The Slow Recovery in the Euro Area*

Romanos Priftis†, Werner Roeger‡ and Jan in 't Veld§

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Preliminary Draft

Abstract

The slow recovery of the Euro area from the crisis since 2009 and persistently disappointing GDP growth figures have been accompanied by low inflation, a sharp fall in the investment and employment shares, stable consumption shares, and rising wage shares. We attempt to match these stylised facts with a structural macroeconomic model by examining the contributions of shocks related to declining TFP growth, higher risk premia associated with the financial and sovereign crises, fiscal policy and household deleveraging. We find that risk premia shocks in particular go a long way in explaining the recession but that only the decline in trend TFP growth can explain its prolonged nature and slow recovery.

JEL classification: E6, E32, F4, F47

Keywords: Business cycle, DSGE modelling, deleveraging, Euro area, growth slowdown, risk premia, simulation, TFP growth

* The views expressed in this paper are those of the authors and do not necessarily represent the views of the European Commission.

† DG Economic and Financial Affairs, European Commission, and European University Institute. romanos.priftis@ec.europa.eu

‡ DG Economic and Financial Affairs, European Commission. werner.roeger@ec.europa.eu

§ DG Economic and Financial Affairs, European Commission. jan.intveld@ec.europa.eu

1. INTRODUCTION

By now it is evident that the economic recovery after the onset of the Great Recession in 2009 has been very slow both in industrialised countries as well as in the Euro area in particular. In a recent study, Ball (2014) estimates an average output loss of 8.4% for a sample of OECD countries. Based on projections of the European Commission the output loss has been approximately 9% in the Euro area under the assumption that pre-crisis TFP, capital accumulation and employment trends would have continued. Following a financial crisis episode this in itself is not surprising, since there is by now ample evidence that output losses tend to be large and persistent after recessions (see e.g. Schularick and Taylor (2012)). However, the Euro area economy stands out since even in 2014, real GDP has not yet regained its pre-crisis peak, and the episode since 2009 has been characterised by a double dip recession and low inflation. By investigating further dimensions of the data we find that the slow recovery is also characterised by a persistent decline in investment and employment shares and an increase in the share of private consumption in GDP, an increase in the wage share and an increase in the current account to GDP ratio.

The aim of this paper is to attempt to match the subdued growth recovery of the Euro area, as well as the behaviour of other macroeconomic variables of interest through the lens of a structural macroeconomic model subjected to several shocks that we identify from the data as being relevant.

We proceed by focusing on various hypotheses. Those can be divided into demand and supply effects. Among the former we consider risk premia shocks associated with the financial and the sovereign debt crisis (uncertainty), fiscal policy shocks (a stimulus in 2009 followed by consolidations) as well as household deleveraging, that is adjustment to excess asset accumulation (residential investment). Among supply shocks we focus on the decline in trend TFP growth and the backward revision of overly optimistic pre-2009 trend TFP expectations. The demand factors are certainly playing an important role and are consistent with the stylised fact of low growth and low inflation. However, similar to Justiniano et al (2013) it is nevertheless difficult to generate a persistent decline in the growth rate even by assuming a high persistence in demand shocks.

We use a standard two-country model comprising of the Euro area (EA) and a rest of the world aggregate (RoW) with nominal frictions in prices and wages, a distinction of households into liquidity-constrained and Ricardian, an expanded fiscal sector with a role for productive government investment, as well as other features arising from rigorous microfoundations and that have been established as empirically relevant.

We look at two mechanisms which can possibly explain a more persistent decline of GDP, namely first, a sequence of unanticipated risk shocks in the EA, accounting the sovereign debt crisis in 2012/13 which followed the financial crisis in 2009 and, second, a slowdown of TFP growth which can be identified from looking at various vintages of potential growth estimates for the EA.

The results suggest that the TFP shocks we identify in the data, namely a permanent level shift in 2009 and a slowdown of TFP growth rates are in principle consistent with lower

growth and low inflation. Since the model predicts that households will adjust consumption rather rapidly in anticipation of expected lower future income growth, adverse supply shocks can generate low demand and prove to be deflationary. However, we require the selected shocks not only to match GDP growth and inflation since 2009, but also other observed trends such as a decline in the investment rate, an increase in the ratio of private consumption to GDP, an increase in the trade balance, a decline of the employment rate and an increase in the wage share

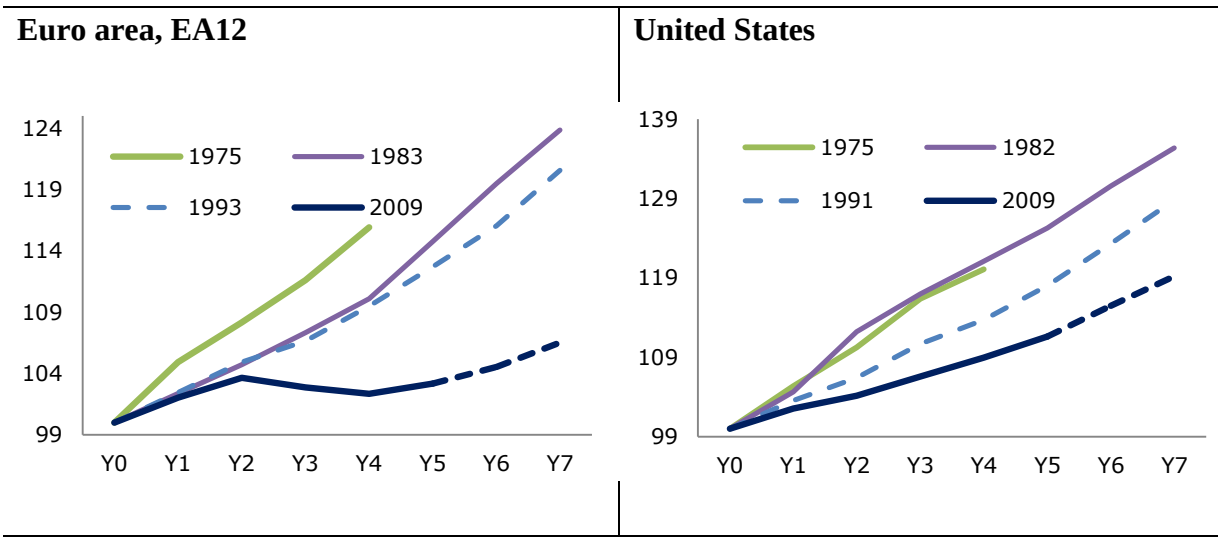
This remainder of the paper is organised as follows. In section 2 we first provide information about the nature of the (slow) recovery. In section 3 we present the variant of the European Commission´s QUEST model which we use for quantifying the impact of these shocks. Section 0 discusses the construction of shocks and their calibration. Section 5 presents the model-based outcomes for each individual shock and combined, and finally Section 6 concludes.

2. EVOLVING VIEWS ABOUT THE POST CRISIS SLUMP

In this section we document the severity of the post crisis slump. This can be best illustrated by comparing GDP growth since 2009 with previous recoveries from recessions.

As shown by Figure 1 and Figure 2 compared to previous recessions the recovery from the financial crisis of 2009 is exceptionally weak, this being especially true for the period since 2012. The double dip nature of the recession is also particular for the case of the EA. While output gaps are seen as very persistent, a substantial part of low growth is attributed to a decline of potential growth by standard procedures.

Figure 1: Recoveries after Major Recessions, real GDP (Y0=100)

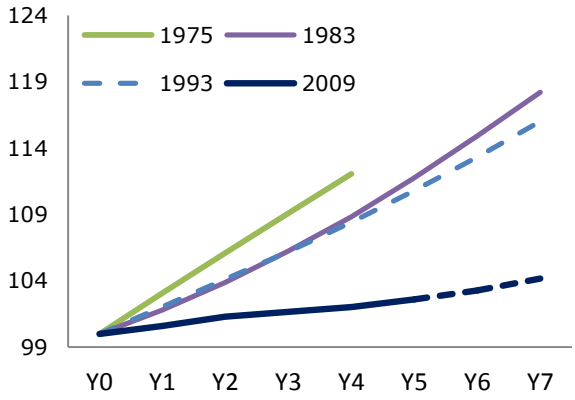


Note: Y0 marks the year of the cyclical trough as measured by ECFIN's output gap estimate. For the recovery after 2009, Y6 and Y7 are based on the Winter Forecast. EA 12 comprises of BE, DE, IE, EL, ES, FR, IT, LU, NL, AT, PT, FI.

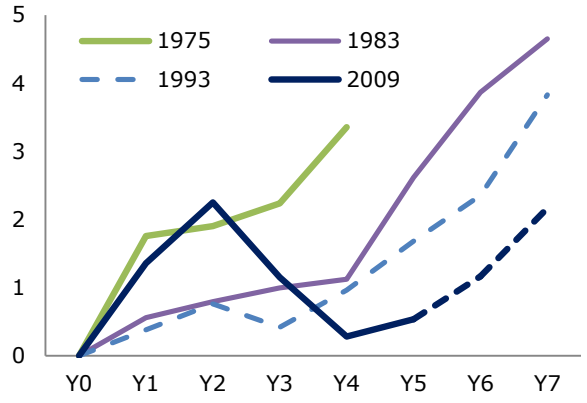
Source: AMECO. DG ECFIN calculations

Figure 2: Recoveries after Major Recessions, EA12

Potential output (Y0=100)



Output gap (in pp, rescaled so that



Note: Y0 marks the year of the cyclical trough as measured by ECFIN's output gap estimate. For the recovery after 2009, Y6 and Y7 are based on the Winter Forecast. EA 12 comprises of BE, DE, IE, EL, ES, FR, IT, LU, NL, AT, PT, FI.

Source: AMECO. DG ECFIN calculations

Though there exist differences about the size of the output gap and the magnitude of revisions a general tendency of reducing potential growth estimates can be observed from both the OECD and the European Commission[5].

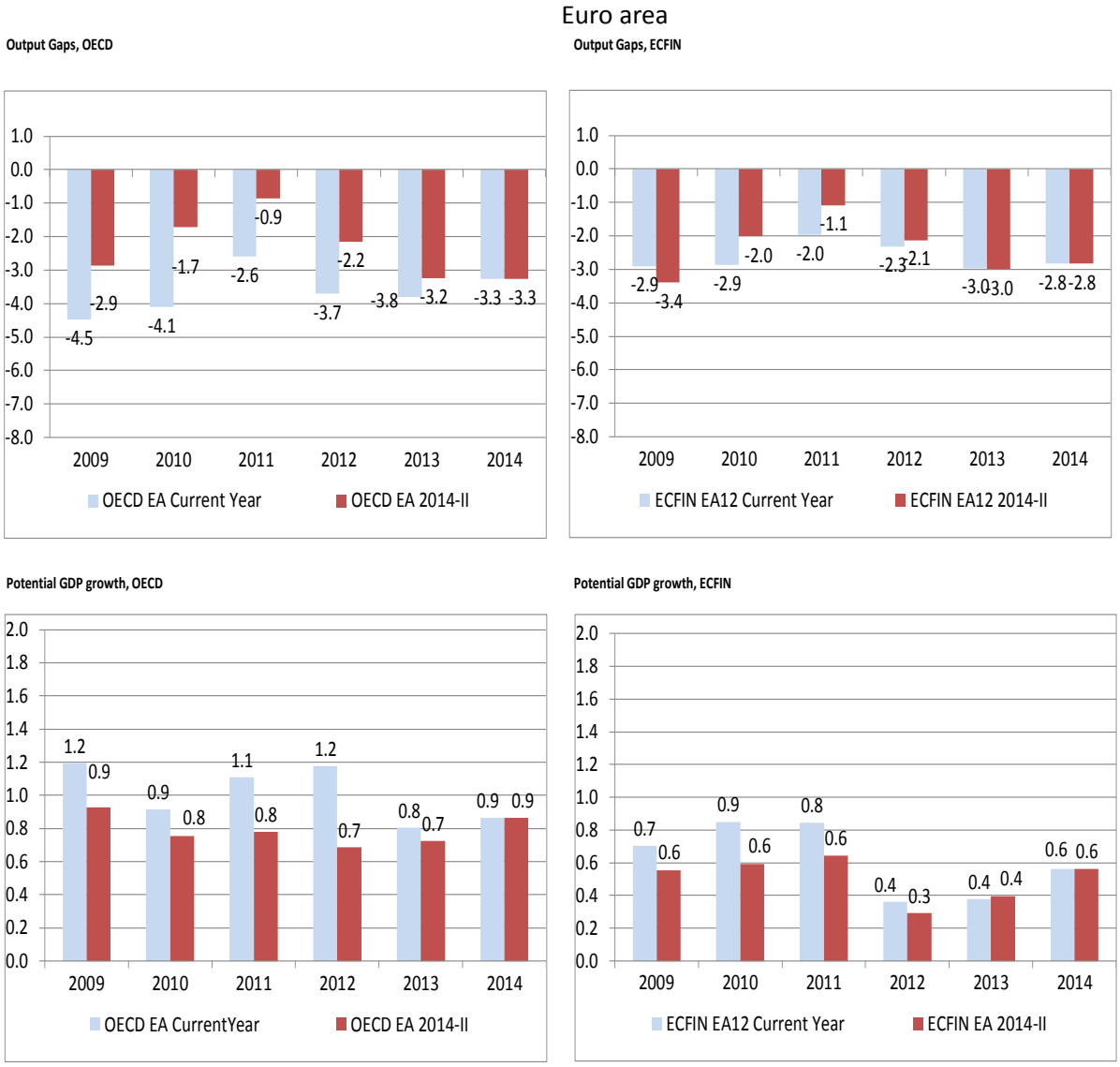
As can be seen by Figure 3 this view has evolved over time. The figure shows potential growth and output gap estimates in real time (for the respective current year) and the ex-post assessment based on the 2014 data vintage. While initially the financial crisis was seen as resulting in a large recession, some optimism about its limited impact on potential growth prevailed. As time moved on we can observe a tendency towards a downward revision of initially large negative output gap estimates accompanied by downward revisions of potential growth estimates. The International Monetary Fund (IMF) in its recent World Economic Outlook from April 2015 (IMF, WEO 2015) concludes that potential growth has slowed down significantly in advanced industrialised countries. We interpret this evidence as supporting the view expressed in this paper that the magnitude of the adverse shocks associated with the financial crisis only gradually revealed itself to economic agents.

