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The macroeconomic effects of the Euro Area's fiscal consolidation 2011-2013: A Simulation-based approach

Ansgar Rannenberg, Christian Schoder & Jan Stráský

Banc Ceannais na hÉireann
Central Bank of Ireland
Eurosystem

Non-Technical Summary

Since 2010, fiscal policy in the Euro Area (EA) turned progressively more restrictive. According to estimates by the European Commission (2012), spending cuts and tax increases accumulated to about 4% of annual Euro Area GDP between 2011 and 2013. The switch to fiscal austerity has been associated with a return of the EA economy to recession. The role of the fiscal consolidation in driving the Euro Area's disappointing economic performance is uncertain and disputed. This paper gauges the impact of this policy employing variants of two DSGE models used for policy analysis by the ECB (the New Area Wide Model, NAWM) and the European Commission (QUEST III). We find that, first, the simulated effect of the Euro Area's fiscal consolidation strongly depends on one's view regarding the expected persistence of the measures anticipated by the agents. If agents believe the measures to be permanent, the consolidation might even have been expansionary due to strong riccardian effects. However, it is plausible to assume that households and firms did not expect the measures to permanent, and have a finite horizon due to some degree of myopia. We operationalize these concerns by simulating the measures as very persistent but not permanent. In this scenario, which we treat as our baseline, GDP contracts in both models, with the cumulative multiplier of the fiscal consolidation amounting to 0.7 and 1.0 over the 2011-2013 period, respectively. The government debt-to-GDP ratio declines below the non-consolidation case only after one or three years. We then investigate the impact of two plausible enhancements of the degree of financial frictions in the models. First, we add a reasonably parameterised financial accelerator along the lines of Bernanke et al. (1999). As a result, the output contraction becomes considerably bigger. Second, we allow for a plausible crisis-related increase of the share of liquidity constrained households. With both of these enhancements, the debt-to-GDP ratio increases for 4 or 5 years relative to the non-consolidation case. The cumulative multiplier equals 1.3. These results would imply that, in our baseline scenario, fiscal consolidation is responsible for between one third (NAWM) and one half (QUEST III) of the decline of the Euro Area's output gap from the beginning of 2011 until the end of the EA's recent recession in 2013, with the share rising to about 80% in the presence of enhanced financial frictions. Moreover, most of the output costs of fiscal consolidation could have been avoided if it had been postponed until the zero lower bound constraint on monetary policy was no longer binding, and under such conditions the government debt-to-GDP ratio could have been reduced much more quickly.

The macroeconomic effects of the Euro Area's fiscal consolidation 2011-2013: A Simulation-based approach.*

Ansgar Rannenberg[†] Christian Schoder[‡] Jan Stráský[§]

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Abstract

We simulate the Euro Area's fiscal consolidation between 2011 and 2013 by employing two DSGE models used by the ECB and the European Commission, respectively. The cumulative multiplier amounts to 0.7 and 1.0 in the baseline, but increases to 1.3 with a reasonably calibrated financial accelerator and a crisis-related increase of the share of liquidity constrained households. In the latter scenario, fiscal consolidation would be largely responsible for the decline in the output gap from 2011-2013. Postponing the fiscal consolidation to a period of unconstrained monetary policy (until after the economic recovery) would have avoided most of these losses.

Keywords: Fiscal policy simulations, fiscal consolidation, fiscal multiplier, Euro Area
JEL Classification: E32, E62

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[†]Central Bank of Ireland and Macroeconomic Policy Institute; Ansgar.Rannenberg@centralbank.ie

[‡]Vienna University of Economics and Business, Welthandelsplatz 1, Building D4, 1020 Vienna; christian.schoder@wu.ac.at

[§]Organisation for Economic Co-operation and Development (OECD), 2 rue André Pascal, 75016 Paris; jan.strasky@oecd.org

1 Introduction

In 2010, when the Euro Area (EA) was just for about a year into recovery from the downturn caused by the world financial crisis, fiscal policy in the EA turned progressively more restrictive. According to estimates by the European Commission (2012b) which are reported in Table 1, spending cuts and tax increases accumulated to about 4% of annual Euro Area GDP from 2011 and 2013. The switch to fiscal austerity has been associated with a return of the EA economy to recession by the end of 2011, from which it emerged by the middle of 2013, thereby repeatedly undershooting predictions by the European Commission, the IMF and the OECD. The role of the fiscal consolidation in driving the Euro Area's disappointing economic performance is uncertain and disputed. Blanchard and Leigh (2013) argue that the growth forecast errors in the IMF's and the European Commission's projections are systematically positively correlated with the size of fiscal consolidation in 2010 and 2011, suggesting that these institutions have consistently underestimated the adverse effects of austerity, and that the multiplier was in fact substantially larger than one. However, others have challenged this result.[1]

This paper therefore gauges the impact of the Euro Area's fiscal consolidation employing variants of two DSGE models used for policy analysis by the ECB (the NAWM) and the European Commission (QUEST III). We find that, first, the simulated effect of the Euro Area's fiscal consolidation strongly depends on one's view regarding the expected persistence of the measures anticipated by the agents. If agents believe the measures to be permanent, the consolidation might even have been expansionary, depending on the model used, due to strong riccardian effects. However, it is plausible to assume that households and firms did not expect the measures to permanent, and have a finite horizon due to some degree of myopia. We operationalize these concerns by simulating the measures as very persistent but not permanent. In this scenario, which we treat as our baseline, GDP contracts in both models, with the cumulative multiplier of the fiscal consolidation amounting to 0.7 and 1.0, respectively. The government debt-to-GDP ratio declines below the non-consolidation case after one or three years. We then investigate the impact of two plausible enhancements of the degree of financial frictions in the models on the costs of fiscal consolidation. First, we add a reasonably parameterized financial accelerator along the lines of Bernanke et al. (1999). As a result, the contraction becomes considerably bigger, and the government debt-to-GDP ratio remains above the non-consolidation case for longer. Second, we allow for plausible crisis-related increase of the share of liquidity constrained households, which we calibrated to equal 48% based on the recent ECB Household Finance and Consumption Survey (HFCS 2013). In the presence of both the financial accelerator and an increased share of liquidity constrained households, the debt-to-GDP ratio increases for 4 or 5 years relative to the non-consolidation case. The cumulative multiplier over the 2011-2013 period equals 1.3.

These results would imply that, in our baseline scenario, fiscal consolidation is responsible for between one third (NAWM) and one half (QUEST III) of the decline of the Euro Area's output gap from the beginning of 2011 until the end of the EA's recent recession in 2013, with the share rising to about 80% in the presence of both a financial

[1] European Commission (2012a) and Lewis and Pain (2015) argue that the evolution of sovereign bond yields is a more important source of errors than the underestimation of the effects of fiscal consolidation.

accelerator and an increased share of rule of thumb households. Moreover, most of the output costs of fiscal consolidation could have been avoided if it had been postponed until the zero lower bound constraint on monetary policy was no longer binding, and under such conditions the government debt-to-GDP ratio could have been reduced much more quickly.

