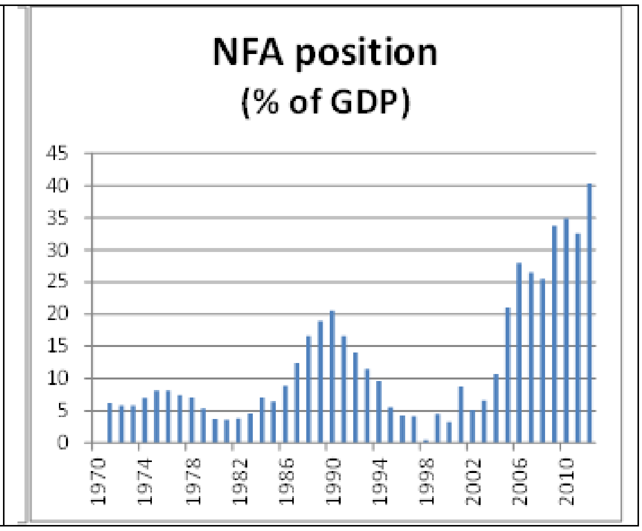









Germany, measures of CA & NX, in % of GDP
CA: MEI; (Y-C-G-I): IFS; X-M: IFS
CA/Y
(Y-C-G-I)/Y
(X-M)/Y


NFA position
(% of GDP)

Not for Publication Appendix: Detailed model description and econometric methodology

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

We consider an open economy that faces exogenous foreign interest rates, world prices and world demand. Domestic firms produce a continuum of differentiated goods. The goods produced by domestic firms are imperfect substitutes for the goods produced abroad. There are three production sectors: a sector producing final goods, a sector producing investment goods and a construction sector.

We distinguish between Ricardian and credit-constrained households. Ricardian households have full access to financial markets. They engage in international financial markets and there is near perfect international capital mobility. Credit-constrained households borrow from Ricardian households and face a collateral constraint on their borrowing.

The economy is part of monetary union with policy interest rates determined on the basis of monetary union aggregates. There is a fiscal authority in the home country which follows rule-based stabilization policies. The behavioral relationships and technology can be subject to autocorrelated shocks denoted by U_t^k, where *k* stands for the type of shock. The logarithm of $u_t^k \equiv \ln U_t^k$ will generally follow an AR(1) process with autocorrelation coefficient ρ^k and innovation ε_t^k.[1]

A.1. Firms

A.1.1. Final goods producers

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

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

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

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

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

The parameter $\theta > 1$ determines the degree of substitutability between different types of labour. Firms also decide about the degree of capacity utilization ($ucap_t^j$). There is an economy-wide labour-augmenting productivity shock u_t^Y 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 firms *j*:

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

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

The objective of the firm is to maximize profits $\Pr_t$:

(4) $$\Pr_t^j = p_t^j Y_t^j - w_t L_t^j - i_t^K p_t^C K_t^j - (adj^P(P_t^j) + adj^L(L_t^j) + adj^{ucap}(ucap_t^j)),$$

where $i_t^K = i_t^r + rpk + u_t^{rpk}$ is the rental rate of capital, which equals the borrowing rate of Ricardian consumers (i_t^r) plus an equity premium (rpk) and a stochastic shock to the perceived investment risk (u_t^{rpk}). 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_t^C).

The firms face technological and regulatory constraints that restrict the price setting, employment and capacity utilization decisions. Price adjustment costs adj^P 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:

(5) $$\begin{aligned} &adj^L(L_t^j) = 0.5\gamma_L \Delta L_t^{j2} w_t \\ &adj^P(P_t^j) = 0.5\gamma_P (P_t^j / P_{t-1}^j - 1)^2 P_{t-1}^j \\ &adj^{ucap}(ucap_t^j) = p_t^C K_t \left(\gamma_{ucap,1}(ucap_t^j - 1) + \gamma_{ucap,2}(ucap_t^j - 1)^2\right) \end{aligned}.$$

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:

(6) $$\begin{aligned} &\varepsilon_t^j (1 - t_t^K)(1-\alpha) Y_t^j / (p_t^C K_t^j) + t_t^K \delta^K \\ &= q_t^j - (1 - i_t^K - \delta^K) E_t q_{t+1}^j + (1 - t_t^K)\left(\gamma_{ucap,1}(ucap_t^j - 1) + \gamma_{ucap,2}(ucap_t^j - 1)^2\right) \end{aligned}$$

(7) $$w_t (1 + u_t^w) = \varepsilon_t^j \alpha Y_t^j / L_t^j - \gamma_L \Delta L_t^j w_t + \gamma_L / (1 + r_t^r) E_t (\Delta L_{t+1}^j w_{t+1})$$

(8) $$\varepsilon_t^j (1-\alpha) Y_t^j / (p_t^C K_t^j) = \left(\gamma_{ucap,1} + 2\gamma_{ucap,2}(ucap_t^j - 1)\right) ucap_t^j$$

(9) $$\varepsilon_t^j = 1 - (1/\eta + u_t^\varepsilon) - \gamma_P \left(\beta^r (sfp E_t \pi_{t+1}^j + (1 - sfp)\pi_{t-1}^j) - \pi_t^j\right),$$

where β^r is the discount factor of Ricardian households that own the firms, δ^K is the rate of capital depreciation, t_t^K is the tax on corporate revenue, w_t is the real wage, ε_t^j is the inverse of the price mark-up, sfp is the degree of forward-looking behavior among price setters in forming inflation expectations and $r_t^r \equiv i_t^r - E_t \pi_{t+1}$ 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_t^L sold by (Ricardian) households and final goods J_t^{Con} to produce new houses with a CES technology:

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

The firms in the residential construction sector are monopolistically competitive and face quadratic adjustment costs for house prices P_t^H:

(11) $adj^{Ph}(P_t^H) = 0.5\gamma_{Ph}(P_t^H / P_{t-1}^H - 1)^2 P_{t-1}^H$.