It is also important to examine which component of potential growth has mostly been revised downwards. In Figure 4 we illustrate the estimates provided DG ECFIN of the European Commission, which attribute a large component of potential growth to have declined due to a fall in trend TFP. Trend TFP growth was already revised down in 2009, however at that time it was rather seen as a revision of too optimistic trend growth projections associated with the pre-crisis boom. In the meantime trend TFP growth has been further reduced.

[5] This observation is not only confined to the OECD and ECFIN, but is also true for the IMF and national estimates, as for example carried out by the CBO in the US.

It is clear from Figure 4 that there was a substantial change in the TFP trend growth rate from the pre-crisis baseline of 2008. More specifically in 2009 the trend growth rate decline by approximately 16% and then a further 5% in 2012. This change in growth rates was at the same time accompanied by a reduction in levels of approximately 2% in 2009 and a further 1% in 2012.

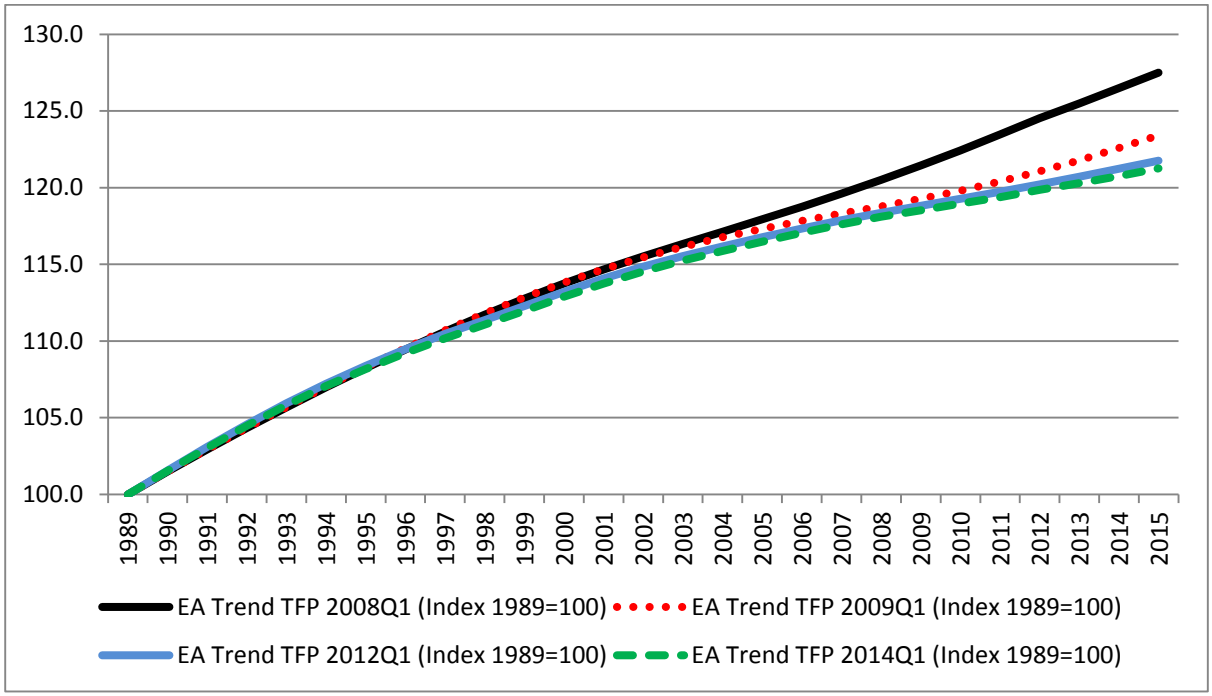
Figure 3: Euro Area Output Gap Estimates, Real time vs. Ex-post



Source: DG ECFIN calculations and OECD

When interpreting these trend growth revisions and the most recent trend estimate, one should also keep in mind that compared to average actual TFP growth, the trend estimate for the rate of technical progress still appears optimistic (Figure 5). While levels of TFP have so far not reached the peak in 2008, the trend TFP growth estimates still show a positive rate.

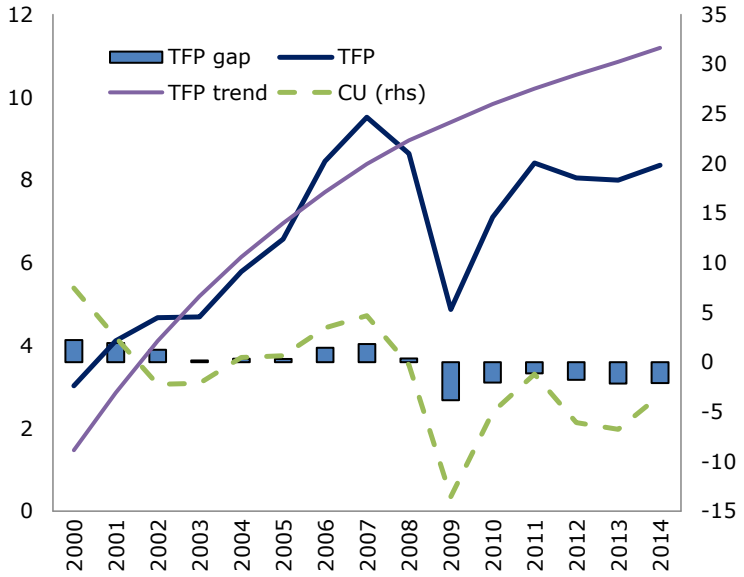
Figure 4: TFP trend estimates for EA (various vintages)



Source: DG ECFIN calculations

Figure 5: Actual TFP, Trend TFP and Capacity Utilisation

(2000-2014)



Source: DG ECFIN calculations

As is evident, the difference is mostly explained by correcting actual TFP for the degree of capacity utilisation which has been low persistently since 2009[6].

Finally, a slowdown of growth and inflation are the phenomena most often mentioned when characterising the post-2009 crisis episode. A closer look at the data does, however, reveal that other economic ratios also show particular patterns since 2009. The most striking of those are summarised in Table 1 and represent important evidence a model in conjunction with selected shocks should match.

Table 1: Stylized Facts for Euro Area

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
GDP growth	0.5	-4.5	2.0	1.6	-0.7	-0.5	0.8
Consumption (% of GDP)	55.3	56.5	56.3	56.2	56.2	56.0	55.8
Investment (% of GDP)	23.0	21.1	20.6	20.7	20.1	19.6	19.5
Employment share	69.3	67.9	67.6	67.6	67.4	66.9	67.1
Wage share	62.0	63.8	63.2	63.0	63.6	63.8	63.9
Nominal interest rate	3.5	1.1	1	1.25	0.8	0.5	0.25
Inflation (GDP deflator)	1.9	1.0	0.7	1.1	1.3	0.9	1.1
Real effective exchange Rate	103.0	108.1	100.0	100.4	96.1	102.5	103.8
Government debt (% of GDP)	68.5	78.3	83.8	86.4	90.8	93.1	94.5
Household debt (% of GDP)	N/A	68.9	69	67.7	66.8	65.6	N/A
Trade balance (% of GDP)	-0.5	0.4	0.5	0.6	1.9	2.5	2.6

[6] See Mc Morrow et al (2014) for an explanation of the TFP trend estimation method used by DG ECFIN.

The most important characteristics of Table 1 relate to the W-shaped response of GDP, that is the double dip recession and implying a persistent decline of GDP growth. At the same time however, there is a persistent increase of the consumption-to-GDP ratio (starting in 2008), as well as a persistent declines in the investment-to-GDP and ratios and the employment rate. Moreover, the wage share appears to be increasing and inflation (given by the GDP deflator) persistently declines. There is also a persistent decline in the nominal short term interest rate as well as a gradual increase in the government debt-to-GDP ratio. Finally, the real effective exchange rate remains roughly constant, but we observe a persistent increase in in the trade balance as a share of GDP.

The paper argues and then shows that a disciplined and data-motivated combination of the following shocks can generate these stylised facts: i) a risk premium shock for corporate investment in 2009, ii) a risk premium shock for corporate investment in 2012, iii) a reduction in housing investment (to correction for overinvestment), iii) fiscal stabilisation in 2009, iv) declining TFP growth, vi) increased wage mark up (rising NAWRU).

3. MODEL DESCRIPTION

The analysis in this paper uses the QUEST III model (Ratto et al., 2009). QUEST III is a quarterly macroeconomic model and a member of the class of New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) models. The model has rigorous microeconomic foundations derived from utility and profit maximization and includes frictions in goods, labour and financial markets.

The model version used here is a multi-region open-economy setup with two production sectors that, respectively, produce tradable (T) and nontradable (NT) goods. There are two types of households: liquidity-constrained households (l), and intertemporally optimising Ricardian households (r). All households consume and supply labour. In addition, Ricardian households invest into domestic productive capital, domestic government bonds and a foreign bond, own the firms, and obtain the firms' profits. There is no cross-border mobility of labour. The government levies taxes and spends its revenue on consumption, public investment, social benefits, transfers, and debt service.

The paper uses a 2-region setup with the Euro area (EA), and the rest of the world (RoW).

3.1. PRODUCTION

Each region is home to firms j operating in the T and NT sectors. Individual firms in T and NT are indexed by the superscript j=(t, nt). Each firm produces a variety of the T or NT good that is an imperfect substitute for varieties produced by other firms. Sectoral output O_t^J with J=(T, NT) is a CES aggregate of the varieties O_t^j:

$$(1) \qquad O_t^J \equiv \left[\int_0^1 (O_t^j)^{(\sigma_j - 1)/\sigma_j} dj \right]^{\sigma_j/(\sigma_j - 1)}$$

where σ_j is the elasticity of substitution between varieties j in sector J. The elasticity value can differ between T and NT, implying sector-specific price mark-ups. Given the imperfect substitutability, firms are monopolistically competitive in the goods market and face a demand function for their output:

$$(2) \qquad O_t^j = (P_t^j / P_t^J)^{-\sigma_j} O_t^J$$

The firms in sector T sell consumption and investment goods and intermediate inputs to domestic and foreign private households and firms and consumption and investment goods to domestic and foreign governments. The NT sector sells consumption goods to domestic households, consumption and investment goods to the domestic government, and intermediate inputs to domestic firms. Hence, all private investment in physical capital consists of T goods.