Other quantitative assessments of the effects of the fiscal consolidation in the EA using structural models have been conducted by Holland and Portes (2012), European Commission (2012b) and in 't Veld (2013). Holland and Portes (2012) find austerity to be self-defeating but use the National Institutes Global Economic Model (NIGEM), which is a large scale macro-econometric model with loose microfoundations. The European Commission (2012b) finds a fairly low multiplier effect based on a version of QUEST III. However, in their simulation monetary policy is constrained only in 2012, which in our view is too short. Similarly to us, in 't Veld (2013) also uses QUEST III and allows for significant constraints on monetary policy and a degree of fiscal policy credibility more limited than we do, and an elevated share of liquidity constraint households. He finds substantial intra-EA spillovers of simultaneous consolidation in different member states, but does not report GDP effects for the EA aggregate. Finally, Gechert et al. (2015) follow a reduced form approach by applying fiscal multipliers from the meta-regression analysis of Gechert and Rannenberg (2014) to the Euro Area's fiscal consolidation effort, and find very large effects.

The paper proceeds as follows. Section 2 reviews the models employed and discusses some initial changes we make to them. Section 3 addresses some important issues of the simulation design and presents our baseline results. Section 4 analyses the effects of adding to the models a financial accelerator and increasing the share of liquidity constrained households. Furthermore, we illustrate the degree to which fiscal consolidation contributed to the weak performance of the Euro Area economy over the 2011-2013 period under the various scenarios considered. Section 5 discusses the evidence for and against the so-called sovereign risk channel of fiscal policy, and shows how results are affected if a conventional sovereign risk channel is added. Section 6 concludes.

2 Reviewing and adapting the NAWM and QUEST III

Our simulations are based on adapted versions of two open economy medium-scale DSGE models of the EA, namely the ECB's New Area Wide Model (NAWM) published in Coenen et al. (2008) and the QUEST III model developed by the European Commission and published in Ratto et al. (2009), with sticky prices, wages and many other common standard features. Both are two region models of the EA and the US (NAWM) and the rest of the world in reduced form (QUEST III), respectively. All models feature a considerable degree of dis-aggregation of government revenues and expenditures and are, therefore, suitable for fiscal policy simulations While the parameters of QUEST III have been estimated by Ratto et al. (2009) on 1981Q1 to 2006Q1 data, the parameters in the NAWM were largely calibrated by Coenen et al. (2008) to estimates of the Smets and Wouters model of the Euro Area (Smets and Wouters 2003). Apart from the so-called *Ricardian* households with frictionless access to financial markets and infinite horizon, both models are also populated by a fraction of households whose consumption is closely linked to their current disposable income. In QUEST III, consumption of these households simply equals their disposable income. In the NAWM, they have considerable money holdings, which limits their consumption response to declines in their disposable income.

Both models feature lump sum taxes and transfers as well as distortionary taxation on wages, profits and consumption, implying that an economic downturn adversely affects government revenues. Regarding the government's expenditure on goods and services, unproductive government consumption appears in both models, while QUEST III also incorporates government investment, which enhances the total factor productivity of private companies. Hence, we add public capital also to the Euro Area bloc of the NAWM, so as to be able to distinguish between cuts of public investment and public consumption. The elasticity of private production with respect to public capital has been calibrated as in Freedman et al. (2010) and Stähler and Thomas (2012). In particular, private sector output $Y_{f,t}$ is now determined by

$$Y_{f,t} = z_t K_{g,t}^{\alpha_g} K_{f,t}^{\alpha} L_{f,t}^{1-\alpha} - \psi$$

where z_t, $K_{g,t}$, $K_{f,t}$ and $L_{f,t}$ denote exogenous productivity, the government capital stock, the private capital stock, and private sector employment, respectively.

Furthermore, QUEST III features transfers to households depending negatively on the deviation of employment from trend, expressed as a fraction of the average real wage. We add this automatic stabilizer to the NAWM as well. This modification somewhat lowers the adverse consequences of fiscal consolidation by stabilizing non-Ricardian household consumption while increasing the feedback of the state of the economy to the fiscal balance. More specifically, we assume that for each household type h, employment related transfers $T_{h,t}^N$ are given by

$$T_{h,t}^N = -0.597 * w_{h,t}(N_{h,t} - N_h)$$

where $w_{h,t}$, $N_{h,t}$ and N_h denote the real wage, employment and steady state employment of household type h, respectively.

In the original version of the models, the fiscal rule relates lump-sum taxes to the level of public debt, so as to keep public debt as a share of GDP stationary in the long run. We assume for both models that the government instead uses the distortionary wage tax as an instrument in the fiscal rule, which is arguably more realistic. Furthermore, to the extent that fiscal consolidation succeeds in lowering the government's debt-to-GDP ratio persistently, the gains from fiscal consolidation are also likely to be higher. More formally, the wage tax is set in response to deviations of the debt-to-GDP ratio from its target and the lagged labor tax

$$\tau_t^w - \tau^w = \rho(\tau_{t-1}^w - \tau^w) + (1-\rho)\phi^w(((B_{t-1})/(P_{t-1}Y_{t-1})))$$

with τ_t^w, B_{t-1} and $P_{t-1}Y_{t-1}$ denoting the wage tax, the stock of government debt and nominal GDP, respectively, with $\rho, \phi^w > 0$. In order to limit the short run endogenous response of the labor tax to the consolidation measures as much as is consistent with a long-run stationary government debt-to-GDP ratio, we calibrate ρ and ϕ^w to 0.99 and 0.04.

Both models feature monetary policy rules relating the central bank interest rate to inflation and measures econmic activity. In the NAWM, we modify the policy rule and assume that the interest rate is described by

$$R_t^4 = \phi_R R_{t-1}^4 + (1-\phi_R)\left[R^4 + \phi_\Pi\left(\frac{P_{C,t}}{P_{C,t-4}} - \Pi\right) + \phi_{gY}\left(\frac{Y_t}{Y_{t-1}} - g_Y\right)\right]$$

with $\phi_{gY} = 0.612$, as in the estimated version of the NAWM by Christoffel et al. (2008). By contrast, the rule specified by Coenen et al. (2008) is

$$R_t^4 = \phi_R R_{t-1}^4 + (1-\phi_R)\left[R^4 + \phi_\Pi\left(\frac{P_{C,t}}{P_{C,t-4}} - \Pi\right)\right] + \phi_{gY}\left(\frac{Y_t}{Y_{t-1}} - g_Y\right)$$

with R_t^4, $\frac{P_{C,t}}{P_{C,t-4}}$ and $\frac{Y_t}{Y_{t-1}}$ denoting the annualized nominal interest rate, inflation and quarterly GDP growth. Note that the implied nominal output growth rate response is given by $\frac{\phi_{gY}}{(1-\phi_R)} = \frac{0.1}{1-0.95} = 2$. This is much higher than what is typically estimated. In simulations where the the monetary policy rule is switched off for a number of quarters to approximate the zero lower bound, which will be the case in most of the simulations reported below, this calibration dramatically *increases* the adverse output effects of fiscal consolidation. The reason is that once the rule is switched back on, the EA-economy is already recovering from the adverse affects of fiscal consolidation and thus a response to output growth tends to increase the nominal interest rate. As we do not consider the mechanism plausible, we re-paramterize the policy rule as just discussed.