The first-order conditions for the pricing of construction services, and houses are:

(12) $p_t^{Con} = 1 + u_t^{Con} + \gamma_{Pcon}\left(\beta^r(sfpconE_t\pi_{t+1}^{Con} + (1-sfpcon)\pi_{t-1}^{Con}) - \pi_t^{Con}\right)$

(13) $\varepsilon_t^L = 1 - \gamma_{Pl}\left(\beta^r(sfplE_t\pi_{t+1}^L + (1-sfpl)\pi_{t-1}^L) - \pi_t^L\right)$

(14) $E_t(\varepsilon_{t+1}^L p_{t+1}^L)/(\varepsilon_t^L p_t^L) = 1 + i_t^l - g^L$

(15) $p_t^H = \left(1 + \gamma_{Ph}(\beta^r[sfphE_t\pi_{t+1}^H + (1-sfph)\pi_{t-1}^H] - \pi_t^H)\right)\left(s_L(p_t^L)^{1-\sigma_L} + (1-s_L)(p_t^{Con})^{1-\sigma_L}\right)^{1/(1-\sigma_L)}$

where the equilibrium return on land equals the Ricardian interest rate plus a risk premium $i_t^l = i_t^r + rpl + u_t^{rpl}$, γ_{Pcon}, γ_{Pl} and γ_{Ph} are construction, land and house price adjustment costs, $sfpcon$, $sfpl$ and $sfph$ are the degrees of forward-looking behavior in the formation of construction service, land and house price expectations, ε_t^L is the mark-up on land prices and g^L 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_t^{inp}, then real output of the investment goods sector is produced by the following linear production function:

(16) $J_t = J_t^{inp} U_t^{PI}$

where U_t^{PI} is a technology shock specific to the production technology for investment goods that follows a random walk $u_t^{PI} = u_{t-1}^{PI} + \varepsilon_t^{UPI}$.

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_t^i) and housing services (H_t^i) plus separable utility from leisure ($1 - L_t^i$). We also allow for habit persistence in consumption (h^C) and leisure (h^L). The temporal utility for household *i* is given by:

$$U(C_t^i, H_t^i, 1-L_t^i) =$$

(17) $$\ln\left(\left[\left(\frac{C_t^i - h^C C_{t-1}^i}{1-h^C}\right)^{\frac{\sigma_H - 1}{\sigma_H}} + (s_H^i)^{\frac{1}{\sigma_H}} H_t^{i\,\frac{\sigma_H-1}{\sigma_H}}\right]^{\frac{\sigma_H}{\sigma_H - 1}}\right) + e^{u_t^L}\vartheta(1 - PENS_t - L_t^h - h^L \Delta L_t^h)^{1-\kappa} .$$

where $PENS_t$ is the exogenous population share of retired persons. Ricardian and credit-constrained households supply differentiated labour services L_t^i 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_t^G) and bonds issued by other domestic and foreign households (B_t^r, B_t^F), 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_t^r). In addition, Ricardian households keep bank deposits (D_t^r) with return $i_t^{d,r} = i_t^r - \omega^{d,r}(C^r / D^r)^{\kappa_d}$.

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_t^j from final-goods producers, Pr_t^H from residential construction and Pr_t^B from banks.[2] All domestic firms are owned by domestic Ricardian households. The government taxes labour income and consumption at rates t_t^W and t_t^C, respectively, and pays the lump-sum transfers TR_t. The discount factor β^r is subject to random shocks U_t^β adding exogenous changes to the intertemporal consumption path.

The Lagrangian of this maximization problem is given by:

$$Max \quad V_0^r = \mathrm{E}_0 \sum_{t=0}^{\infty} U_t^\beta \beta^{r,t} U(C_t^r, 1-L_t^r, H_t^r)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{r,t} \begin{pmatrix} (1+t_t^C) p_t^C C_t^r + p_t^C I_t + p_t^H (1+t_t^C) I_t^{H,r} + B_t^G + B_t^r + D_t^r + rer_t B_t^F \\ +0.5\gamma_W \Delta W_t^2 / W_{t-1} - (1-t_t^W - ssc_t) w_t L_t^r - ((1-t_t^K) i_{t-1}^K + t_t^K \delta^K) p_{t-1}^C K_{t-1} \\ -(1+r_{t-1}^g) B_{t-1}^G - (1+r_{t-1}^c) B_{t-1}^r - (1+r_{t-1}^{d,r}) D_{t-1}^r - (1+r_{t-1}^r) rer_t B_{t-1}^F - p_t^L J_t^L \\ -\sum_{j=1} \mathrm{Pr}_t^j - \mathrm{Pr}_t^H - \mathrm{Pr}_t^B - TR_t - BEN_t (1 - PENS_t - NPART_t - L_t^r) \end{pmatrix}$$

(18) $$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t^r \beta^{r,t} \left(K_t - J_t - (1-\delta^K) K_{t-1} \right)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t^r \beta^{r,t} \left(H_t^r - J_t^{H,r} - (1-\delta^H) H_{t-1}^r \right)$$

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \xi_t^r \beta^{r,t} \left(Land_t + J_t^L - (1+g_t^L) Land_{t-1} \right)$$

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 , $I_t^{H,r}$) and physical investment (J_t , $J_t^{H,r}$). Investment expenditure of Ricardian households including adjustment costs is given by:

(19) $$I_t = J_t^r \left(1 + \frac{\gamma_K}{2} \left(\frac{J_t}{K_{t-1}} - \delta^K \right)^2 K_{t-1} \right) + \frac{\gamma_J}{2} (\Delta J_t)^2$$

(20) $$I_t^{H,r} = J_t^{H,r} \left(1 + \frac{\gamma_H}{2} \left(\frac{J_t^{H,r}}{H_{t-1}^r} - \delta^H \right)^2 H_{t-1}^r \right) + \frac{\gamma_{Jh}}{2} (\Delta J_t^{H,r})^2$$

The stock of capital per efficient unit evolves according to:

(21) $$K_t = J_t + (1 - \delta^K - g^{POP} - g^{TFP}) K_{t-1},$$

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:

[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.