Output is produced with a CES technology that combines value-added (Y_t^j) and intermediate inputs (INT_t^j). It nests a Cobb-Douglas technology with capital (K_t^j), production workers ($L_t^j - LO_t^j$) and public infrastructure (KG_t) for the production of Y_t^j:

$$(3) \qquad O_t^j = [(1-\sin^j)^{1/\sigma_{in}} (Y_t^j)^{(\sigma_{in}-1)/\sigma_{in}} + (\sin^j)^{1/\sigma_{in}} (INT_t^j)^{(\sigma_{in}-1)/\sigma_{in}}]^{\sigma_{in}/(\sigma_{in}-1)}$$

$$(4) \qquad Y_t^j = A_t^j (ucap_t^j K_t^j)^{1-\alpha} (L_t^j - LO_t^j)^{\alpha} KG_t^{\alpha_g} - FCY_t^j$$

where $\sin^j$ and σ_{in} are, respectively, the steady-state share of intermediates in output and the elasticity of substitution between intermediates and value-added, and A_t^j, $ucap_t^j$, LO_t^j and FCY_t^j are total factor productivity (TFP), capacity utilisation, overhead labour and fixed costs of producing.[7]

Firm-level employment L_t^j is a CES aggregate of the labour services supplied by individual households i:

$$(5) \qquad L_t^j \equiv \left[\int_0^1 L_t^{i,j(\theta-1)/\theta} di \right]^{\theta/(\theta-1)}$$

where θ indicates the degree of substitutability between the different types of labour i.

The objective of the firm is to maximise real profits (Pr_t^j):

$$(6) \qquad \mathrm{Pr}_t^j = p_t^j O_t^j - p_t^{INT,j} INT_t^j - (1+ssc_t^J) w_t L_t^j - p_t^I I_t^j - (adj_t^{P,j} + adj_t^{L,j} + adj_t^{ucap,j})$$

[7] Lower case letters denote ratios and rates. In particular, $p_t^j \equiv P_t^j / P_t$ is the price of good *j* relative to the GDP deflator, $w_t \equiv W_t / P_t$ is the real wage, $ucap_t^j$ is actual relative to steady-state (full) capital utilisation, and e_t is the nominal exchange rate defined as the price of foreign in domestic currency.

where ssc_t^J , w_t , i_t^J and p_t^I are the employer social security contributions, the real wage, the rental rate of capital, and the price of capital. The firms are owned by the intertemporally optimising households that receive the firms' profits.

The firms face technology and regulatory constraints that restrict their capacity to adjust. These constraints are modelled as adjustment costs with the following convex functional forms:

(7a) $$adj_t^{L,j} \equiv \gamma_L w_t (\Delta L_t^j)^2 / 2$$

(7b) $$adj_t^{P,j} \equiv \gamma_P (\pi_t^j)^2 Y_t^j / 2 \text{ with } \pi_t^j \equiv P_t^j / P_{t-1}^j - 1$$

(7c) $$adj_t^{ucap,j} \equiv p_t^I K_t^j [\gamma_{ucap,1}(ucap_t^j - 1) + \gamma_{ucap,2}(ucap_t^j - 1)^2] / 2$$

The firms choose labour input, capital services, capacity utilisation, the price of output j, and the volume of output j given the demand function (2), the production technology (3) and (4), and the adjustment costs (7). The first-order conditions (FOC) are:

(8a) $$\frac{\partial \Pr_t^j}{\partial L_t^j} => \frac{\partial O_t^j}{\partial L_t^j}\eta_t^j - \gamma_L w_t \Delta L_t^j + \gamma_L \beta E_t(\lambda_{t+1}^r / \lambda_t^r \, w_{t+1} \Delta L_{t+1}^j) = (1 + ssc_t^J) w_t$$

(8b) $$\frac{\partial \Pr_t^j}{\partial K_t^j} => \frac{\partial O_t^j}{\partial K_t^j}\eta_t^j = i_t^J \, p_t^I$$

(8c) $$\frac{\partial \Pr_t^j}{\partial ucap_t^j} => \frac{\partial O_t^j}{\partial ucap_t^j}\eta_t^j = p_t^I K_t^j [\gamma_{ucap,1} + \gamma_{ucap,2}(ucap_t^j - 1)]$$

(8d) $$\frac{\partial \Pr_t^j}{\partial O_t^j} => \eta_t^j = 1 - 1/\sigma^j - \varepsilon_t^J - \gamma_P \left[\beta E_t(\lambda_{t+1}^r / \lambda_t^r \, \pi_{t+1}^j) - \pi_t^j \right]$$

where η_t^j is the Lagrange multiplier associated with the production technology, λ_t^r the marginal value of wealth in consumption terms as defined by equation (13) below, and ε_t^J is a sector-specific shock to the price mark-up.

Equation (8a) implies that optimising firms equate the marginal product of labour net of adjustment costs to wage costs. Social security contributions (ssc_t^J) affects labour costs for employers and, hence, labour demand. Temporary (permanent) shocks to ssc_t^J have temporary (permanent) effects on labour demand. The model includes employment adjustment frictions, but no hysteresis effects following which temporary shocks to employment would affect employment levels in the long run.

Equations (8b-c) jointly determine the optimal capital stock and capacity utilisation by equating the marginal value product of capital to the rental price and the marginal product of capital services to the marginal cost of increasing capacity. Equation (8d) defines the price mark-up factor as function of the elasticity of substitution and price adjustment costs. QUEST follows the empirical literature and allows for backward-looking elements in price setting by

assuming that the fraction *1-sfp* of firms indexes prices to past inflation, which leads to the specification:

$$(8d') \quad \eta_t^j = 1 - 1/\sigma^j - \varepsilon_t^J - \gamma_P \left[\beta E_t(\lambda_{t+1}^r / \lambda_t^r)(sfpE_t\pi_{t+1}^j + (1-sfp)\pi_{t-1}^j) - \pi_t^j \right] \text{ with } 0 \le sfp \le 1$$

for the inverse of the price mark-ups in the T and NT sectors. Given the symmetry of objectives and constraints across firms j in sector J, the superscript j for individual firms can be dropped to obtain aggregate sectoral equations for T and NT. The price setting decision establishes a link between output and prices in the economy. For constant technology, factor demand and/or capacity utilisation increase (decline) with increasing (declining) demand for output, which leads to an increase (decline) in factor and production costs and, hence, an increase (decline) in the price level of domestic output.

3.2. RESIDENTIAL CONSTRUCTION

Monopolistically competitive firms *h* in the residential construction sector use new land (J_t^{Land}) sold by (Ricardian) households and final goods (J_t^{Constr}) to produce new houses using a CES technology

$$(4) \quad J_t^H = \left(s_L^{\frac{1}{\sigma_L}} J_t^{Land\frac{(\sigma_L-1)}{\sigma_L}} + (1-s_L)^{\frac{1}{\sigma_L}} J_t^{Constr\frac{(\sigma_L-1)}{\sigma_L}} \right)^{\frac{\sigma_L}{\sigma_L-1}}$$

Subject to a quadratic adjustment cost constraint

$$(5) \quad adj^{PH}(P_t^H) = \frac{\gamma_P}{2}\left(\frac{P_t^H}{P_{t-1}^H} - 1\right)^2 Y_t$$

New and existing houses are perfect substitutes. Thus households can make capital gains or suffer capital losses depending on house price fluctuations.

3.2.1. Investment goods producers

There is a perfectly competitive investment goods production sector which combines domestic and foreign final goods, using the same CES aggregators as households and governments do 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,

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

where U_t^{PI} is a technology shock to the investment good production technology which itself follows a random walk [8]

(7) $$u_t^{PI} = u_{t-1}^{PI} + \varepsilon_t^{UPI}$$

3.3. HOUSEHOLDS

The household sector consists of a continuum of households $h \in [0,1]$. A fraction s^r of all households are Ricardian and indexed by *r* and s^c households are credit constrained and indexed by *c*. The period utility function is identical for each household type and specified as a nested constant elasticity of substitution (CES) aggregate of consumption (C_t^h) and housing services (H_t^h) and separable in leisure ($1-L_t^h$). We also allow for habit persistence in consumption. Thus temporal utility for consumption is given by

(8) $$U(C_t^h, H_t^h, 1-L_t^h) = \log\left\{\left[s_C^{\frac{1}{\sigma^H}}\left(C_t^h - hC_{t-1}^h\right)^{\frac{\sigma^H-1}{\sigma^H}} + s_H^{\frac{1}{\sigma^H}} H_t^{h\,\frac{\sigma^H-1}{\sigma^H}}\right]^{\frac{\sigma^H}{\sigma^H-1}}\right\} + \exp(u_t^L)\vartheta\left(1-L_t^h\right)^{1-\kappa}$$

All two types of households supply differentiated labour services to unions which maximise a joint utility function for each type of labour *i*. It is assumed that types of labour are distributed equally over the two household types. Nominal rigidity in wage setting is introduced by assuming that the household faces adjustment costs for changing wages. These adjustment costs are borne by the household.

[8] This shock is introduced to capture a divergent trend in relative investment prices.

3.3.1. Ricardian households

Ricardian households have full access to financial markets. They hold domestic government bonds ($B_t^{G,r}$) and bonds issued by other domestic and foreign households ($B_t^r, B_t^{F,r}$), real capital in the tradable and non tradable sector, (indexed by j) ($K_t^{r,j}$) used in the final goods production sector as well as the stock of land ($Land_t$) which is still available for building new houses. In addition they hold a stock of deposits (D) with a financial intermediary who provides loans to credit constrained households. The household receives income from labour, financial assets, rental income from lending capital to firms, selling land to the residential construction sector plus profit income from firms owned by the household (final goods Pr_t^j, residential construction Pr_t^H and financial intermediaries Pr_t^B). We assume that all domestic firms are owned by Ricardian households. Income from labour is taxed at rate t^w, consumption at rate t^c. In addition households pay lump-sum taxes T^{LS}. We assume that income from financial wealth is subject to different types of risk. Domestic bonds and interest income from deposits yield risk-free real return equal to r_t. Domestic and foreign bonds are subject to (stochastic) risk premia linked to net foreign indebtedness. An equity premium on real assets arises because of uncertainty about the future value of real assets. Furthermore, the discount factor β^r is subject to random shocks.

The Lagrangian of this maximisation problem is given by

(9)

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

$$-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^r \beta^{r\,t} \left(\begin{array}{l} (1+t_t^c) p_t^C C_t^r + \sum_j p_t^{I,j} I_t^{r,j} + p_t^H (1+t_t^c) I_t^{H,r} + (B_t^{G,r} + B_t^r + D_t) + rer_t B_t^{F,r} - \\ (1+r_{t-1})(B_{t-1}^{G,r} + B_{t-1}^r + D_{t-1}) - (1+r_{t-1}^F) rer_t B_{t-1}^{F,r} - \sum_j ((1-t^K) i_{t-1}^{K,j} + t^K \delta^K) p_{t-1}^{I,j} K_{t-1}^{r,j} \\ -(1-t_t^W) w_t L_t^r + adj^W(W_t) - p_t^L J_t^{Land} - \sum_{j=1} \mathrm{Pr}_t^j - \mathrm{Pr}_t^H - \mathrm{Pr}_t^B + T_t^{LS,r} \end{array} \right)$$

$$-\mathrm{E}_0 \sum_j \sum_{t=0}^{\infty} q_t^{r,j} \beta^{r\,t} (K_t^{r,j} - J_t^{r,j} - (1-\delta^K) K_{t-1}^{r,j})$$

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

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

The investment decisions w.r.t. physical capital and housing are subject to convex adjustment costs, therefore we make a distinction between real investment expenditure ($I_t^{r,j}, I_t^{H,r}$) and physical investment ($J_t^{r,j}, J_t^{H,r}$). Investment expenditure of households including adjustment costs is given by

(10a) $$I_t^{r,j} = J_t^{r,j} \left(1 + \frac{\gamma_K}{2} \left(\frac{J_t^{r,j}}{K_t^{r,j}} \right) \right) + \frac{\gamma_I}{2} (\Delta J_t^{r,j})^2$$

(10b) $$I_t^{H,r} = J_t^{H,r} \left(1 + \frac{\gamma_H}{2} \left(\frac{J_t^{H,r}}{H_t^r} \right) \right) + \frac{\gamma_{I^H}}{2} (\Delta J_t^{H,r})^2$$

The budget constraint is written in real terms with all prices expressed relative to the GDP deflator (*P*). Investment is a composite of domestic and foreign goods.