3 The simulation design and our baseline results

In this section, we first address some important questions regarding the simulation design, namely the composition of the fiscal consolidation, the duration of the fiscal consolidation measures expected by agents and the expected length of the zero lower bound constraint. We then present some initial simulation results, and make the case for increasing the degree of nominal wage rigidity present in both models. That allows us to limit the decline of inflation caused by the fiscal consolidation to plausible magnitudes.

3.1 Magnitude and composition of the fiscal consolidation

The components of the consolidation package are summarized in Table 1, which is taken from European Commission (2012b). The table lists estimates of the budgetary effects of the legislated changes in individual expenditure items and taxes in the respective year, holding GDP and the tax base constant (the so called "ex-ante" effect, as it abstracts from endogenous changes in government expenditure and the tax base). For instance, in 2011, consumption taxes are increased such that holding the level of consumption and GDP constant, revenues would increase by 0.3% of GDP. Following that, in 2012 and 2013, consumption taxes are increased again such that revenues rise by 0.4% and 0.2%

Table 1: Ex-ante deficit effects of consolidation measures implemented in the EA, % of GDP

	2011	2012	2013
Consumption taxes	0.3	0.4	0.2
Labor taxes	0	0.3	0
Corporate taxes	0.1	0	0
Social security contributions	0.2	0	0
Total revenue	0.6	0.7	0.2
Transfers	-1	-0.2	-0.3
Consumption expenditure	-0.2	-0.2	-0.1
Gross fixed capital formation	-0.2	-0.2	0
Total expenditure	-1.4	-0.6	-0.4

Notes: Source: European Commission (2012). The numbers reported indicate by how much the respective measure affects the public deficit as percent of GDP assuming everything else staying the same.

respectively. Similarly, transfer are cut by 1.0%, 0.2% and 0.3% in 2011, 2012 and 2013 respectively. Hence by the end of 2013, the total deviation of expenditures from their path in the absence of fiscal consolidation amounts to 2.4% of GDP (the sum of the "total expenditure" line of the table)), while the total deviation of revenue amounts to 1.5% of GDP, implying that by 2013, the total fiscal impulse amounts to 3.9%. The fiscal consolidation is dominated by expenditure changes, which in turn are dominated by transfer cuts (1.5 % of GDP by 2013).

Regarding the distribution of the transfer cuts, we assume that transfer cuts are borne largely by liquidity constrained households. For a specific numerical estimate, we draw on Broda and Parker (2014), who estimate a marginal propensity to consume out of 2008 US stimulus payments for working households of 0.74 based on the Nielsen Consumer Panel and National accounts data. We therefore assume that 74% of the transfer cuts are distributed to non-Ricardian households.[2] We do so because we are not aware of data on how transfer cuts were distributed across different income groups in the Euro Area. However, since transfer systems exist for redistributive purposes, it seems likely that such households are hurt disproportionately by transfer cuts. OECD (2012) and Rawdanowicz et al. (2013) provide evidence that transfer cuts tend to increase inequality of disposable income.

[2]Note that in the NAWM, the marginal propensity to consume out of the transfer cuts will be below 0.74, as liquidity constrained households in that model hold some transaction balances they can draw on, as mentioned above.

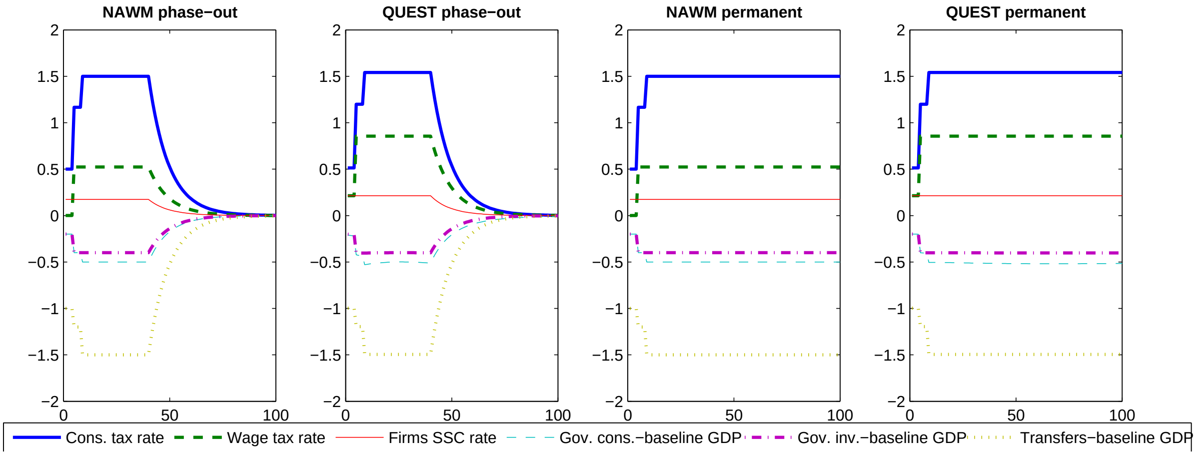

Figure 1: The paths of the fiscal instruments implied by the EA fiscal consolidation package (summarized in Table 1) assuming temporary measures (left panels) and permanent measures (right panels), respectively.

3.2 Perceived duration of consolidation measures

In an infinite horizon environment, fully credible permanent expenditure cuts will tend to crowd in the consumption of Ricardian households who anticipate that a lower future share of output consumed by the government implies higher future private consumption, as shown in the context of a stylized model by Denes et al. (2013), and also pointed out by European Commission (2012b). Thus, the smaller multipliers of permanent measures crucially depend on the infinite horizon assumption.

However, it is plausible to assume that governments cannot commit to permanent expenditure cuts. Political resistance against the cuts has been mounting in many Euro Area member states. What is more, the infinite horizon assumption is arguably unrealistic and results might differ if forward-looking agents have a certain degree of myopia, as for instance in the GIMF model of the IMF, in which the planning horizon is only 10 years in some versions of the model (Kumhof et al. 2010).[3] An operational approach to account for the existence of myopia in the models we use is to simulate the consolidation measures as temporary.