(22) $H_t^r = J_t^{H,r} + (1-\delta^H - g^{POP} - g^{TFP}) H_{t-1}^r$.

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

(23) $i_t^r = i_t^{EA} - rpe\left(B_t^F / (P_t Y_t) - bwy^T\right) + u_t^{rpe}$.

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) $U_t^{\beta} \beta^r E_t U_{C,t+1}^r / U_{C,t}^r = 1/(1 + i_t^r - E_t \pi_{t+1}^C)$

(25) $U_{C,t}^r = (1 + t_t^C) p_t^C \lambda_t^r$

(26) $q_t^{H,r} = (p_t^C / U_{C,t}^r)/(p_t^H / U_{H,t}^r) + \gamma_H \left(1 - \delta^H - (i_t^r - E_t \pi_{t+1}^H - u_t^{rph})\right) E_t q_{t+1}^{H,r}$

(27) $q_t^{H,r} - 1 = \gamma_H (J_t^{H,r} / H_{t-1}^r - \delta^H - g^{POP} - g^{TFP}) + \gamma_{Jh} \Delta J_t^{H,r} - \beta^r \gamma_{Jh} E_t \Delta J_{t+1}^{H,r}$

(28) $q_t - 1 = \gamma_K (J_t / K_{t-1} - \delta^K - g^{POP} - g^{TFP}) + \gamma_J \Delta J_t - \beta^r \gamma_J E_t \Delta J_{t+1}$

A.2.2 Credit constrained households

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

(29)
$$\begin{aligned} &Max \quad V_0^c = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{c,t} U(C_t^c, 1-L_t^c, H_t^c) \\ &-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{c,t} \begin{pmatrix} (1+t_t^C) p_t^C C_t^c + p_t^H (1+t_t^H) I_t^{H,c} + (1 + r_{t-1}^c - g^{POP} - g^{TFP}) B_{t-1}^c + D_t^c + 0.5 \gamma_W \Delta W_t^2 / W_{t-1} \\ -B_t^c - (1 + r_{t-1}^{d,c}) D_{t-1}^c - (1 - t_t^W - ssc_t) w_t L_t^c - BEN_t (1 - PENS_t - NPART_t - L_t^c) - TR_t \end{pmatrix}. \\ &-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \xi_t^c \beta^{c,t} \left(H_t^c - J_t^{H,c} - (1-\delta^H) H_{t-1}^c\right) - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t^c \beta^{c,t} \left((1 + r_t^c) B_t^c - \chi_t^c p_t^H H_{t-1}^c\right) \end{aligned}$$

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 $\chi_t^c = \chi^c + u_t^{\chi}$. It increases the shadow price of borrowing as determined by the Lagrange multiplier ψ_t^c of the collateral constraint. The real interest rate on credit-constrained debt is $r_t^c = i_t^c - E_t \pi_{t+1}$ with $i_t^c = (1 - s^d) i_t^r + s^d i_t^{d,r}$ and s^d as 1 minus the capital requirement, whereas deposits D_t^c pay the return $r_t^{d,c} = i_t^{d,c} - E_t \pi_{t+1}$ with $i_t^{d,c} = i_t^c - \omega^{d,c} (C^c / D^c)^{\kappa_d}$.

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

(30) $$I_t^{H,c} = J_t^{H,c} \left(1 + \frac{\gamma_H}{2} \left(\frac{J_t^{H,c}}{H_{t-1}^c} - \delta^H\right)^2 H_{t-1}^c\right) + \frac{\gamma_{Jh}}{2} (\Delta J_t^{H,c})^2$$

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

(31) $H_t^c = J_t^{H,c} + (1 - \delta^H - g^{POP} - g^{TFP}) H_{t-1}^c$.

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

(32) $(1 + t_t^C) p_t^C \lambda_t^c = U_{C,t}^c$

$$(33)\quad \begin{aligned}&1-\beta^r(1+i_t^c-E_t\pi_{t+1}-g^{POP}+g^{TFP})\psi_t\\ &=U_t^\beta\beta^c\frac{E_t\lambda_{t+1}^c}{\lambda_t^c}\frac{1+i_t^c-E_t\pi_{t+1}-\beta^r(1+i_t^c-E_t\pi_{t+1}-g^{POP}-g^{TFP})\rho^{d,c}E_t\psi_{t+1}}{1+g^{POP}+g^{TFP}}\end{aligned}$$

$$(34)\quad \begin{aligned}&q_t^{H,c}-1=\gamma_H(J_t^{H,c}/H_{t-1}^c-\delta^H-g^{POP}-g^{TFP})+\gamma_{Jh}\Delta J_t^{H,c}\\ &-\frac{\gamma_{Jh}(1-(1+i_t^c-E_t\pi_{t+1}-g^{POP}-g^{TFP})/\beta^r\psi_t)E_t\Delta J_{t+1}^{H,c}}{1+i_t^c\text{-E}_t\pi_{t+1}^H+\text{u}_t^{rph}-(1+i_t^c-E_t\pi_{t+1}-g^{POP}-g^{TFP})/\beta^r\rho^{d,c}E_t\psi_{t+1}}\end{aligned}$$