We follow Bernanke and Gertler (1999) and assume that residential and non-residential investment decisions are subject to fundamental and non-fundamental shocks. From the FOCs of the house hold investment problem we obtain the shadow price of non-residential and residential capital

(11a) $q_t^{r,j} = \beta E_t\left[q_{t+1}^{r,j}(1-\delta^K) + \left(\left(1-t^K\right)i_t^j + t^K\delta^K\right)p_t^{I,j}\right]$

(11b) $q_t^{r,H} = U_{H,t}^r + \beta E_t\left(q_{t+1}^{r,H}(1-\delta^H)\right)$

which is equal to the present discounted value of fundamental shocks, namely the after-tax rental rate of capital and the marginal utility of housing services respectively. As in Bernanke and Gertler, we assume that in addition there are non-fundamental shocks x_t^i with $i \in (K^t, K^{nt}, H)$, which follow a 'near rational bubble' process $x_{t+1}^i = \frac{a^i}{\beta}x_t^i + e_t^i$ with $a^i < \beta$.

We then define the modified shadow price $Q_t^{r,i} = q_t^{r,i} + x_t^i$, which follows the process

(12a) $(1-z_t^j)Q_t^{r,j} = \beta E_t\left(Q_{t+1}^{r,j}(1-\delta^K) + \left(\left(1-t^K\right)i_t^j + t^K\delta^K\right)p_t^{I,j}\right)$

(12b) $(1-z_t^H)Q_t^{r,H} = U_{H,t}^r + \beta E_t\left(Q_{t+1}^{r,H}(1-\delta^H)\right)$

where $z_t^i = (1-a^i)\frac{x_t^i}{\beta}$

Like Bernanke and Gertler, we use the term "bubble" loosely to denote temporary deviations of asset prices from fundamentals due to waves of optimism and excessive risk taking in periods of rising asset prices, and waves of pessimism or panics in periods of increased uncertainty.

In the context of the current crisis, alternative explanations could be given for a sudden fall in asset prices. For example, an increase in z_t^i could capture what Gorton (2010) calls a "panic", to describe the uncertainty about the value of certain asset classes which have forced banks to deliver and dump assets, leading to falling asset values. A rising z_t^i could also capture what Hall (2010) refers to as "principal agent frictions", which he models by introducing an exogenous wedge shock between safe (government bonds) and risky assets (equity and houses) in order to empirically match rising spreads between safe and risky assets.

The interest rate that households face when making consumption and investment decisions depends on the aggregate level of foreign indebtedness (defined as $(-B_t^{F,r})/(p_t Y_t)$)

$$(13) \qquad i_t^h = i_t + rprem\left(\frac{(-B_t^F)}{P_t\ Y_t}\right)$$

This specification corresponds to the debt-elastic interest rate premium in the comparison of methods studied by Schmitt-Grohe and Uribe (2003) in closing small open economy models. The major reason for this specification is that it induces stationarity. However, we also regard the interest elasticity w.r.t. foreign debt as an important behavioural parameter describing the risk tolerance of foreign creditors. The parameter *rprem* together with the rate of time preference of Ricardian households determines the steady state debt level of the economy.

3.3.2. 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 maximisation problem is given by

(14)

$$\begin{aligned}
&Max \quad V_0^c = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^{ct} U(C_t^c, 1-L_t^c, H_t^c) \\
&-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \beta^{ct} \left((1+t_t^c) p_t^C C_t^c + p_t^H (1+t_t^H) I_t^{H,c} - B_t^c + (1+r_{t-1}) B_t^c) - (1-t_t^W) w_t L_t^c + adj^W(W_t) + T_t^{LS,c}\right) \\
&-\mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \zeta_t^c \beta^{ct} \left(H_t^c - J_t^{H,c} - (1-\delta^H) H_{t-1}^c\right) - \mathrm{E}_0 \sum_{t=0}^{\infty} \lambda_t^c \psi_t^c \beta^{ct} \left((1+r_t) B_t^c - \chi_t^c p_t^H H_{t-1}^c\right)
\end{aligned}$$

Notice, the collateral constraint increases the shadow price of borrowing as determined by the Lagrange multiplier ψ_t^c of the collateral constraint.

There is a non-fundamental shock to housing investment which is constrained to be equal across household types.

3.3.3. Wage setting

A trade union is maximising a joint utility function for each type of labour *i* where it is assumed that types of labour are distributed equally over constrained and unconstrained households with their respective population weights. The trade union sets wages by maximising a weighted average of the utility functions of these 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 of these two household types, adjusted for a wage mark up

$$(15) \qquad \frac{s^c U^c_{1-L,t} + s^r U^r_{1-L,t}}{s^c U^c_{c,t} + s^r U^r_{c,t}} = \frac{(1-t^W_t)}{(1+t^C_t)} \frac{W_t}{P^C_t} \eta^W_t$$

where η^W_t is the wage mark-up factor, with wage mark ups fluctuating around $1/\theta$ which is the inverse of the elasticity of substitution between different varieties of labour services. The trade union sets the consumption wage as a mark-up over the reservation wage. The reservation wage is the ratio of the marginal utility of leisure to the marginal utility of consumption. This is a natural measure of the reservation wage. If this ratio is equal to the consumption wage, the household is indifferent between supplying an additional unit of labour and spending the additional income on consumption and not increasing labour supply. Fluctuation in the wage mark-up arises because of wage adjustment costs

$$(16) \qquad adj^W(W_t) = \frac{\gamma_W}{2} \left(\frac{1}{\Pi^{1-sfw}_{t-1} \overline{\Pi}^{sfw}} \frac{W_t}{W_{t-1}} - 1 \right)^2 Y_t$$

3.4. EQUILIBRIUM

Equilibrium in our model economy is an allocation, a price system and monetary and fiscal policies such that both non-constrained and constrained households maximise utility, final

goods producing firms, firms in the construction sector and investment goods producers maximise profits and the following market clearing conditions hold for final domestic goods:

(29) $Y_t = C_t^d + J_t^{inp,d} + J_t^{Constr} + C_t^{G,d} + I_t^{G,d} + X_t$,

and final imported goods

(30) $M_t = C_t^f + J_t^{inp,f} + C_t^{G,f} + I_t^{G,f}$,

where total domestic and imported consumption C_t^i is the sum of savers and borrowers consumption, with their per-capita consumption multiplied by the respective population shares s^r and s^c:

(31a) $C_t^i = s^r C_t^{r,i} + s^c C_t^{c,i}$,with $i = d, f$

Similarly, total housing investment is defined as:

(31b) $J_t^H = s^r J_t^{H,r} + s^c J_t^{H,c}$

and equilibrium in the labour market is given by

(31c) $L_t = s^r L_t^r + s^c L_t^c$ with $L_t^r = L_t^c$.

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

(32) $B_t^c = \frac{s^r}{s^c} B_t^r$.

3.5. FISCAL AND MONETARY POLICY

Real government purchases (G_t) and investment (IG_t) are kept constant in real terms. The stock of public infrastructure that enters the production function (4) develops according to:

(21) $KG_t = IG_t + (1-\delta^g) KG_{t-1}$

Nominal transfers (TR_t) are indexed to consumer prices:

(22) $TR_t = \overline{tr} P_t^C$

The nominal benefits paid to the non-employed part of the labour force correspond to the exogenous replacement rate (*benr*) times the nominal wage:

(23) $BEN_t = \overline{benr} W_t$

The government receives consumption tax, labour tax, corporate tax and lump-sum tax revenue as well as social security contributions. Nominal government debt (B_t) evolves according to:

(24)
$$B_t = (1+i_{t-1})B_{t-1} + P_t^C(G_t + IG_t) + TR_t + BEN_t(1 - NPART_t - L_t) - T_t^{LS} - t_t^c P_t^C C_t$$
$$-\sum_J (t_t^w + ssc_t^J) W_t L_t^J - \sum_J t_t^k [P_t^J O_t^J - P_t^{INT,J} INT_t^J - (1+ssc_t^J) W_t L_t^J - \delta^J P_t^I K_{t-1}^J]$$

The labour tax is used to stabilise the debt-to-GDP ratio:

(25) $\Delta t_t^w = \tau^b (B_t / (4 P_t Y_t) - \overline{btar}) + \tau^{def} \Delta (B_t / P_t)$

with btar being the target level of government debt to GDP. The consumption tax and corporate income tax rates, the rate of social security contributions and the amount of lump-sum taxes are exogenous.

Monetary policy follows a Taylor rule that allows for a smoothing of the interest rate response to inflation and the output gap:

(26) $i_t = \rho_i i_{t-1} + (1-\rho_i)\left(\bar{r} + \pi^{tar} + \tau_\pi (\pi_t^C - \pi^{tar}) + \tau_y ygap_t\right)$

The central bank has an inflation target π^{tar}, adjusts its policy rate when actual CPI inflation deviates from the target and also responds to the output gap (*ygap*). Monetary policy in the EA focuses on EA averages of inflation and the output gap.

The output gap is not calculated as the difference between actual and efficient output, but derived from a production function framework, which is the standard practice of output gap calculation for fiscal surveillance and monetary policy. More precisely, the output gap is defined as deviation of factor utilisation from its long-run trend:

(27) $ygap_t \equiv \alpha \ln(L_t / L_t^{ss}) + (1-\alpha) \ln(ucap_t / ucap_t^{ss})$

The variables L_t^{ss} and $ucap_t^{ss}$ are moving averages of employment and capacity utilisation rates:

(28a) $L_t^{ss} = \rho^L L_{t-1}^{ss} + (1-\rho^L) L_t$

(28b) $ucap_t^{ss} = \rho^{ucap} ucap_{t-1}^{ss} + (1-\rho^{ucap}) ucap_t^j$

The moving averages are restricted to move slowly in response to actual values.

3.6. TRADE AND FINANCIAL LINKAGES

This sub-section describes the key relationships for the dynamics of the trade balance, the current account and the net foreign asset position in response to relative price and demand adjustment. Previous sub-sections have determined aggregate domestic consumption,

investment and government expenditure, but not the allocation of demand between T versus NT output and domestically produced versus imported T goods.

In order to facilitate aggregation, private households and the government are assumed to have identical preferences across goods used for private and government consumption and public investment. Let $Z \in (C, G, IG)$ be the demand by private households and the government, and let their preferences for T and NT goods be given by the CES functions:

$$(29) \qquad Z_t = \left[(1-s_{tnt})^{1/\sigma_{tnt}} (Z_t^{NT})^{(\sigma_{tnt}-1)/\sigma_{tnt}} + s_{tnt}^{1/\sigma_{tnt}} (Z_t^{TT})^{(\sigma_{tnt}-1)/\sigma_{tnt}} \right]^{\sigma_{tnt}/(\sigma_{tnt}-1)}$$

where Z^{NT} is an index of demand across the NT varieties, and Z^{TT} is a bundle of domestically produced (Z^T) and imported (Z^M) T goods:

$$(30) \qquad Z_t^{TT} = \left[(1-s_m)^{1/\sigma_x} (Z_t^T)^{(\sigma_x-1)/\sigma_x} + s_m^{1/\sigma_x} (Z_t^M)^{(\sigma_x-1)/\sigma_x} \right]^{\sigma_x/(\sigma_x-1)}$$

The elasticity of substitution between the bundles of NT and T goods is σ_{tnt}. The elasticity of substitution between the bundles of domestically produced and imported T goods is σ_x. The steady-state shares of T goods in Z_t and of imports Z_t^{TT} are s_{tnt} and s_m, respectively. All investment in physical capital in the T and NT sectors consists of T goods.