Based on these considerations, in our baseline simulation, we assume that the measures are kept in place for 10 years, after which they are gradually phased out following an AR(1) process with a coefficient of 0.9. Note that our assumed duration of the consolidation measures is considerably longer than what is assumed in in 't Veld's (2013) baseline specification, where measures are kept in place for one year and are then phased out with an autoregressive coefficient of 0.9. Thus, the Ricardian effects limiting the adverse effects of fiscal consolidation will also be higher in our case. The predicted trajectories of the fiscal instruments as implied by the consolidation package implemented in the EA are plotted in Figure 1 for the case of temporary measures (left) and for the case of permanent measures (right).

[3]Other authors interpreting the horizon of households in finite horizon models as myopia are Kumhof and Laxton (2013) and Almeida et al. (2013)

3.3 Perceived duration of the zero lower bound

The second key issue is the monetary policy response to the decline in output and inflation caused by the fiscal consolidation. In our simulations, we switch off the monetary policy rule after 6 quarters (i.e. in 2012Q3) and switch it on again after three years (i.e. 2015Q3). This is similar to what is assumed by in 't Veld (2013). In the NAWM, we assume that the Federal Reserve Bank is constrained by the zero lower bound for three years.

This calibration choice is based on the following observations. At the beginning of 2011, the Euro Over-Night Index Average (EONIA) rate was already at a quite low level of 0.7% and was reduced to close to its effective zero lower bound by the second half of 2012. Arguably, this reduction would have taken place even in the absence of fiscal consolidation, as the financial sector problems had a contractionary effect on the EA economy via a tightening of credit markets and increased the borrowing costs for non-financial corporations. Al-Eyd and Berkmen (2013) estimate that bank funding pressures increased lending rates on small loans by about 1 percentage point in both 2012 and 2013. Other contributions also find a negative effect of the sovereign debt crisis on lending.[4] Furthermore, there is microeconomic evidence that credit supply restrictions adversely affected non-financial firms employment and investment decisions in periphery countries (Bentolila et al. 2013, Garicano and Steinwender 2013).

We simulate the funding-pressure-related increases in the cost of external finance found by Al-Eyd and Berkmen (2013) for 2012 and 2013 as a persistent shock to the wedge between the central bank interest rate and the cost of funding of private households and financial intermediaries. We set the first-order auto-regressive coefficient to 0.95 and assume that the ECB follows the monetary policy rule discussed above. As can be seen in Figure 2, output and inflation decline sharply and, as a result, the ECB's interest rate declines by about 0.7 percentage points for more than 8 years.[5]

The very large output and inflation effects in the model arise because the central bank responds only to inflation and output growth, rather than responding directly to the shocks arising from the financial market, which in our simulation are captured by the exogenous risk wedge. However, the the ECB's decision to start lowering the main refinancing rate as well as its unconventional monetary policies, such as the Longer-Term Refinancing Operation (LTRO) and the Outright Monetary Transactions (OMT) programme, were arguably responses to problems in the banking sector and financial markets in general and contributed to the lowering of the EONIA rate. A direct response

[4] Bedendo and Colla (2013) find a statistically significant impact of sovereign risk on the credit risk of non-financial corporations in the Euro Area from January 2008 to December 2011. The magnitude is about one fourth of the impact on financial institutions' credit risk as estimated by Acharya et al. (2011). De Marco (2013) argues that the sovereign debt crisis considerably reduced corporate credit supply and increased the lending rates in the EU between 2009 and 2012. The ECB interventions, Longer-Term Refinancing Operations in December 2011 (LTRO 1) and February 2012 (LTRO 2) are argued not to have alleviated the impact of the credit crunch. Bofondi et al. (2013) put forward some evidence for Italian bank-firms relationships between December 2010 and December 2011 suggesting that lending of Italian banks grew on a rate 3%-points lower than the lending of foreign banks. The sovereign debt crisis seems to have caused an increase of their interest rates by 15-20 basis points.

[5] If we increase the Calvo Wage parameter to 0.95, which, as discussed below, we will do in later simulations to account for downward nominal wage rigidity, the central bank interest rate is still reduced by this amount for more than three years.

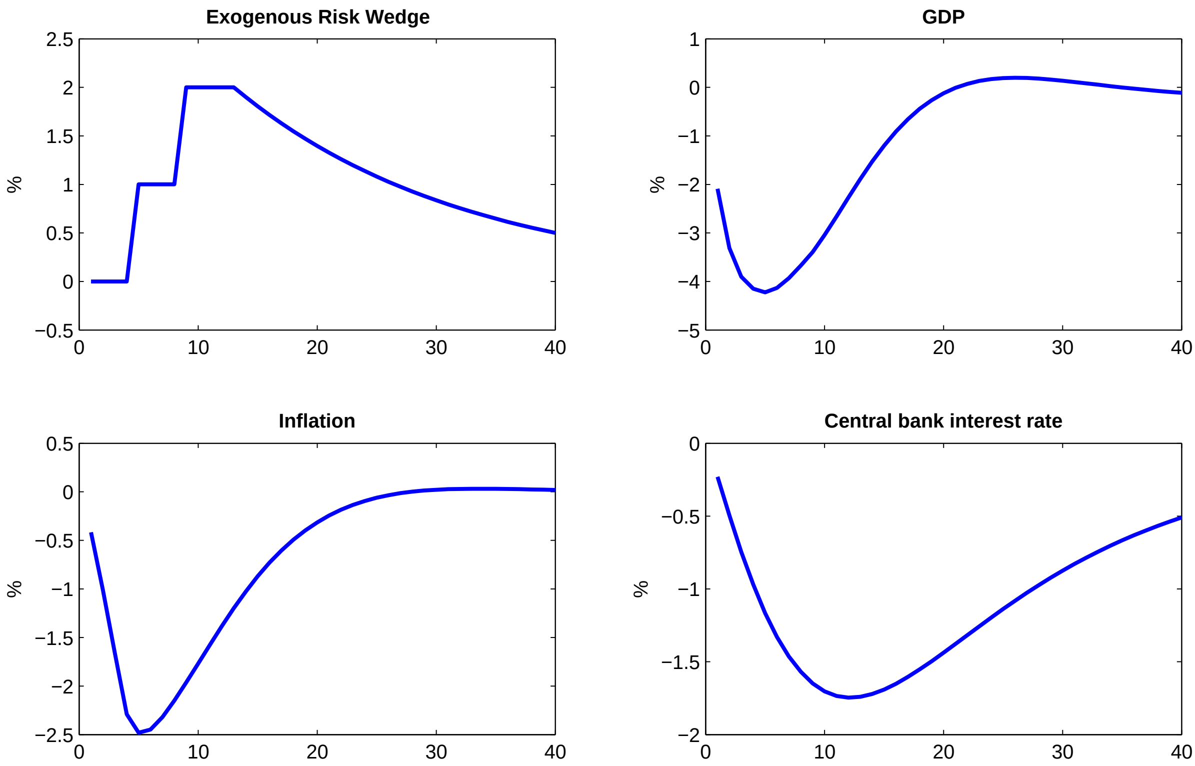

Figure 2: Responses of selected variables of the EA to a shock to the wedge between the central bank interest rate and and the interest rate paid by households and financial intermediaries. The wedge increases by one percentage point in both the first and the second year.

of the central bank interest rate to the exogenous risk wedge would cause a quicker, deeper and longer lasting reduction of the central bank interest rate and would thus limit the fallout of the financial market tensions for the real economy.