$$(35)\quad \begin{aligned}&q_t^{H,c}=\frac{p_t^C}{p_t^H}\frac{U_{H,t}^c}{U_{C,t}^c}+(1-\rho^{d,c})\psi_t(1-\chi_t^c)(1+E_t\pi_{t+1}^H)\\ &+\frac{(1-(1+i_t^c-E_t\pi_{t+1}-g^{POP}-g^{TFP})/\beta^r\psi_t)(1-\delta^H+E_t\pi_{t+1}^H)E_tq_{t+1}^{H,c}}{1+i_t\text{-E}_t\pi_{t+1}^H+\text{u}_t^{rph}-(1+i_t^c-E_t\pi_{t+1}-g^{POP}-g^{TFP})/\beta^r\rho^{d,c}E_t\psi_{t+1}}\end{aligned}$$

The non-fundamental shock to housing investment u_t^{rph} 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 leisure to a weighted average of the marginal utility of consumption times the real wage adjusted for a wage mark-up:

$$(36)\quad \begin{aligned}&\left(\frac{s^rU_{1-L,t}^r+(1-s^r)U_{1-L,t}^c}{(1-s^r)\lambda_t^c+s^r\lambda_t^r}\right)^{1-\rho^w}\left((1-\frac{1}{\theta})\left((1-t_{t-1}^W-ssc_{t-1})w_{t-1}-BEN_{t-1}\right)\right)^{\rho^w}\\ &=(1-\frac{1}{\theta})\left((1-t_t^W-ssc_t)w_t-BEN_t\right)+\frac{\gamma_W}{\theta}w_t\left(\pi_t^W-(1-sfw)\pi_{t-1}\right)-\beta^r\frac{\gamma_W}{\theta}w_t\left(\pi_{t+1}^W-(1-sfw)\pi_t\right)\end{aligned}$$

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:

$$(37)\quad adj^W(W_t)=0.5\gamma_W(W_t/W_{t-1}-1)^2W_{t-1}\ .$$

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 ρ^w. The unit labour costs in the economy are $ULC_t\equiv w_tL_t/Y_t$, which equals the wage share in total domestic income.

A.2.4. The labour market and effects of ‘Hartz’ labor market reforms

This Section describes the labour market in the QUEST model and shows how the labour market shocks (wage mark up shock and the Hartz reform) are implemented.

We assume there is a continuum of households $i\in(0,1)$ and household i offers type of labour i which is an imperfect substitute for labour offered by other households. The elasticity of substitution is given by θ and household i is faced with a demand function for labour

(1) $L(i) = \left(\frac{w(i)}{w}\right)^{-\theta} L$, with $\theta > 1$

The household maximises a utility function over consumption and leisure. The total time/number of persons available to the household is normalised to one. There is a social security system which provides 'unemployment' benefits to a sub group of household members which are eligible for these benefits (i. e. pensioners, children and non working age participants) The group of non-eligible benefit receivers is denoted by np . The remaining non working household members are entitled to unemployment benefits. It is further assumed that benefits are indexed to w_i : $ben = b_0 w(i)$

(2) $$\underset{(C(i),w(i))}{Max} \quad U(C(i), 1-\left(\frac{w(i)}{w}\right)^{-\theta} L) - \lambda(C(i) - \frac{w(i)}{P}\left(\frac{w(i)}{w}\right)^{-\theta} L - (1-np-b_0 \frac{w(i)}{P}\left(\frac{w(i)}{w}\right)^{-\theta} L)$$

(3) $$U_c - \lambda = 0$$

(4) $$U_{(1-L)}(-1)(-\theta)w(i)^{-\theta-1}\frac{L}{w^{-\theta}} + \lambda\frac{1}{P}(1-\theta)w(i)^{-\theta}\frac{L}{w^{-\theta}} - \lambda\frac{1}{P}(1-\theta)b_0 w(i)^{-\theta}\frac{L}{w^{-\theta}} = 0$$

Using these two FOCs we can derive the following labour supply rule

(5) $$\frac{U_{1-L}}{U_c}\left(\frac{-\theta}{1-\theta}\right) = \frac{w}{P}(1-b_0)$$

The term $\left(\frac{-\theta}{1-\theta}\right)$ can be interpreted as a wage mark up. This term goes to one as labour types become perfectly substitutable. Both the wage mark up and the benefit replacement rate drive a wedge between the real wage and the elasticity of substitution between consumption and leisure.

A. 3 Trade and the current account

In order to facilitate aggregation we assume that households, investment goods producers and the government have identical preferences across goods used for private consumption, public expenditure and investment. Let $Z^i \in \left\{C^i, I^i, C^G, I^G\right\}$ be demand by an individual household, investment good producer or the government. Then their preferences are given by the utility function:

(38) $$Z^i = \left((s^d - u_t^M)^{\frac{1}{\sigma_M}} Z^{d\,i\,\frac{\sigma_M - 1}{\sigma_M}} + (1 - s^d + u_t^M)^{\frac{1}{\sigma_M}} Z^{f\,i\,\frac{\sigma_M - 1}{\sigma_M}} \right)^{\sigma_M/(\sigma_M - 1)}$$

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

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

(39) $$p_t^X = 1/\left(1 - u_t^{PX} - \gamma_{Px}\beta^r(sfpxE_t\pi_{t+1}^X + (1-sfpx)\pi_{t-1}^X - \pi_t^X)\right),$$