The CES aggregate (29) combining T and NT goods gives the following demand functions:

$$(31a) \qquad Z_t^T = s_{tnt} (P_t^T / P_t^C)^{-\sigma_{tnt}} (C_t + G_t + IG_t)$$

$$(31b) \qquad Z_t^{NT} = (1-s_{tnt}) (P_t^{NT} / P_t^C)^{-\sigma_{tnt}} (C_t + G_t + IG_t)$$

The intermediate inputs in sector J=(T, NT) are also composites of T and NT analogously to equations (29) and (30) with T either domestically produced or imported:

$$(32) \qquad INT_t^J = \left[(1-\sin_{tnt}^J)^{1/\sigma_{tnt}} (INT_t^{NT,J})^{(\sigma_{tnt}-1)/\sigma_{tnt}} + (\sin_{tnt}^J)^{1/\sigma_{tnt}} (INT_t^{T,J})^{(\sigma_{tnt}-1)/\sigma_{tnt}} \right]^{\sigma_{tnt}/(\sigma_{tnt}-1)}$$

$$(33) \qquad INT_t^{TT,J} = \left[(1-s_m)^{1/\sigma_x} (INT_t^{T,J})^{(\sigma_x-1)/\sigma_x} + s_m^{1/\sigma_x} (INT_t^{M,J})^{(\sigma_x-1)/\sigma_x} \right]^{\sigma_x/(\sigma_x-1)}$$

This gives demand functions for T and NT intermediates analogously to (31):

$$(34a) \qquad INT_t^{T,J} = \sin_{tnt}^J (P_t^T / P_t^{INT,J})^{-\sigma_{tnt}} INT_t^J$$

$$(34b) \qquad INT_t^{NT,J} = (1-\sin_{tnt}^J) (P_t^{NT} / P_t^{INT,J})^{-\sigma_{tnt}} INT_t^J$$

Combining the demand functions corresponding to (30) and (33) and allowing for sluggish volume responses to price changes (ρ_m) gives the import demand equation:

$$(35) \qquad M_t = \rho_m M_{t-1} + (1-\rho_m) s_m \left(\frac{e_t P_t^M}{P_t^T} \right)^{-\sigma_x} (Z_t^T + \sum_J I_t^j + \sum_J INT_t^{T,J})$$

Including inertia in the response of trade volumes to prices is able to generate a J-curve response of the trade balance to changes in the real exchange rate; in addition there is inertia in import prices (ρ_{pm}):

$$(36) \qquad P_t^M = \rho_{pm} P_{t-1}^M + (1-\rho_{pm}) \left[\sum\nolimits_{f=1}^{F} \left(s_m^f \frac{e_t^f P_t^{T,f}}{P_t^X} \right)^{1-\sigma_f} \right]^{1/(1-\sigma_f)}$$

where s_m^f is the share of the country of origin f in domestic imports and $P_t^{T,f}$ the price of tradables set by producers in f.

Bilateral imports from the individual model regions (f), which are foreign regions from the perspective of the domestic economy, are given by:

$$(37) \qquad M_t^f = \rho_{m1} M_{t-1}^f + (1-\rho_{m1}) s^f \left(\frac{e_t^f P_t^{T,f}}{e_t P_t^M} \right)^{-\sigma_f} M_t$$

which allows for sluggish adjustment (ρ_{m1}) of the import basket to changes in the relative price.

The exports of the domestic economy equal the sum of bilateral imports of foreign regions from the domestic economy. The trade balance of the domestic economy is net trade in value terms:

$$(38) \qquad TB_t \equiv P_t^T X_t - e_t P_t^M M_t$$

Adding interest income on the net foreign asset (NFA) position gives the current account:

$$(39) \qquad CA_t \equiv i_{t-1}^* e_t B_{t-1}^* + P_t^T X_t - e_t P_t^M M_t$$

The law of motion for the NFA position is:

$$(40) \qquad e_t B_t^* = (1+i_{t-1}^*) e_t B_{t-1}^* + P_t^T X_t - e_t P_t^M M_t$$

The focus on the NFA position abstracts from valuation effects on the gross asset or liability side.

The model requires an external closure to rule out explosive NFA dynamics as illustrated by Schmitt-Grohé and Uribe (2003). The model uses a closure rule that relates the external risk premium in (16) to the NFA position of the domestic economy relative to the baseline (target) position bwy^T :

$$(41) \qquad rprem_t = -rprem(e_t B_t^F / (4 P_t Y_t) - bwy^T)$$

An increase (decline) in the NFA position of the domestic economy increases (reduces) the risk on foreign relative to domestic bonds. An increase in the relative risk of domestic assets in response to a fall in the domestic NFA position reduces domestic consumption and investment demand, which improves the trade balance and stabilises the NFA position.

3.7. PARAMETERISATION

The paper uses a 2-region version of QUEST with tradable (T) and non-tradable (NT) sectors. We distinguish between the Euro area (EA) and a rest of the world aggregate (ROW).

The parameterisation of the model's long-term equilibrium is based on input-output tables, public finance statistics and the AMECO database and summarised in Table 1 for the EA region. The parameter values governing the model dynamics in the short and medium term, e.g. substitution elasticity values, nominal and real adjustment costs, inertia in trade prices and volumes, the share of liquidity-constrained households, consumption habits, and policy response parameters, are based on an estimated version of the model by Ratto et al. (2009) and Kollmann et al. (2014).

Table 1: Model parameters and ratios[9]

Name	**Value**	**Name**	**Value**
Frictions:		Elasticity of substitution between value added and intermediates (σ_{in})	0.50
Average price duration (quarters)	5	Fix costs of production (FCY) to GDP	0.17
Average wage duration (quarters)	3	Overhead labour (LO) to total employment	0.06
Import price stickiness (ρ_{pm})	0.90	Steady-state intermediate share T (sin^{T})	0.74
Labour adjustment cost (γ_L)	25.0	Steady-state intermediate share NT (sin^{NT})	0.44
Capital adjustment cost (γ_K)	20.0	Steady-state T intermediate share in T (sin_{tnt}^{T})	0.61
Investment adjustment cost (γ_I)	75.0	Steady-state T intermediate share in NT (sin_{tnt}^{NT})	0.43
Linear capacity-utilisation adjustment cost ($\gamma_{ucap,1}$)	0.04	Elasticity of substitution between types of labour (θ)	6.5
Quadratic capacity-utilisation adjustment cost ($\gamma_{ucap,2}$)	0.05	Depreciation rate T capital stock (δ^{T})	0.02
Share of forward-looking price setters (sfp)	0.90	Depreciation rate NT capital stock (δ^{NT})	0.01
Share of forward-looking wage setters (sfw)	0.90	Depreciation rate public capital stock (δ^{g})	0.01
Preferences:		Equity premium (i^{K}-i)	0.01
Share of LC households (s^{l})	0.40	Persistence of potential employment (ρ_L)	0.95
Discount factor (β)	0.997	Potential capacity utilisation persistence (ρ_{ucap})	0.99
Habit persistence (h)	0.70	**Fiscal policy:**	

[9] Note: Parameter table to be updated

Inverse of elasticity of labour supply (κ)	-5.00	Corporate profit tax (t^k)	0.28
Utility weight of leisure (ω)	0.001	Consumption tax (t^c)	0.17
Labour force to population (1-NPART)	0.71	Labour income tax (t^w)	0.25
Steady-state employment to population (L)	0.66	Social security contributions (ssc)	0.15
Elasticity of substitution T varieties (σ_T)	8.3	Transfer share (try)	0.16
Elasticity of substitution NT varieties (σ_{NT})	5.0	Benefit replacement rate (benr)	0.40
Elasticity of substitution T-NT (σ_{tnt})	0.50	Baseline government debt to GDP (btar)	0.62
Elasticity of substitution in total trade (σ_x)	1.50	Parameter debt (τ^b)	0.01
Elasticity of substitution between import sources (σ_f)	0.99	Parameter deficit (τ^{def})	0.10
Steady-state consumption share of T (s_{tnt})	0.41	Risk premium *(*risk)	0.0025
Steady-state consumption share of imports (s_m)	0.41	**National accounts (share of GDP):**	
Persistence in total import demand (ρ_m)	0.90	Private consumption	0.67
Persistence in bilateral import demand (ρ_{m1})	0.90	Investment	0.10
Production:		Government purchases	0.19
Cobb-Douglas labour parameter (α)	0.65	Government investment	0.04
Cobb-Douglas public capital stock parameter (α_g)	0.09	Imports	0.46

4. SCENARIOS *(TO BE COMPLETED)*

The aim of this section is to describe the exogenous disturbances we subject the model to in order to attempt to capture economic developments in the Euro area since 2009 in a stylised fashion. We divide up the period of interest (2009 - 2015) into two sub-periods: the first lasts from 2009 until the end of 2011 and marks the financial crisis and subsequent (short-lived) recovery. The second period starts in 2012 and covers the sovereign debt crisis and subsequent recovery. We make this distinction in horizons as it is implausible to assume that shocks attributed to the sovereign debt crisis in 2012 could have been anticipated at the beginning of the financial crisis in 2009.

Risk premia:

Both the 2009 and the 2012/13 recession was characterised by a strong reduction of corporate investment (in particular equipment investment). We choose a "risk premium" shock in these

periods in order to allow us to generate this decline of investment, when combined with other shocks. To concentrate on risk premia shocks is justified by the fact that these two periods are characterised by peaks in various financial risk measures (e.g. yields on non-financial firms). To appropriately calibrate a risk premium shock we would ideally need data on observed risk measures (e.g. a corporate bond spread). However, such corporate bond spreads are generally only reported for bonds with a maturity of 5 to 10 years and hence fail to display the underlying term structure of risk. As a result, we are obliged to discipline our shock calibration by using the risk premium on yields of non-financial firms of the Euro area from the European Central Bank's key policy rate. We adjust upwards our implied risk premium shock in order to account for the generally higher risk premia implied by corporate bond spreads, but restrict its size so as not to exceed the 5 year corporate bond spread. As suggested by the unanticipated nature of the sovereign debt crisis, we feed the risk premium shock to the model at two stages: in 2009 and subsequently as an unexpected event in 2012/13.

Housing investment

In several Euro area countries (e.g. Spain) housing investment before 2009 was largely driven by housing bubbles. This suggests that the quantification of a risk shock in the housing sector is more problematic.

To calibrate the risk premium shock in housing investment we proceed in the following fashion. First, we take as given the persistent decline in housing investment which can be observed in the data. Second, we engineer a persistent increase in the housing investment risk premium, which will be able to replicate the pattern we observe. In particular, we choose the size of the shock such that the model can replicate the decline in the housing investment-to-GDP ratio and the fall in house prices since 2009.

It is shown in In 't Veld et al (2014) that the bursting of a housing bubble in the model can be approximated with a highly persistent increase of the risk premium on residential investment. Equally, the same effect can be generated through a highly persistent reduction of a negative risk premium.

A further question we want to address with these risk premium shocks is to what extent such shocks (capable of explaining the decline of corporate investment in 2009 and 2012/13 respectively and residential investment since 2009), can explain the slowdown of growth, disinflation as well as the other stylised facts for the Euro area economy.

TFP

Concerning trend TFP shocks we use information from DG ECFIN's medium term projection exercise. Using this data gives us two sets of useful information. First, by comparing various post 2008 medium-term projection vintages we can trace how the severity of the growth slowdown is unfolding over time. Second, by comparing pre-crisis and post-crisis medium-term projections we can evaluate the extent in which trend income/productivity growth projections have changed. This provides us with quantitative information about the revision of trend income growth expectations before and after 2009. Note also, the Production Function method not only provides us with information about revisions in GDP growth, but it also decomposes these growth revisions into revisions of underlying supply side trends, in

particular TFP. The latter is particularly useful for identifying the type of TFP shocks we are interested in.

With each forecasting exercise DG ECFIN calculates output gaps using a production function approach. A crucial output of this exercise is the estimate of trend TFP in addition to a 5-10 year projection. Our exercise in this paper assumes that the trend TFP projections summarise well expectations about technology trends. Comparing various vintages allows us hence to trace the speed in which revisions about the technology trend have occurred.