A three-year duration of the zero lower bound also appears to be broadly in line with financial market expectations. In 2012Q3, Bund and OIS yields suggested that financial markets expected the EONIA to be on average close to the zero lower bound (i.e. 0.25%) for three years (3). At the same time the one-year forward yield two years hence, implied by two- and three-year OIS, suggests average EONIA in the third year of 0.4% which is higher than the effective ZLB. OIS-based predictions of the most likely ZLB duration may be downward biased because the distribution of shocks affecting the EONIA is truncated close to the ZLB. Evidence of Lemke and Vladu (2014) is consistent with a downward bias of one year in August 2012.[6]

Finally, there was a widespread perception that during the period when the fiscal consolidation measures were implemented, the monetary transmission mechanism was

[6]Lemke and Vladu (2014) estimate that in August 2012 the most likely time span until the EONIA would cross the 50 bp threshold was 42 months, while the forward curve suggested 30 months. Unfortunately, the authors do not report results for the 25 bp threshold. However, if we assume that the difference between the date the forward curve predicts the crossing of the 25 bp threshold and the "true" most likely crossing date is the same as for the 50 bp threshold, the OIS yields from mid-2012 are consistent with an expected duration of the ZLB of three years.

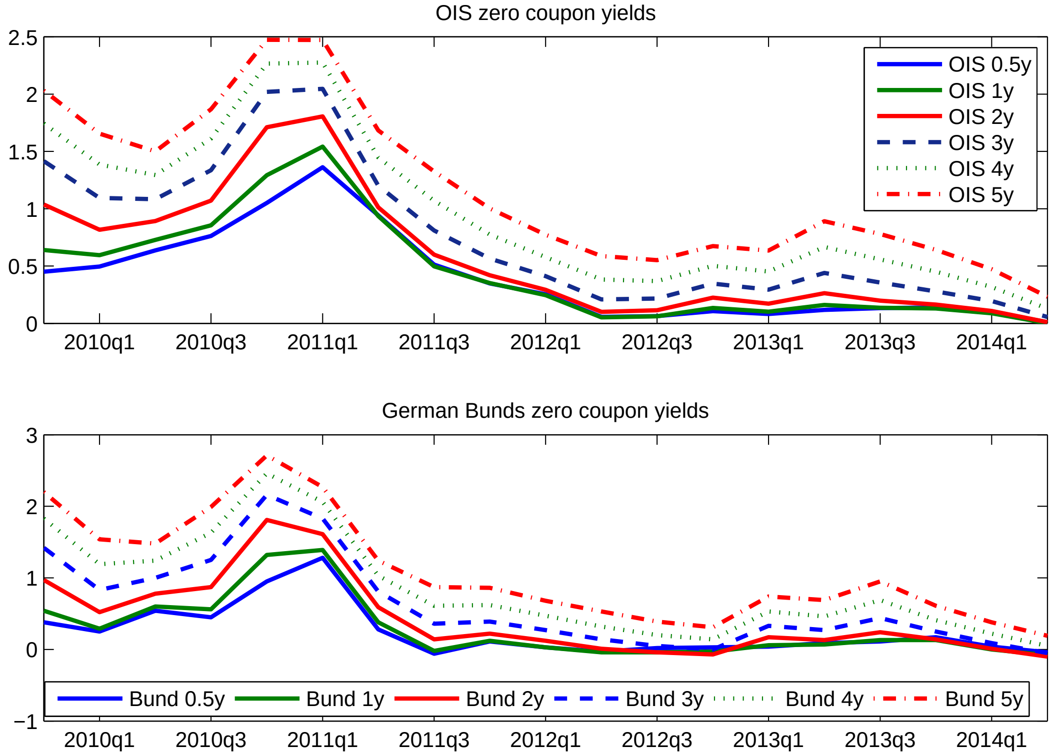

Figure 3: OIS and Germand Bunds zero coupon yields

malfunctioning (Cœuré 2013), due to problems in the banking sector and the European sovereign debt crisis. Changes in the EONIA rate were not completely passed through to the borrowing costs of households and non-financial firms. Such a phenomenon would effectively constrain monetary policy even before the central bank interest rate has hit the zero lower bound.

3.4 Baseline simulation results

In this section we present our baseline simulation results. They are based on first order approximations to the model's solutions. The switch-off of the monetary policy rule is implemented using an algorithm described in Appendix C. Let us first focus on the NAWM. As can be seen from Figure 4, in our baseline both the decline of inflation and output are very high. Nominal wage growth (not shown) declines by a similar magnitude as inflation. However, it appears implausible that fiscal consolidation caused such a huge decline in inflation. We therefore increase the Calvo wage parameter to 0.95, which results in a much smaller decline in inflation and GDP. Intuitively, with the monetary policy rule switched off for a significant number of periods, a decline in expected inflation increases the real interest rate, implying that the decline in consumption and investment tends to increase in the degree of nominal flexibility. This is in line with Eggertsson and Krugman (2012) as well as Bhattarai et al. (2014).

The increase the Calvo wage parameter can be justified on the grounds that downward nominal wage rigidity (Bewley (1998, 1999), Fabiani et al. (2010)) in the Euro Area was likely more severe during the period fiscal consolidation took place as compared to the (pre-financial crisis) period for which the NAWM was calibrated. At the macrolevel, such an increase is suggested by the observation that Euro Area inflation and nominal labor cost growth actually increased somewhat in 2011 and declined only later (Figure 5) in spite of an unemployment increase of 2 percentage, in stark contrast to the financial crisis related downturn, where core inflation and labor cost growth had visibly declined. Furthermore, Fabiani et al. (2015) report microevidence from the first two waves of the Wage Dynamics Network survey showing that in the cross section, the decline in average nominal wage growth was associated with a disproportional increase of the share of wage freezes. The share of employees experiencing wage freezes increased from 3.9% in 2007 to 34.4% in 2009, while the incidence of wage cuts increased by a mere 0.9 percentage points to 1.1%. This bunching of the wage change distribution at zero during the financial crisis suggests that any further increase in unemployment or excess capacity would lead to a smaller decline in nominal wage growth than during pre-crisis times, when both average inflation and nominal wage growth were higher and both wage cuts and freezes a very rare phenomenon. Furthermore, we have re-estimated the parameters of the QUEST III model governing wage and price rigidities for the period 2009Q1 to 2014Q4 using Bayesian Maximum Likelihood. Overall, the results suggest that wages in particular did become more rigid after 2009 and so did prices in some sectors. The estimation results are discussed in the appendix.