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

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

(40) $$p_t^M / p_t^W = 1/\left(1-u_t^{PM} - \gamma_{Pm}\beta^r (sfpmE_t\pi_{t+1}^M + (1-sfpm)\pi_{t-1}^M - \pi_t^M)\right),$$

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

The demand for exports allows for some inertia in demand adjustment (ρ_X) and is given by:

(41) $$X_t = (1-s^d + u_t^X)(p_t^X / p_t^W)^{-\sigma_X} X_t^W (E_t X_{t+1}^{sfx} X_{t-1}^{1-sfx} / X_t)^{\rho_X}$$

Similarly, import demand includes some inertia (ρ_M) and follows:

(42) $$M_t = (1-s^d + u_t^M)(p_t^M / p_t^C)^{-\sigma_M} \left(C_t + I_t + \frac{p_t^G}{p_t^C} G_t + \frac{p_t^{Con}}{p_t^C}(I_t^G + J_t^{Con}) \right) (E_t M_{t+1}^{sfim} M_{t-1}^{1-sfim} / M_t)^{\rho_M}.$$

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:

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

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

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:

(44) $$c_t^G - \overline{c^G} = \tau_{Lag}^{CG}(c_{t-1}^G - \overline{c^G}) - \tau^{CGDEF}(\Delta B_t / (Y_t P_t) - def^T) + u_t^{CG}$$

(45) $$i_t^G - \overline{i^G} = \tau_{Lag}^{IG}(i_{t-1}^G - \overline{i^G}) - \tau^{IGDEF}(\Delta B_t / (Y_t P_t) - def^T) + u_t^{IG},$$

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 b^U and b^R. Transfers may react to the debt-to-GDP ratio and the government deficit, where b^T is the government debt target:

(46) $$tr_t = b^R w_t PENS_t - \tau^{TRB}\left(B_{t-1}^G / (Y_{t-1}P_{t-1}) - b^T\right) - \tau^{TRDEF}\left(\Delta B_t^G / (Y_t P_t) - def^T\right) + u_t^{TR}.$$

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

(47) $$KG_t = I_t^G + (1 - \delta^G - g^{POP} - g^{TFP}) KG_{t-1}.$$

The government revenue R_t^G consists of taxes on consumption, labour and corporate income:

(48) $$R_t^G = t_t^C p_t^C C_t + t_t^C p_t^H I_t^H + (ssc_t + t_t^W) w_t L_t + t_t^K (Y_t - w_t L_t - \delta^K p_t^C K_t).$$

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

(49) $$t_t^w = \tau_0^w Y_t^{\tau_1^w}$$

where τ_0^w measures the average tax rate and τ_1^w the degree of progressivity. A simple first-order Taylor expansion around the steady-state growth rate yields:

(50) $$t_t^w = \tau_0^w + \tau_0^w \tau_1^w (\sum_{i=0}^{3} \Delta y_{t-i} - 4\overline{\Delta y})$$

Government debt (B_t) evolves according to:

(51) $$\begin{aligned} B_t^G &= (1 + i_{t-1}^g - \pi_{t-1}) / (1 + g^{POP} + g^{TFP}) B_{t-1}^G \\ &+ p_t^G C_t^G + p_t^H I_t^G + BEN_t (1 - PENS_t - NPART_t - L_t) + TR_t - R_t^G \end{aligned},$$

where i_t^g 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_t^{rpb}:

(52) $$i_t^g = \rho^g i_{t-1}^g + (1-\rho^g)(i_t^{EA} + rpb_t + u_t^{rpb}).$$

The systematic part of the sovereign risk premium $rpb_t = rpb + rpdebt(B_{t-1}^G / (4Y_{t-1}) - b^T)$ 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 $P_t^C / P_t^G = U_t^{PG}$.

Monetary policy is modeled as being exogenous with interest rates i_t^{EA} set by the ECB. In the years prior to EMU, the differential between the policy rate in Germany and the synthetic EA-average rate was eliminated gradually. We define a monetary policy shock from the perspective of the German economy as the deviation of i_t^{EA} from a synthetic interest rate determined by a Taylor rule for Germany, which responds to consumer price inflation and the annual growth rate of output:

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

and where the weights are based on the estimates for the euro area by Ratto et al. (2009).

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:

(54) $$Y_t = p_t^C (C_t + J_t) + p_t^{Con} (J_t^{Con} + I_t^G) + p_t^G C_t^G + p_t^X X_t - p_t^M M_t$$

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^r and $1 - s^r$:

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

Similarly, total housing investment is defined as:

(56) $$J_t^H = s^r J_t^{H,r} + (1-s^r) J_t^{H,c}$$

and equilibrium in the labour market is given by:

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

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

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

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

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

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

(60) $$i_t^r - i_t^{d,r} = \alpha_g (D_t - s^d (1-s^r) B_r^c)$$

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

(61) $$p_t^C = U_t^{PC}\left((s^d - u_t^M) + (1 - s^d + u_t^M)(p_t^M)^{1-\sigma_M}\right)^{1/(1-\sigma_M)}$$

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

MODEL ESTIMATION

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. A more detailed description of the data sources is given in an appendix.

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.