Given this information we construct a TFP shock that has the following features. In 2009, there is a persistent decline in the growth rate of TFP. This mirrors the downwards revisions of expectations regarding future productivity. In addition, we also impose a downwards shift in the level of TFP of 2.5%. In 2012 and the onset of the sovereign debt crisis, there is a further decline of smaller magnitude in the growth rate, however not with an accompanied level shift.

Fiscal Policy

Changes in fiscal instruments during the years 2009 – 2013 were arguably also one of the important determinants of the observed growth slowdown. In 2009 euro area member states introduced fiscal stimulus measures to support growth (European Economic Recovery Plan), but following the sovereign crisis in 2011 embarked on fiscal consolidations. To calibrate fiscal policy shocks in the model we use the change in the structural balance of the general government for the Euro area. This shows during the first sub-period an expansion, followed by a neutral fiscal stance in 2010, and then consolidations from 2011 onwards. Hence, in the second sub-period, the shock we impose is that of a fiscal consolidation. Given the richness of the model, we are able to distinguish between changes in government consumption, government investment and transfers, and hence appropriately calibrate these disaggregated components rather than setting a unique aggregate fiscal shock through government spending alone.

Private Sector Deleveraging

In order to calibrate the private deleveraging shock we would ideally require information on how financial intermediaries have tightened their loan-to-value ratios during the course of the financial crisis. However, appropriate data for this is problematic to obtain. We thus base our strategy by engineering a tightening of loan-to-value ratios in the model so that we can replicate the observed household debt-to-GDP data. In particular, we restrict the loan-to-value ratio such that we can match the observed 10% in household debt-to-GDP over a 10-year horizon.

Wage Mark-ups

We also include a wage mark-up shock in the model as two stylized facts we are interested in matching are the increase in the consumption-to-GDP ratio and the increase in the wage share (real unit labour cost). Most DSGE models are currently lacking theoretical mechanisms that can endogenously generate decreases in employment at stable nominal wages. By the inclusion of the mark-up shock we are hence attempting to capture the persistently rising wage and consumption shares.

We perform the calibration of this shock last. Once all other shocks have been imposed we set the magnitude of this shock at a level that can engineer an increase in consumption-to-GDP shares.

5. RESULTS[10]

Simulations of Individual Shocks

We proceed by presenting the effects of individual shocks on the macroeconomic variables of interest, and discuss what stylized facts can be replicated each time. We also describe the transmission mechanism as implied by the model.

Private sector deleveraging

As can be seen in Figure 7 a shock to private deleveraging alone falls short from matching many stylised facts of the growth slowdown observed in the data. Although we are able to replicate the improvement of the trade balance, the decline in GDP is not very persistent, returning to its baseline by 2013 (period 5). The drop in GDP is partly triggered by a decline in housing investment, but this decline is not large enough to match the implied construction investment-to-GDP ratio. The latter can be potentially attributed to the share of credit constrained households imposed in the calibration of the model, which is set at 0.4. Furthermore, an important counterfactual result is the implied decline of the consumption-to-GDP ratio. Notably, this directly follows from the nature of the shock, which induces a tightening in households' credit constraints, triggering a decline of both consumption and housing investment. In addition, the decline of consumption induces households to supply more labour at a decreasing wage, leading to a declining real unit labour cost.

Fiscal Policy

In Figure 8 we plot the simulated responses following two fiscal shocks. The first year fiscal expansion increases GDP, employment, the consumption-to-GDP ratio, the real unit labour cost, and reduces investment-to-GDP on impact. Due to the nature of the path we impose for fiscal policy (a one-year expansion, followed by a neutral stance in the second period, and a subsequent consolidation in the third year) implies that all the effects are largely confined to 2009.

TFP

As can be seen from Figure 9 the TFP shock alone can quantitatively explain most of the decline in GDP. It is also successful in replicating the persistent decline in inflation. However, as the Euro area has been subjected to numerous adverse shocks during the crisis years and subsequent recovery period, we would not expect this shock alone to be able to explain the full decline in output.

Furthermore, due to the presence of real and nominal rigidities in the model the TFP shock is able to generate a fall in employment and an increase in the real unit labour cost in the short run. We conjecture that the persistence of the TFP shock (captured by an autocorrelation coefficient of 0.98) may not be strong enough to further lead to reductions in employment in

[10] In order to facilitate reading the simulation results have been introduced in an Appendix

the medium run. Alternatively, the model may be lacking a mechanism to generate a countercyclical wage mark up.

Recall, that the calibration of the TFP shock has been implemented so that in 2009 we also induce a downward level shift of TFP (of approximately 2.5%) in order to capture the revision of overly optimistic pre-crisis trend TFP expectations. Given that the model is solved using deterministic simulations, the assumption of perfect foresight implies in the following periods households and firms can fully anticipate the persistent decline of TFP growth rates. Due to this feature, the model generates a strong downward adjustment of consumption, but also causes investment rates (as a ratio to GDP) to remain stable. As we have shown previously, this is a counterfactual. Due to this, the shock to TFP growth is also unable to generate an improvement in the trade balance.

Risk premium

Our calibration of risk premium shocks has been undertaken by recognizing that in 2009 and 2012/13 the Euro area was subjected to rising risk spreads. The 2009 episode was due to the financial crisis, whereas in 2012/13 the sovereign risk crisis was the main driver. The latter episode also implied large sizable spillovers to the private sector because of the large exposure of the banking sector to sovereign assets. When the 2009 risk premium (financial crisis) shock hits the economy we make the assumption that the subsequent sovereign debt crisis in 2012/13 is not foreseen by agents in the economy. Thus, 2012 and 2013 risk shocks are unanticipated in these years.

A higher price of risk (as shown by higher spreads between risky and safe assets) is able to match a number of stylised facts at least qualitatively. As can be seen in Figure 10, risk shocks to the model are especially able to replicate the strong, but temporary decline of corporate investment as observed in the data. In addition, they are able to capture declining inflation rates. The endogenous monetary policy response due to the decrease in inflation also leads the consumption-to-GDP ratio to increase. However, due the fall in domestic demand, the trade balance (as a % of GDP) declines rather persistently. In addition, the risk premium shocks fail to capture the increasing wage share (real unit labour cost).

Housing risk premium

As mentioned earlier, the persistent increase in the risk premium of housing investment can be interpreted as the expectation of higher future income risk. Alternatively, it can signify the bursting of a housing bubble.

In Figure 11, we can see that the housing risk premium shock appears more successful than the deleveraging shock in matching the stylised facts of interest. The main reason being that this shock shifts spending from investment to consumption. However, as in the case of a private deleveraging shock, the reduced residential investment cannot explain the fall of GDP. In addition, since it operates by inducing a shift mostly in domestic expenditures it cannot explain the increase in the trade balance-to-GDP ratio.

Wage mark-up

All the above individual shocks were found to be struggling to replicate two important characteristics in the data, namely, the observed increase of the wage share (real unit labour cost) in the EA since 2008, as well as the increase in the consumption-to-GDP ratio. This is a

general feature of current DSGE models, which lack mechanisms that keep wages high and prevent an adjustment of employment[11]. Here we show that a rising wage mark-up could indeed account for a persistently rising wage and consumption share as well as a more persistent decline of employment (Figure 12). Clearly, a wage mark-up shock will not be deflationary and hence not be able to explain the increase of the trade balance. However, as already illustrated, these features in the data can be matched by the other proposed shocks.

Simulations of All Shocks

The shocks we have considered in this exercise go a long way in explaining the persistent decline of GDP and inflation in the Euro area (Figure 13). We also can account for a persistent decline in the investment to GDP ratio and a slight increase in the consumption to GDP ratio, which results in a persistent increase in the trade surplus. The main labour market facts, in particular the increase in the wage share can so far only be explained by an exogenous increase in the wage mark up. It remains an interesting area of research to find explanations for stronger countercyclical mark ups than currently generated by DSGE models.

6. CONCLUSION

It is well known that financial crises lead to prolonged periods of low growth. The 2009 financial crisis is no exception. This paper tries to account for the explanatory power of various hypotheses which have been put forward. We find that the shocks most directly associated with financial crises, namely risk premia and deleveraging shocks, are indeed important for matching many of the stylised facts, but the decline in trend TFP growth is the main driver explaining the slow recovery from the crisis. Many of the stylised facts can be partially explained by increasing risk premia but less so by deleveraging, since the later fail to explain the increase in the share of private consumption in GDP. However those shocks are not able to explain the persistent decline of GDP growth in the EA. This can be more successfully done by the decline in the trend growth rate of TFP, as for example identified by potential growth estimates of DG ECFIN. More work is needed to explain the persistence of crucial labour market indicators such as employment or the wage share. Promising avenues for research in this are finding mechanisms to increase countercyclical mark ups or exploring cyclical behaviour in payroll taxes.

The results we have obtained using a DSGE model also support assessments of potential growth as conducted by many policy institutions which all point in the direction that the current slump in the EA is largely due to a decline of potential growth. Notably, potential growth estimates are generally not based on estimated DSGE models but rely on time series filtering of either GDP or its supply side components, using a production function framework. Three elements in our DSGE model based analysis point towards a decline of potential growth. First, we find a declining trend TFP growth necessary to generate a persistent decline of GDP and inflation. Second, the increased risk premia have a sizeable effect on capital formation and third an increase in the NAWRU as often estimated for the

[11] One mechanism, which could lead to an increase in the wage share, is raising social security contributions. That this is important for EA countries has recently been demonstrated by Burda and Weder (2015).

EA is not inconsistent with the need to increase the wage mark-up in a standard DSGE model in order to generate a persistent decline of the employment rate.

REFERENCES[12]

Abiad, Abdul, Giovanni Dell'Ariccia and Bin Li (2011) "Creditless Recoveries." IMF Working Papers 11/58.

Bech M., L. Gambacorta and E. Kharroubi (2012) "Monetary policy in a downturn: Are financial crises special?" BIS Working Papers 388.

Bijsterbosch, M. and T. Dahlhaus (2011) "Determinants of Credit-less Recoveries." European Central Bank, Working Paper Series 1358.

Caballero, R., T. Hoshi and A. Kashyap (2008) "Zombie lending and depressed restructuring in Japan." American Economic Review, 98(5): 1943–77.

Cecchetti, S. G. and E. Kharoubbi (2012) "Reassessing the impact of finance on growth." BIS Working Paper 981.

Cecchetti, S. G., M. S. Mohanty and F. Zampolli (2011) "The real effects of debt." BIS Working Papers 352.

Cerra, Valerie, Ugo Panizza, and Sweta C. Saxena (2009) "International Evidence on Recovery from Recessions." IMF Working Papers 09/183.

Claessens, S., A. Kose and M. Terrones (2009) "What happens during recessions, crunches and busts?" Economic Policy, 24(60): 655–700.

Cuerpo, Carlos, Ines Drumond, Julia Lendvai, Peter Pontuch and Rafal Raciborski (2013) "Indebtedness, Deleveraging Dynamics and Macroeconomic Adjustment." European Economy. Economic Papers. 477.

Eggertsson, Gauti B., and Paul Krugman (2012) "Debt, Deleveraging, and the Liquidity Trap: A Fisher- Minsky-Koo Approach." Quarterly Journal of Economics, 127(3): 1469–1513.

Gertler, Mark and Karadi Peter (2011) "A model of unconventional monetary policy." Journal of Monetary Economics, 58(1): 17-34.

In 't Veld, J., R. Raciborski, M. Ratto and W. Roeger (2011) "The Recent Boom-Bust Cycle: The Relative Contribution of Capital Flows, Credit Supply and Asset Bubbles. " European Economic Review, 55: 386-406.

In 't Veld, J., Kollmann, R., Pataracchia, B., Ratto, M., Roeger, W. (2014), "International Capital Flows and the Boom-Bust Cycle in Spain", Journal of International Money and Finance, vol. 48, pages 314-335.

Jermann, Urban and Vincenzo Quadrini (2012) "Macroeconomic Effects of Financial Shocks." American Economic Review, 102(1): 238-71.

[12] Note: references to be updated

Justiniano, Alejandro and Primiceri, Giorgio and Tambalotti Andrea (2015) "Household Leveraging and Deleveraging." Review of Economic Dynamics, 18(1): 3-20

Kindleberger, Charles P. (1978) Manias, Panics, and Crashes: A History of Financial Crises. New York: Basic Books.