Turning to QUEST III, we run into the additional problem that under the original degree of nominal wage rigidity, the destabilizing effect of switching off the central bank reaction function is so high that the algorithm we use to impose the constant central bank interest rate fails to converge. Therefore the baseline results displayed in Figure 4 have been generated by setting the curvature of the degree of nominal wage adjustment cost such that up to first order, the coefficient on the wage markup is the same as in the NAWM, i.e. corresponds to a Calvo parameter of 0.75. As can be seen in Figure 4, the decline in inflation is also quite high in this case. Therefore, we increase the degree of nominal wage-adjustment cost further, that the coefficient on the wage markup corresponds to a Calvo parameter of 0.95, which substantially reduces the inflation decline and also slightly lowers the output response. In both models, we keep this calibration of the degree of nominal wage rigidity throughout in all simulations reported below.

For completeness, we also report the results obtained when the consolidation measures are assumed to be credible and perceived as permanent. As expected, the results are much more favorable in this case. Austerity even becomes expansionary in the NAWM, while the decline of GDP is much reduced in QUEST III. As discussed above, credibly permanent expenditure cuts lower the steady-state tax burden of forward looking households, which induces them to increase their consumption on impact.

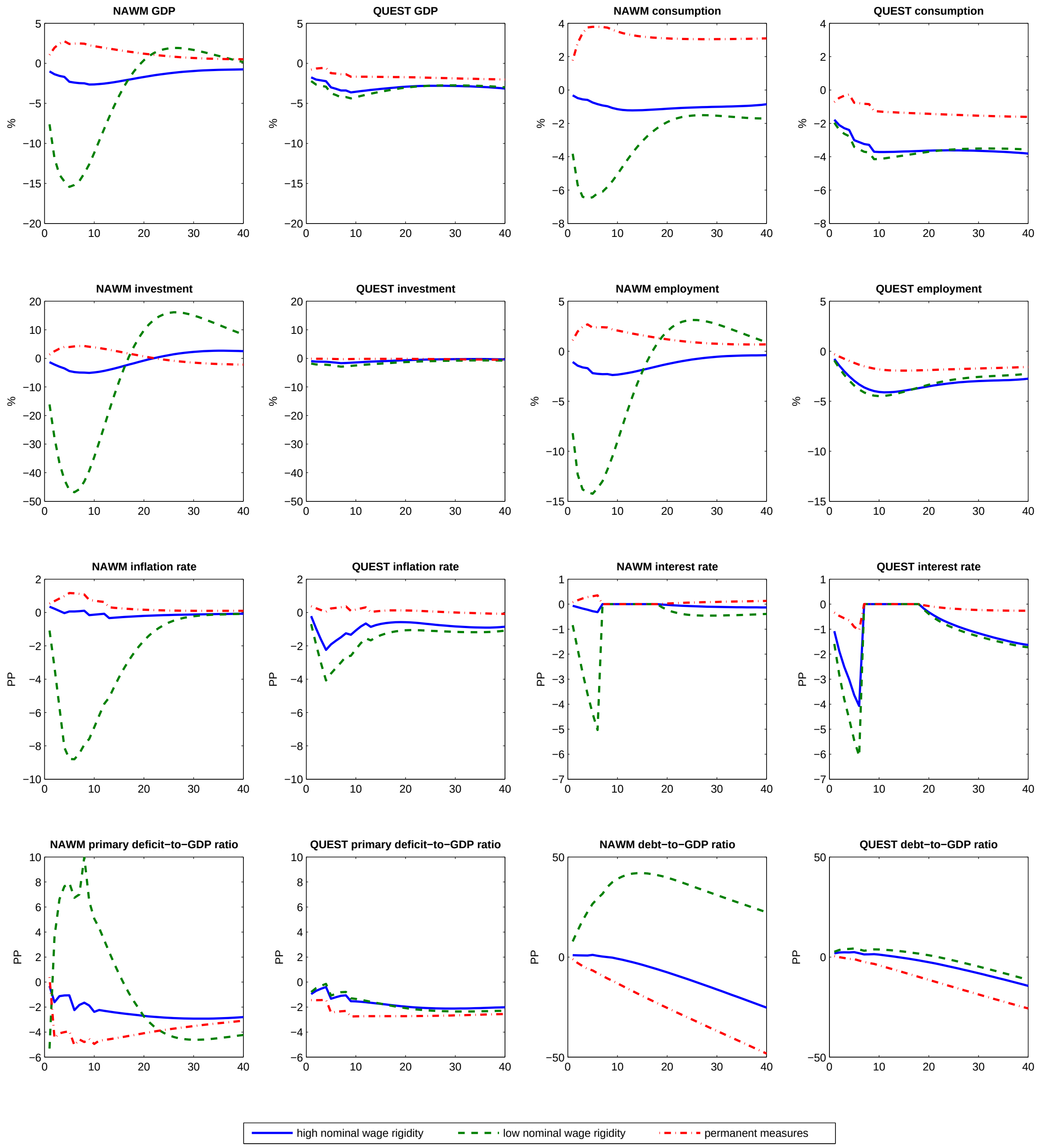

Figure 4: Responses of selected variables of the EA to the consolidation measures implemented in the EA between 2011 and 2013 for the baseline specification (phase-out after 40 quarters, high wage rigidity), a permanent-measures specification (permanent measures, high wage rigidity) and low-wage-rigidity specification (phase-out after 40 quarters, low wage rigidity).

4 Enhancing the degree of financial frictions

The models we use do not feature any financial frictions other than liquidity constrained households. In what follows, we add a reasonably calibrated financial accelerator to

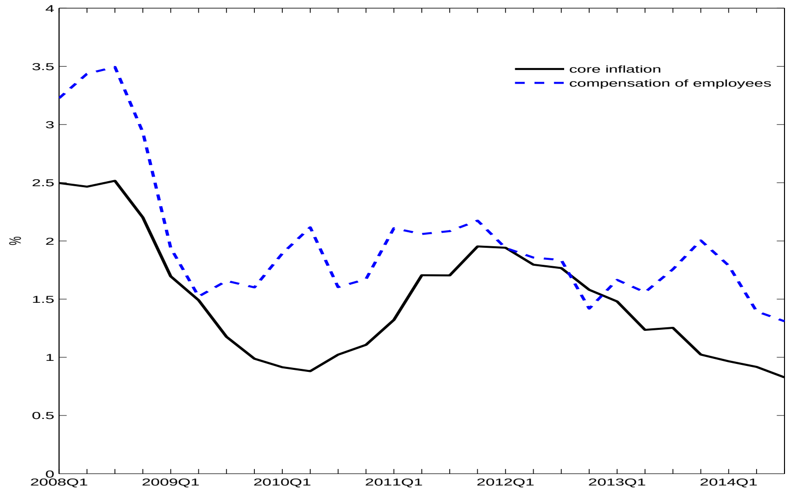

Figure 5: Core inflation and compensation of employees per employee in the Euro Area

the two models to investigate the implications of this modification on the effect of fiscal consolidation. Furthermore, we also consider the possibility that liquidity constraints may have tightened in the households sector as a consequence of the Euro Area's economic crisis. We first discuss the two modifications, and then add them first separately and then jointly to the baseline.