WE IMPOSE THE TARGET OF 60% OF GDP FOR GOVERNMENT DEBT, WHICH IS CLOSE TO THE SAMPLE AVERAGE. THIS TARGET IMPLIES, GIVEN THE NOMINAL GROWTH RATE IN THE STEADY STATE, A DEFICIT TARGET OF 1.8% OF GDP. THE AVERAGE MATURITY STRUCTURE OF SOVEREIGN DEBT IS SET AT 5 YEARS. TAX AND REPLACEMENT RATES ARE CALIBRATED ON SAMPLE AVERAGES. FOR THE CONSTRUCTION OF THE MONETARY POLICY SHOCK, TAYLOR RULE COEFFICIENTS ARE IMPOSED BASED ON ESTIMATES FOR THE EURO AREA (RATTO ET AL., 2009). BASED ON THE WHOLE SAMPLE, THE QUARTERLY GDP TREND GROWTH RATE WAS SET TO 0.27%, WHILE THE INFLATION TREND GROWTH RATE IS SET TO 0.5%. CREDIT-CONSTRAINED HOUSEHOLDS ARE CALIBRATED WITH A HIGH RATE OF TIME PREFERENCE OF 4% QUARTERLY, WHILE THE DISCOUNT RATE FOR NON-CONSTRAINED HOUSEHOLDS IS ESTIMATED (SEE BELOW).

Table 1 Calibrated structural parameters

Parameter name	Symbol	Calibrated value
Elasticity of output w.r.t. capital	$1-\alpha$	0.38
Elasticity of output w.r.t. public capital	$1-\alpha_G$	0.10
Steady-state wage share	$\overline{wL/Y}$	0.59
Steady state employment	$\overline{L}$	0.48
Population share of pensioners	$PENS$	0.325
Population share of non-participation	$NPART$	0.178
Capital depreciation rate	δ^K	0.025
Public capital depreciation rate	δ^G	0.0125
Housing depreciation rate	δ^H	0.01
Risk premium on capital	rpk	0.037
Steady-state share of private investment	$\overline{I/Y}$	0.13
Price mark-up	$1/\eta$	0.05
Habit persistence in labour	h^l	9
Utility weight of leisure	ϑ	0.014
Ricardian utility share of housing	s_H^r	3.169
Credit-constrained utility share of housing	s_H^c	4.248
Credit-constrained rate of time preference	$1/\beta^c-1$	0.04
Country risk premium	rpe	0.002
NFA-to-GDP target	bwy^T	0
Government debt-to-GDP target	b^T	0.60
Government deficit-to-GDP target	def^T	-0.018
Interest persistence on government debt	ρ^B	0.95
Risk premium on government debt	rpb	0.004
Capital requirement ratio	$1-s^d$	0.1
Elasticity parameter for deposit rate spread	α_d	0.9
Interest elasticity of deposits	κ_d	0.1
Scaling factor credit-constrained deposits	$\omega^{d,c}$	0.0022
Scaling factor Ricardian deposits	$\omega^{d,r}$	0.0022
Social security contributions	ssc	0.17
Average labour tax rate	τ_0^W	0.20
Progressivity of labour tax	τ_1^W	0.80
Unemployment benefit replacement rate	b^U	0.39
Pension replacement rate	b^R	0.42
Consumption tax	t_t^C	0.19
Corporate income tax	t_t^K	0.19
Steady-state share of government consumption	$\overline{C^G/Y}$	0.19
Steady-state share of government investment	$\overline{I^G/Y}$	0.03
Persistence of government consumption	τ_{Lag}^{CG}	0.99
Persistence of government investment	τ_{Lag}^{IG}	0.99

Linear capacity utilization adjustment costs	$\gamma_{ucap,1}$	0.074
Land price adjustment costs	γ_{PLand}	0
EA rate of time preference	$1/\beta^{EA,r}-1$	0.001
EA monetary policy persistence	τ^{M}_{lag}	0.90
EA monetary policy response to inflation	τ^{M}_{π}	1.50
EA monetary policy response to GDP growth	τ^{M}_{y}	0.40
Target inflation	π^{T}	0.005
Trend population growth	g^{POP}	0.0002
Trend TFP growth	g^{TFP}	0.0025