Kiyotaki, Nobuhiro, and John Moore (1997) "Credit Cycles." Journal of Political Economy, 105: 211–248.

Lamont, O. (1995) "Corporate-Debt Overhang and Macroeconomic Expectations." American Economic Review, 85(5): 1106-17.

Maudos, Joaquín (2013) "Fragmentation of the European financial market and the cost of bank financing." Spanish Economic and Financial Outlook 2(3).

Minsky, Hyman P. (1977) "The Financial Instability Hypothesis: An Interpretation of Keynes and an Alternative to 'Standard' Theory." Nebraska Journal of Economics and Business 16(1): 5–16.

Philippon, T. (2010) "Debt Overhang and Recapitalization in Closed and Open Economies", IMF Economic Review, 58(1): 157-78.

Schularick, Moritz and Allan M. Taylor (2012) "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870–2008." American Economic Review, 102(2): 1029–1061.

Takats, Elod and Christian Upper (2013) "Credit and growth after financial crises." BIS Working Papers 416.

Figure 6: Private Deleveraging Shock (solid blue line: model, dashed black line: data)

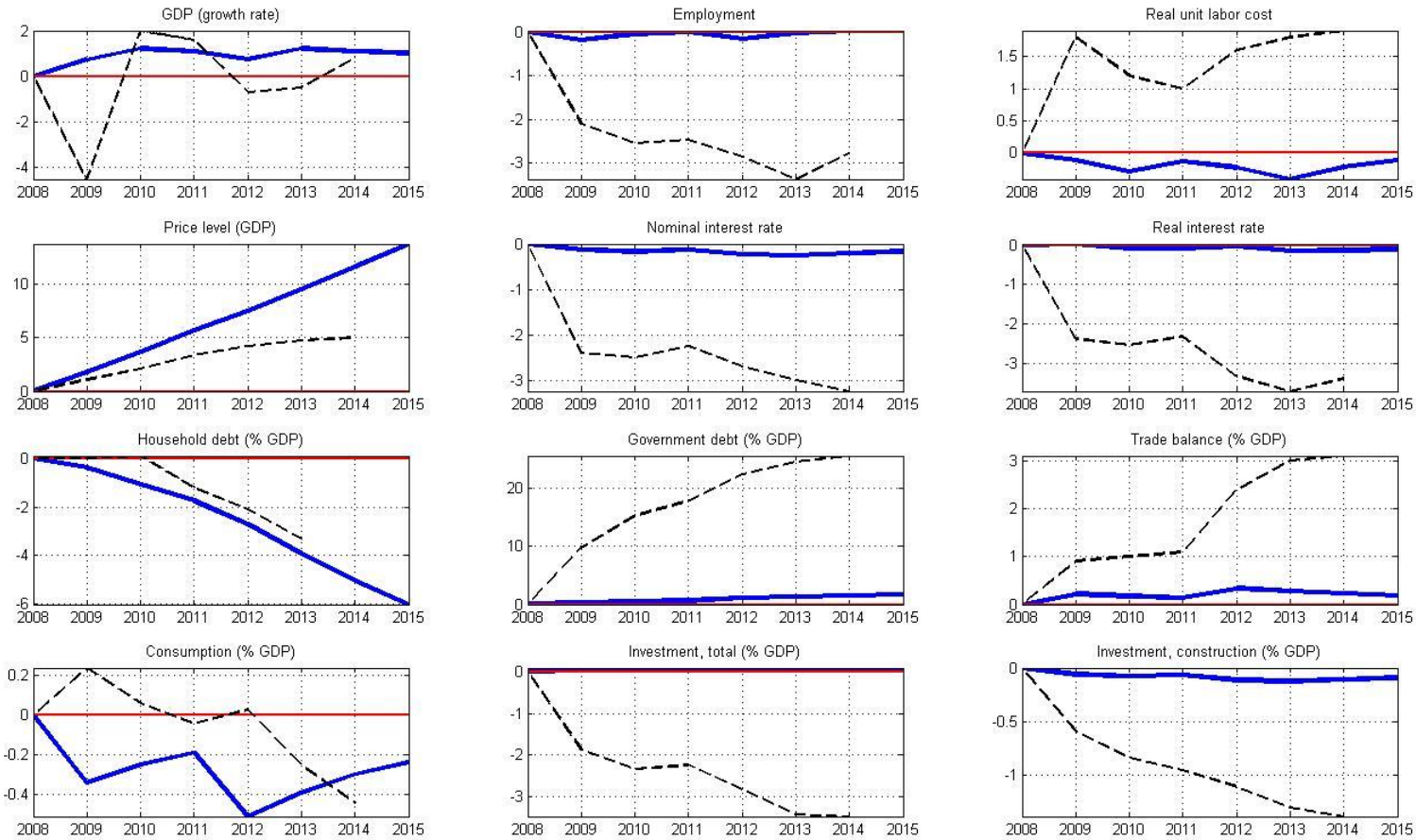


Figure 7: Fiscal Shock (solid blue line: model, dashed black line: data)

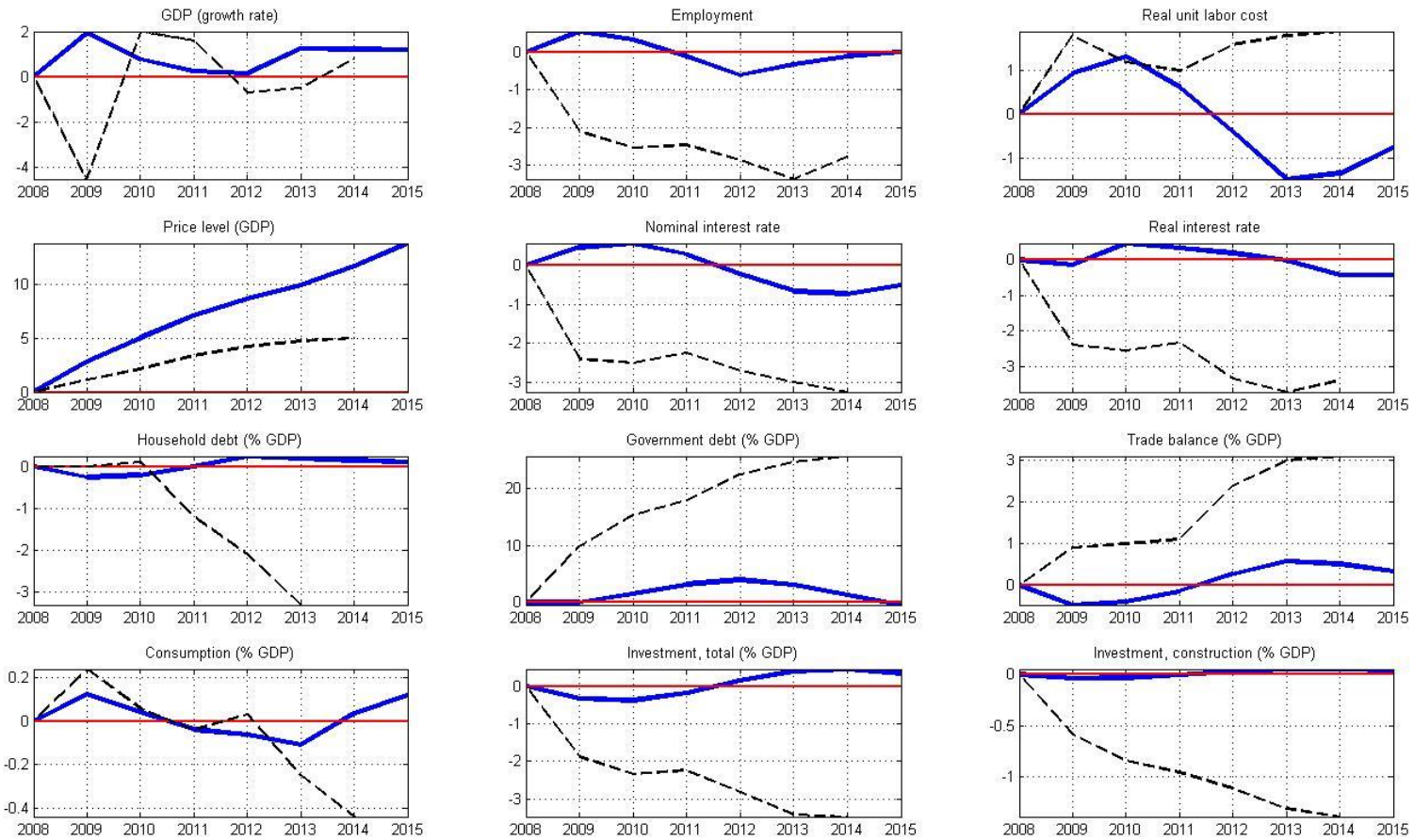


Figure 8: TFP Shock (solid blue line: model, dashed black line: data)

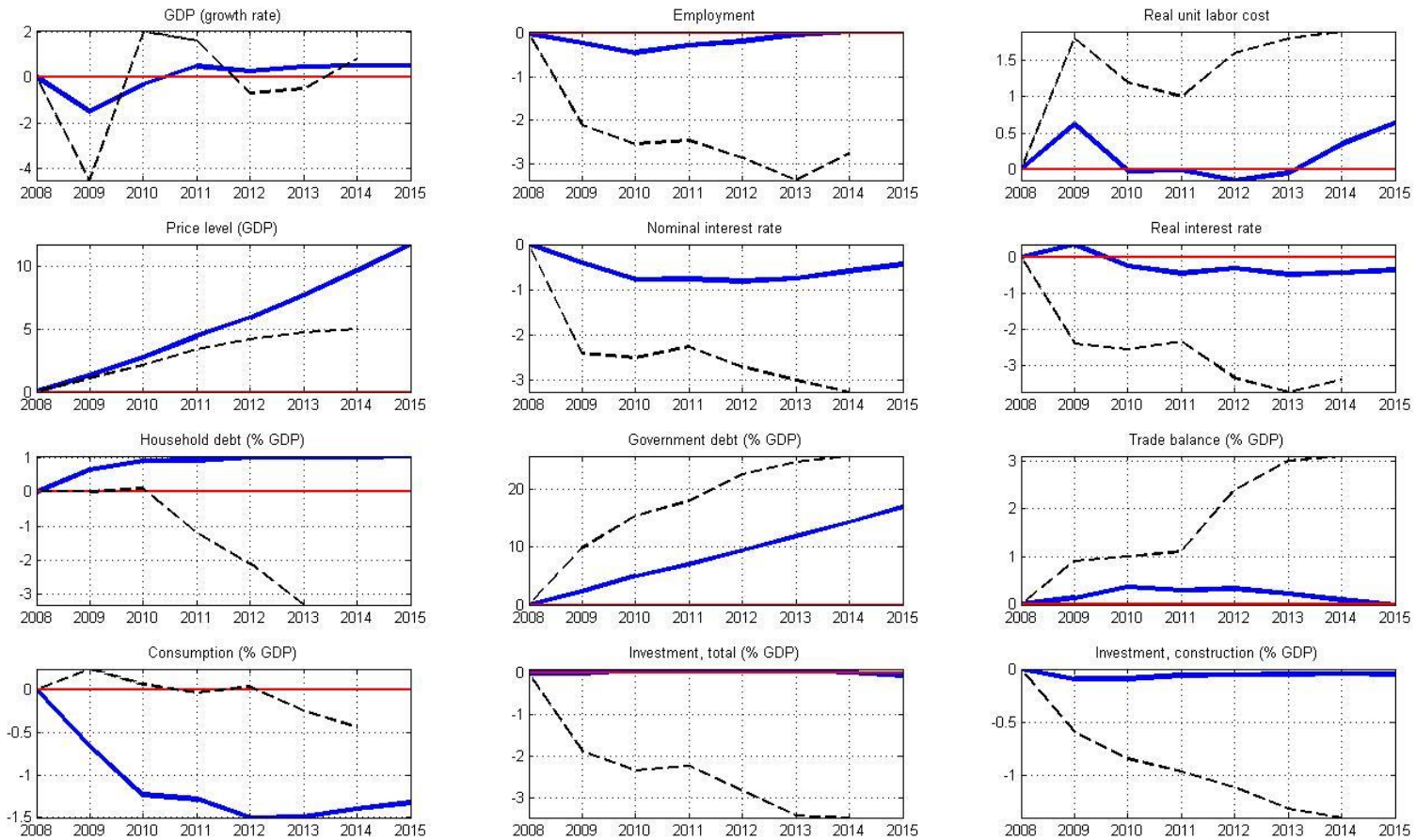


Figure 9: Risk Premium Shock (solid blue line: model, dashed black line: data)