4.1 Adding a financial accelerator

Neither of the two models features any frictions in the relationship between non-financial firms and their creditors, implying that firm leverage does not matter for the cost of external finance and investment spending. However, Queijo von Heideken (2009), Gelain and Kulikov (2011) and Christiano et al. (2010) provide evidence that such frictions matter in the EA by estimating DSGE models extended by a *financial accelerator* along the lines of Bernanke et al. (1999) (henceforth referred to as BGG). Furthermore, Carrillo and Poilly (2013) and Freedman et al. (2010) show that in the presence of a zero lower bound on nominal interest rates, a financial accelerator enhances the effect of fiscal policy shocks. We therefore introduce a simplified version of the Financial Accelerator to the models, which we discuss in more detail in the appendix, and which up to the first order yields the same key relations as the BGG approach.[7] This amplification comes about because the financial accelerator generates a spread between the expected return on capital $E_t\hat{R}^K_{t+1}$ and the risk free rate $\hat{R}_t$ that depends positively on non-financial firm leverage. In linearized form, we have

$$R^K E_t\hat{R}^K_{t+1} - R\hat{R}_t = \chi\hat{\phi}_t \tag{1}$$

where ϕ_t is the leverage ratio, i.e. the value of capital over net worth. For $\chi > 0$, an increase in leverage makes external financing more costly by increasing the probability of bankruptcy and thus the expected costs of bankruptcy, which the bank passes on to

[7]Note that in the NAWM, we added the financial accelerator only to the EA block. Adding it to both regions caused indeterminacy.

firms via a higher loan rate. This relationship implies that any adverse shock that lowers non-financial firm's net worth and thus leverage increases the external finance premium as well, implying that future rental income from capital is discounted at a higher rate, which in turn generates a stronger decline in investment than what would have happened in the absence of the financial accelerator. As we discuss in the appendix, it also generates a link between non-financial firm net worth and private consumption, as the owners of the capital stock, so called entrepreneurs, consume out of their wealth when they die. Our calibration of the parameters related to the financial accelerator equals the choices and estimates of Gelain and Kulikov (2011) who estimate χ directly, unlike Christiano et al. (2010) where χ is determined by steady-state restrictions. Furthermore, as an extension of Smets and Wouters (2003), Gelain's model is closer to ours than the models of Queijo von Heideken (2009) and Christiano et al. (2010).

A possible criticism of our approach is that the parameter values in the original versions of QUEST III and the NAWM are based on estimates in the absence of a financial accelerator. In principle, it is possible that those estimates might have been different if they had been conducted in the presence of a financial accelerator. However, Gelain and Kulikov (2011) find that their estimates of the structural parameters, i.e. parameters unrelated to the exogenous driving processes, do not change much once the financial accelerator is added. Similar conclusion is reached by Queijo von Heideken (2009) and Christiano et al. (2010).

4.2 Increasing the share of non-Ricardian households

As discussed above, all models are populated by *non-Ricardian*, i.e. liquidity-constrained, households whose consumption is closely linked to their disposable income, as well as by *Ricardian* households with frictionless access to financial markets and infinite horizon. The share of Ricardian households assumed by Coenen et al. (2008) and Stähler and Thomas (2012) was based on estimates from the *Great Moderation* period. During periods of economic and financial crises like the one affecting the EA during the last couple of years, the share of these households could have increased. We therefore re-calibrate the share of non-Ricardian households based on the results of the recent ECB Household Finance and Consumption Survey (HFCS 2013), where households are asked whether their expenses exceed, equal or fall short of their income. In the Euro area, 48% of surveyed households reported that their expenses equaled their income, 41% consume less than their income, while 11% report that their expenses exceed their income. In our simulation, we calibrate the share of non-Ricardian households as equal to the share of those households reporting that they consume exactly their income. Note that this calibration may understate the true share of households for whom consumption and disposable income are tightly linked. Some households who consume less than their income may do so in order to pay down debt accumulated during the years before the world financial crisis. The household debt-to-income ratio strongly increased in a number of Euro Area member states (Spain, Ireland, Portugal, Finland) since the launch of the Euro, and in 2010 exceeded its 1999 level by almost 27 percentage points in the Euro Area as a whole.

4.3 Results with enhanced financial frictions

Figure 6 shows that in the presence of a financial accelerator, the effect of the fiscal consolidation on GDP is in both models considerably bigger than in the baseline. The decline in the value of the capital stock (i.e. the physical capital stock times Tobin's Q) caused by the decline in demand expectations and the increase in the real interest rate associated with the decline in inflation also reduces the net worth of non-financial firms and increases their leverage. This in turn increases their cost of external finance, implying that Tobin's Q declines even further. The stronger decline in Tobin's Q implies stronger decline of investment. Furthermore, the decline in non-financial firm net worth in the financial accelerator model also lowers entrepreneurial consumption. As may be seen in Table 3, the cumulative GDP losses by 2013 amount to 10% (NAWM) and 12% (QUEST III) of percent of annual baseline GDP, which implies a cumulative multiplier of 1.1 and 1.3, respectively.

Increasing the share of liquidity constrained households as compared to the baseline value also considerably increases the adverse effect of fiscal consolidation in the NAWM as compared to the baseline, though less than adding the financial accelerator. At the through, GDP is now more than 3% lower than in the steady state. By contrast, in QUEST III, the effect of increasing the share of liquidity constrained households is minuscule.[8] Finally, with both an increased share of liquidity constrained households and a financial accelerator, in the NAWM, the cumulative GDP loss over the 2011 to 2013 period increases to 12% of annual baseline GDP, while the multiplier of the full fiscal consolidation increases to 1.3.

By contrast, the European Commission projects a cumulative loss of the EA's real GDP over the period 2012-2016 of 2.5% assuming perfect credibility and unconstrained monetary policy. With imperfect credibility and a binding zero-bound constraint on nominal interest rates for 2012 the cumulative loss of real GDP in the EA over the same period is reported to be 3.4%. This estimated GDP loss falls short of even our baseline estimate. The difference may be due to the fact that even for the imperfect credibility case, the European Commission assumed only minor constraints on monetary policy.