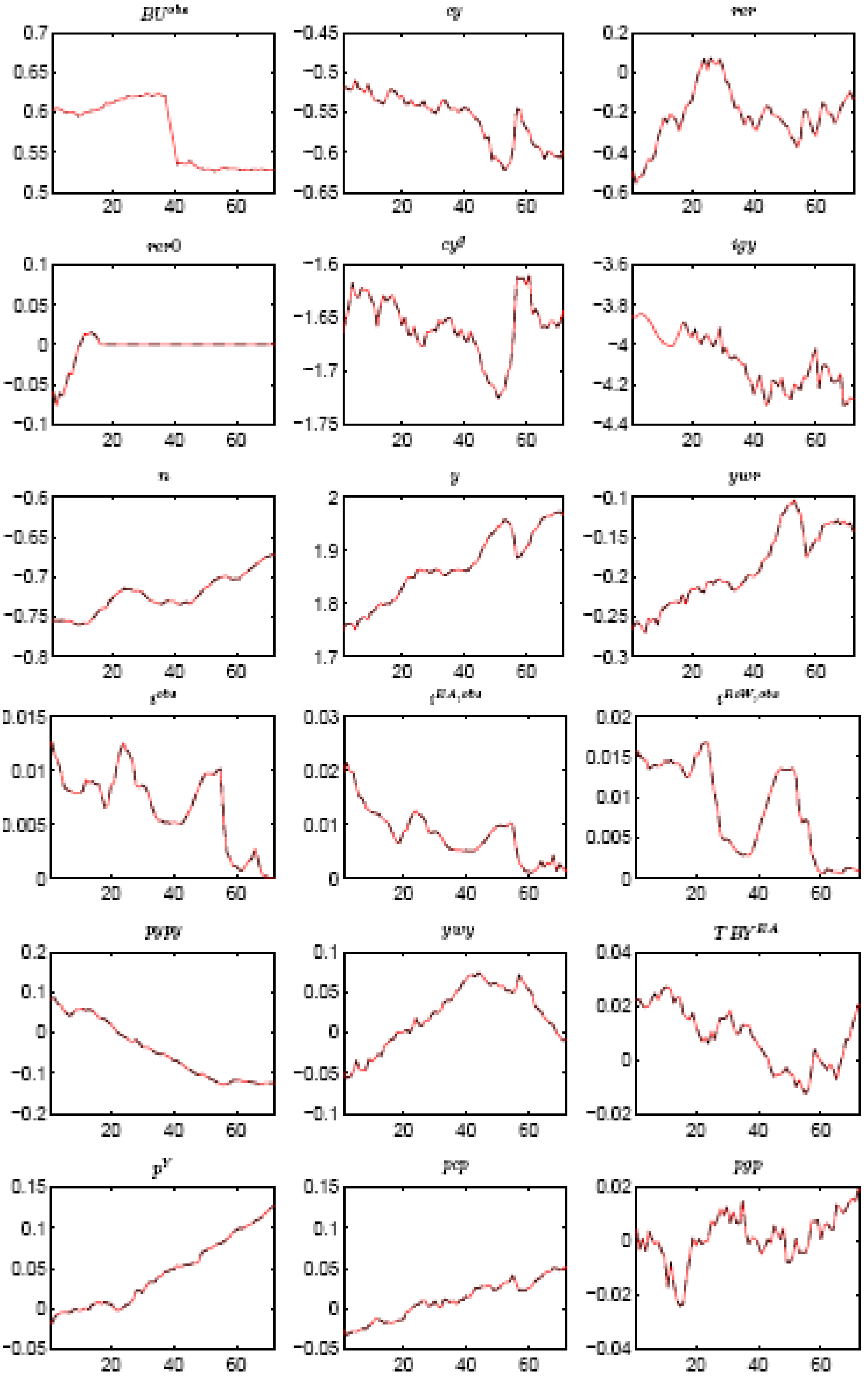
The estimation results of the structural parameters are summarized in Table 2. The population share of Ricardian households s^r is estimated at 0.37, implying the share of credit-constrained households of 0.63. Concerning consumption, the intertemporal elasticity of substitution is set to one, habit persistence h is estimated to be 0.90, and the substitution elasticity for housing services σ_H is estimated at 0.28. The discount factor for German households β^r is estimated close to 1.00, reflecting a lower propensity to consume than for the rest of the euro area. The estimate for rpe implies a highly inelastic interest rate w.r.t the NFA position, i.e. a decline in the risk premium of only 0.2 basis points on annual basis for every 1 percentage points NFA increase. This low estimate reflects the decline in country risk premia in EMU over the sample period. The loan-to-value ratio is estimated to be rather low (0.33). It reflects the relatively low indebtedness of German households. Fiscal policy contains a debt- and deficit-stabilising response in government consumption, government investment and transfers. While the price elasticity of export demand is estimated to be relatively high (2.3), the price elasticity of import demand is rather low (0.8). The estimated shares of forward-looking behavior in price indexation are fairly high.

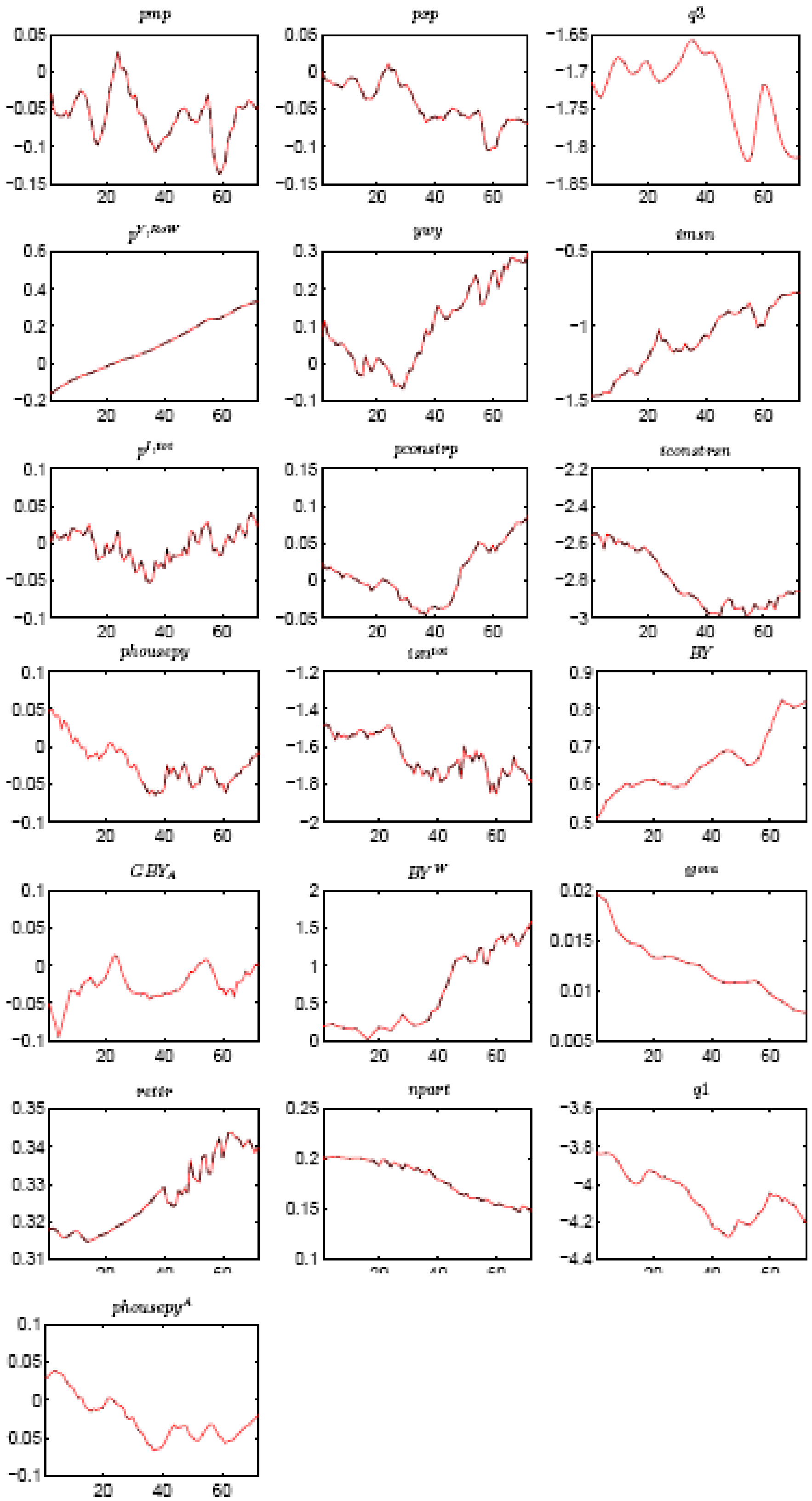
Table 2 Estimation results for structural parameters