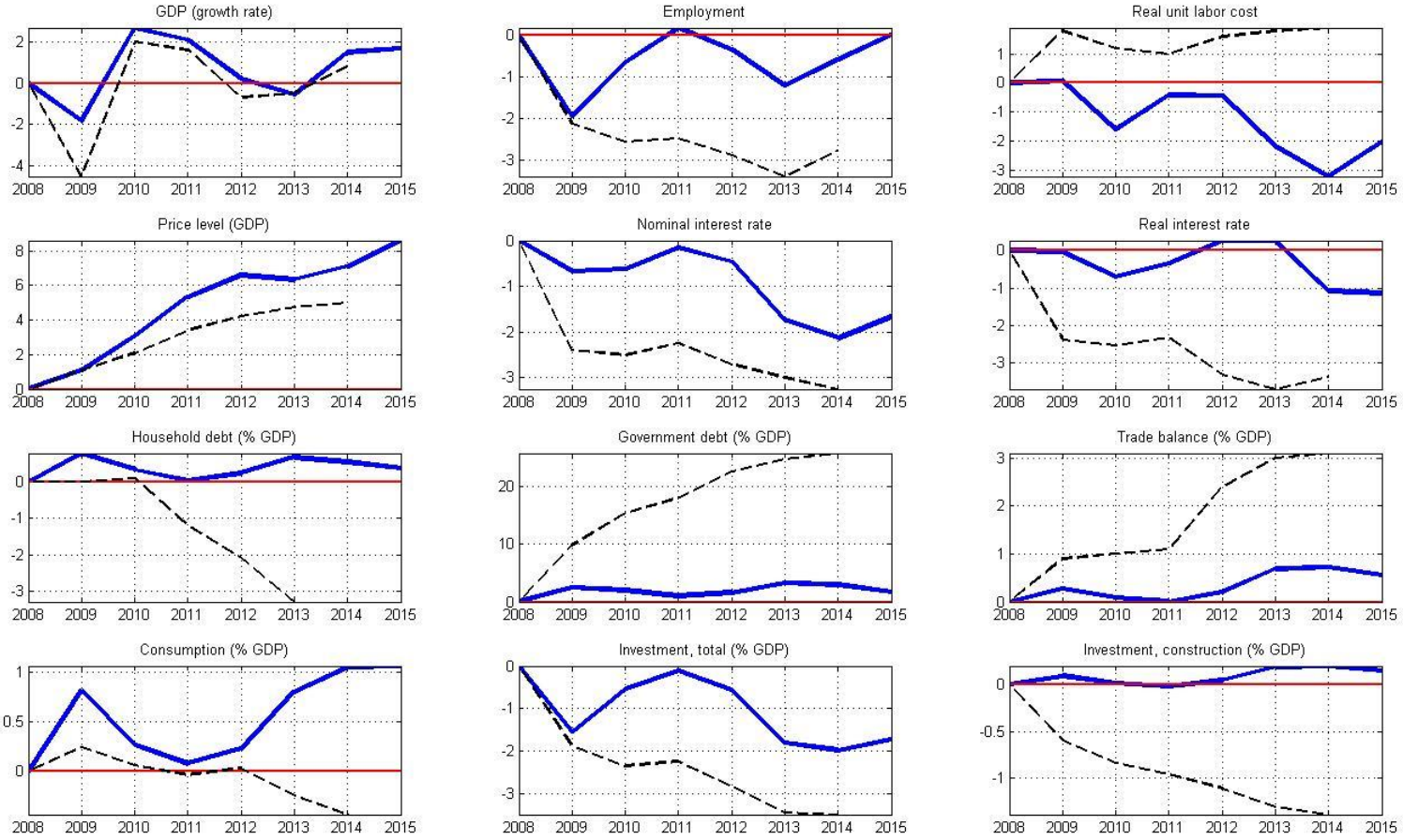


Figure 10: Housing Risk Premium Shock (solid blue line: model, dashed black line: data)

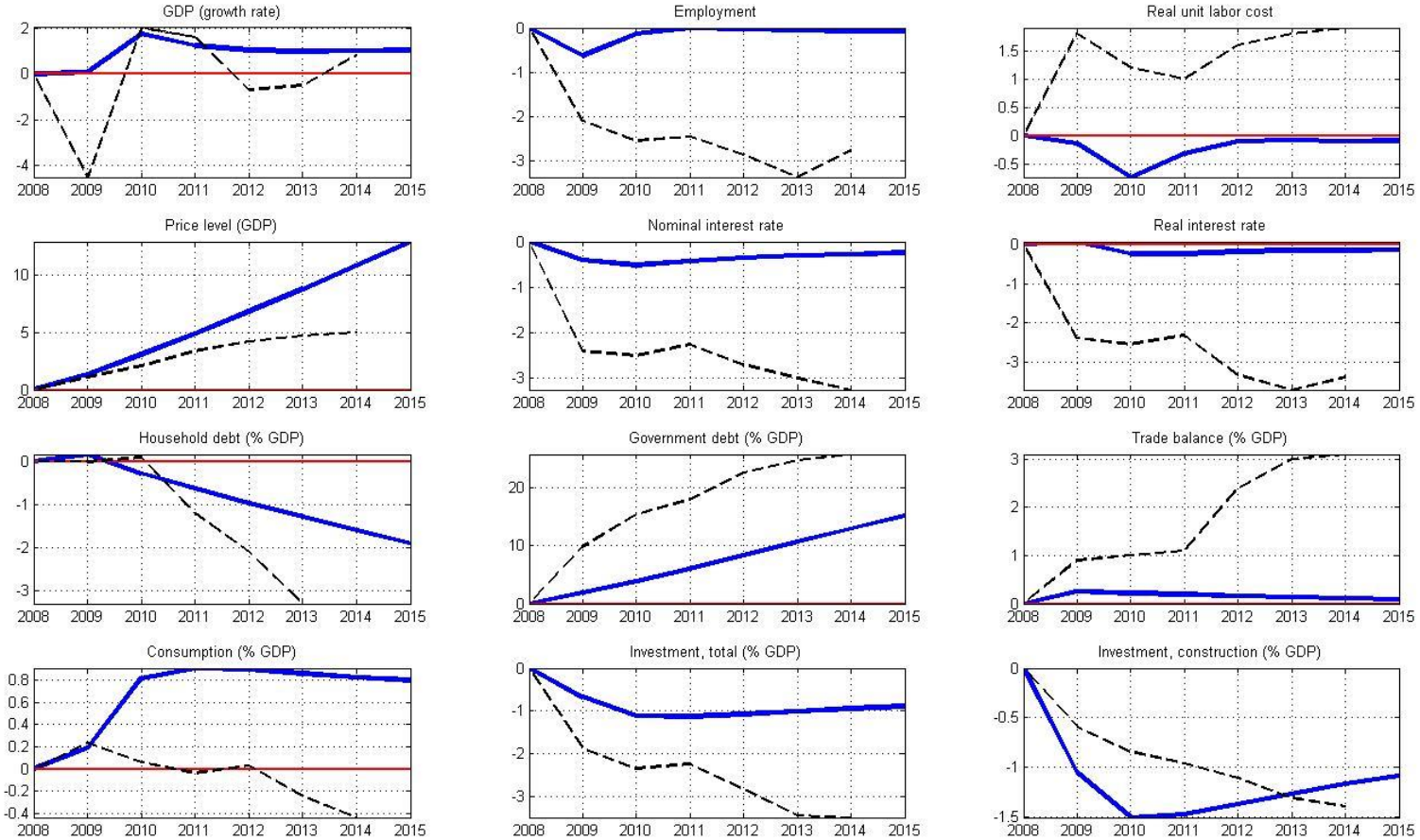


Figure 11: Wage Mark-up Shock (solid blue line: model, dashed black line: data)

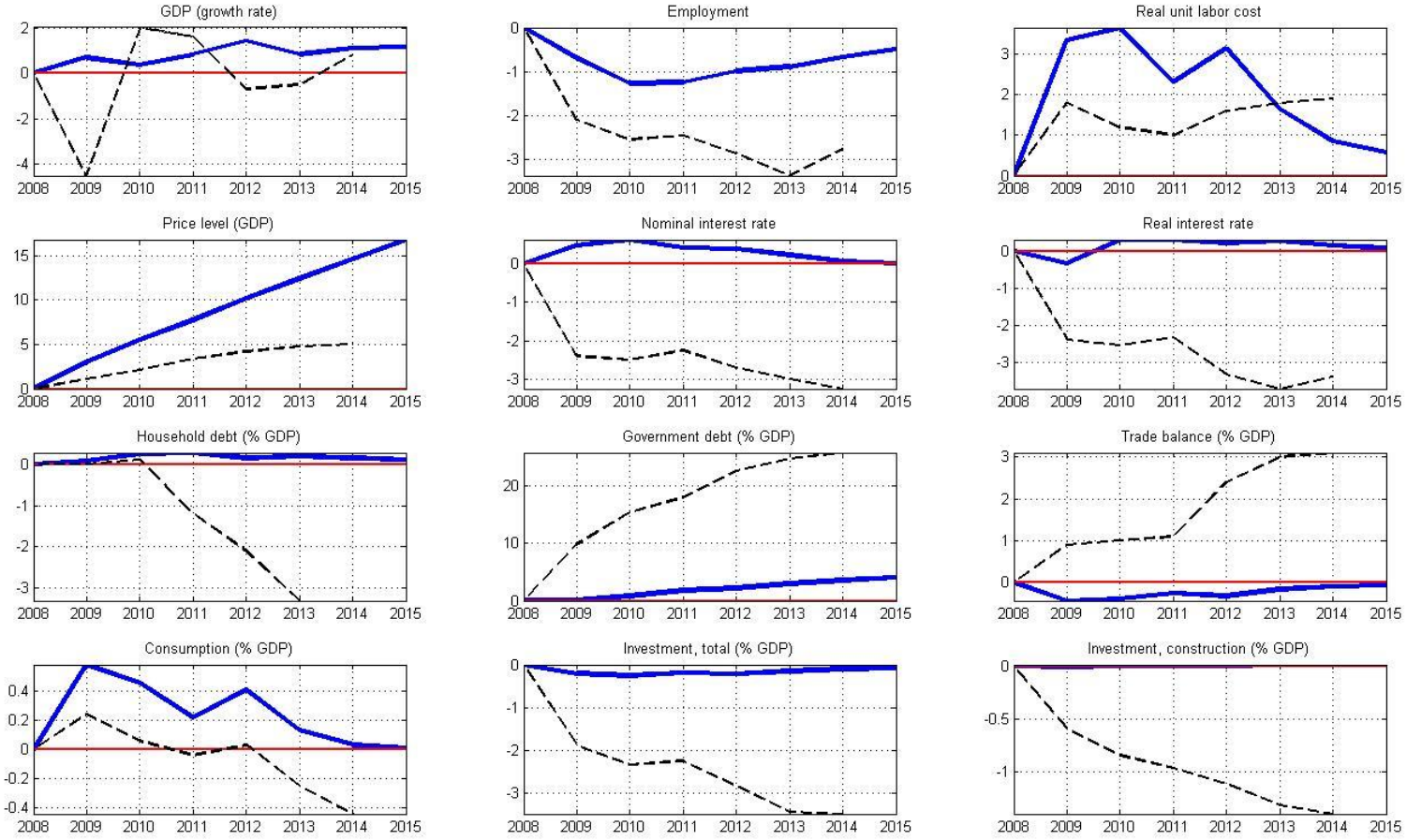


Figure 12: All Shocks Combined (solid blue line: model, dashed black line: data)