Parameter name	Symbol	Prior distribution	Prior mean	Prior s.d.	Posterior mean	Posterior s.d.
Habit persistence in consumption	h	Beta	0.7	0.1	0.896683	0.023001
Inverse of elasticity of labour supply	κ	Gamma	1	0.4	1.259776	0.375891
Share of Ricardian households	s^r	Beta	0.35	0.15	0.371182	0.096053
Ricardian rate of time preference	$1/\beta^r-1$	Beta	0.0005	0.0002	0.000151	0
Real wage persistence	γ^w	Beta	0.5	0.2	0.524074	0.227863
Consumption home bias	s^h	Beta	0.65	0.06	0.753774	0.020333
Export price elasticity	σ_X	Gamma	1.25	0.5	2.344127	0.435826
Import price elasticity	σ_M	Gamma	1.25	0.5	0.807881	0.258332
Price elasticity of house demand	σ_H	Gamma	0.5	0.1	0.278233	0.085621
Price elasticity of land demand	σ_L	Beta	0.5	0.2	0.644894	0.088788
Steady-state share of land	s_L	Beta	0.3	0.1	0.108519	0.009041
Loan-to-value ratio	χ^c	Beta	0.5	0.2	0.327439	0.101707
Persistence in credit-constrained debt	$\rho^{d,c}$	Beta	0.5	0.2	0.955911	0.011
Inverse of wage mark-up	θ	Gamma	1.6	0.3	1.433547	0.206991
Country risk premium	rpe	Beta	0.0025	0.001	0.000479	6.45E-05
Government debt risk premium	$rpdebt$	Beta	0.003	0.0012	0.002869	0.001586
Goods price adjustment costs	γ_P	Beta	4	2	7.663067	1.13692

Export price adjustment costs	γ_{Px}	Gamma	30	20	5.724531	4.259538
Import price adjustment costs	γ_{Pm}	Gamma	30	20	1.642972	0.551849
House price adjustment costs	γ_{Ph}	Gamma	30	20	17.53806	9.745194
Construction price adjustment costs	γ_{Pcon}	Gamma	30	20	0.622073	0.391767
Wage adjustment costs	γ_{W}	Gamma	12	4	10.7406	3.548723
Capacity utilization adjustment costs	$\gamma_{ucap,2}$	Gamma	0.02	0.008	0.009586	0.003311
Capital stock adjustment costs	γ_{K}	Gamma	30	20	25.52059	9.446204
Investment adjustment costs	γ_{J}	Gamma	15	10	1.070704	0.883884
Housing stock adjustment costs	γ_{H}	Gamma	30	20	74.85312	52.56809
Housing investment adjustment costs	γ_{Jh}	Gamma	30	20	113.2267	32.0011
Employment adjustment costs	γ_{L}	Gamma	30	20	55.53046	11.6304
Export adjustment costs	γ_{X}	Gamma	15	10	2.711088	1.997343
Import adjustment costs	γ_{M}	Gamma	15	10	0.803956	1.077855
Forward-looking in goods pricing	sfp	Beta	0.7	0.1	0.956799	0.02877
Forward-looking in export pricing	$sfpx$	Beta	0.7	0.1	0.865849	0.086543
Forward-looking in import pricing	$sfpm$	Beta	0.7	0.1	0.768072	0.109143
Forward-looking in house pricing	$sfph$	Beta	0.7	0.1	0.934314	0.043712
Forward-looking in construction pricing	$sfpconstr$	Beta	0.7	0.1	0.73415	0.148016
Forward-looking in wage setting	sfw	Beta	0.7	0.1	0.900461	0.065751
Forward-looking in exports	sfx	Beta	0.5	0.2	0.798391	0.100279
Forward-looking in imports	sfm	Beta	0.5	0.2	0.816167	0.156907
Deficit response of public consumption	τ^{CGDEF}	Gamma	0.2	0.1	0.034377	0.010039
Deficit response of public investment	τ^{IGDEF}	Gamma	0.5	0.3	0.007712	0.004375
Debt response of public transfers	τ^{TRB}	Beta	0.02	0.01	0.014929	0.009266
Deficit response of public transfers	τ^{TRDEF}	Beta	0.02	0.01	0.012691	0.008408

FIGURE A1 Data used in estimation

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