Note that in the simulations with a financial accelerator, there is a considerable decline in inflation during the first year in the NAWM, and in all simulations in QUEST III, in spite of our assumed increase of the degree of nominal wage rigidity. As mentioned above, consumer price inflation actually increased over the course of 2011 to 2.9% and declined only during the following years to 0.8% by the end of 2013. The increase observed in the data might be related to the direct and indirect impact of commodity prices, which is absent from the simulation. By the end of 2010, commodity prices had increased by 82% since the end of 2008, according to the IMF commodity price index transferred into Euro terms, and increased by an additional 6% throughout 2011. Furthermore, inflation expectations may simply be more sticky in the data than in the models used here, as the inflation response by the end of the third year is much more in line with the data than the first year response.

[8] This lack of an effect of increasing the share of liquidity constrained households appears to be a general property of the QUEST III model, which is also obtained when using the original version published by Ratto et al. (2009).

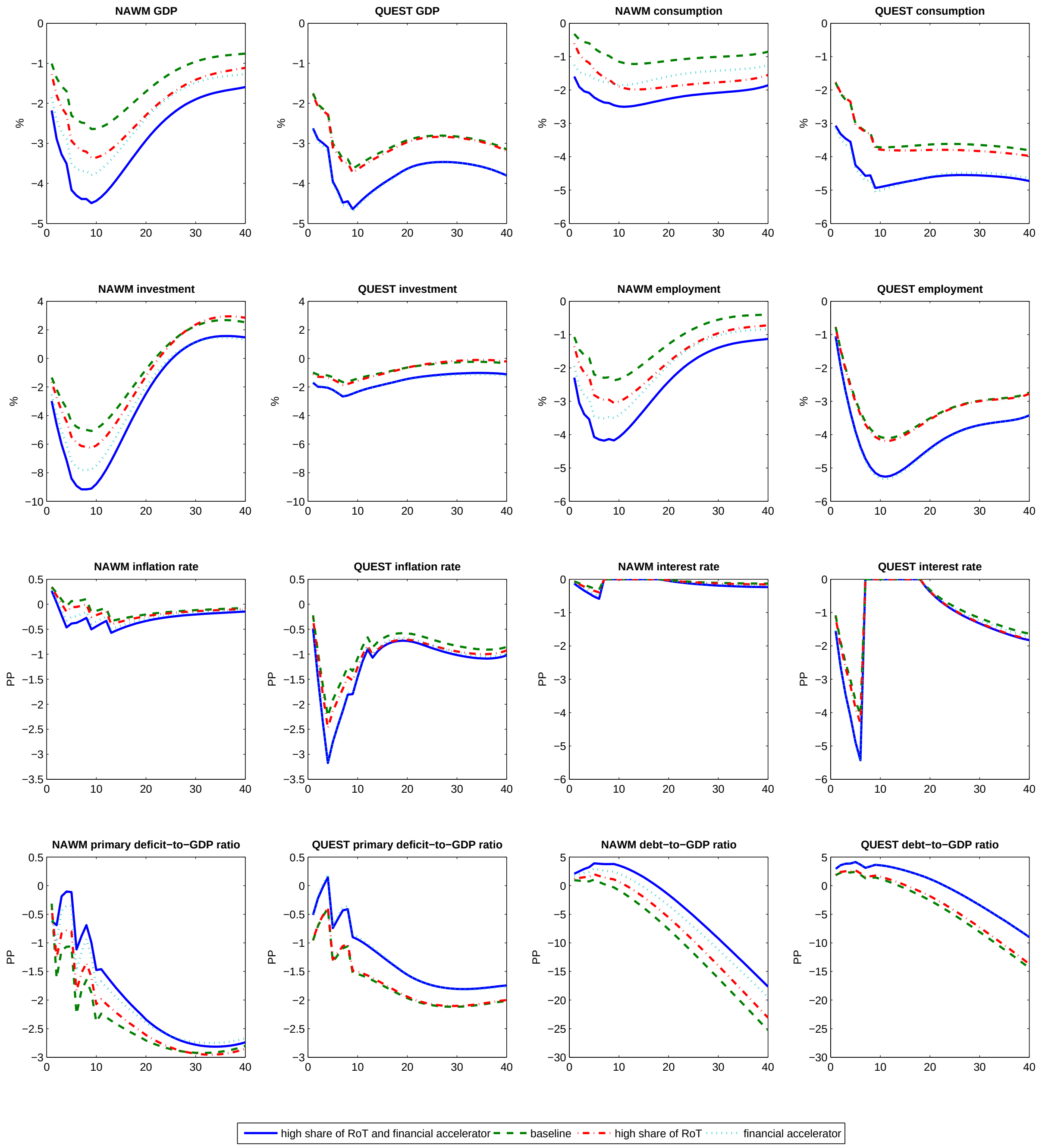

Figure 6: Responses of selected variables of the EA to the consolidation measures implemented in the EA between 2011 and 2013 for the baseline specification (low share of non-Ricardian households, no financial accelerator), the baseline with a high share of non-Ricardian households, the baseline with a financial accelerator, and the baseline with both a high share of non-Ricardian households and a financial accelerator.

The NAWM and QUEST III also offer clues regarding the role of international real and financial linkages in shaping the effect of the EA's fiscal consolidation. In both models, the stabilizing effect on GDP of lower imports caused by lower domestic demand is compensated by an appreciation of the nominal exchange rate, as well as a decline in

US GDP in the NAWM. Therefore, in the NAWM, there is only a small though persistent improvement of the trade balance (not shown), peaking at between 0.1 to 0.2% of GDP depending on the scenario, while in QUEST III, the trade balance is actually worsened by the fiscal consolidation during the first three years, with a through at -0.3% of GDP. In the NAWM, the appreciation of the Euro Area's exchange rate is driven by the accumulation of net foreign assets caused by the improvement in the trade balance, which increases the cost of accumulating dollar assets. By contrast, in QUEST III, the key driver of the appreciation appears to be the very persistent inflation decline. The constant long-run real exchange rate thus requires a long-run nominal appreciation, which via the UIP appreciates the nominal exchange rate on impact.

Not surprisingly, in both models, the decline in the deficit is smaller the bigger the output decline caused by fiscal consolidation. However, in all simulations, the decline in tax revenues and the increase in transfer payment caused by the decline in output imply that the primary deficit only gradually approaches the ex-ante deficit effect of the consolidation package, which as discussed above accumulates to 4% of GDP by the end of 2013. As a result of the merely gradual decline in the deficit and the decline in inflation, which increases the real value of the debt stock as well as the direct effect of the decline in output, the government debt-to-GDP ratio increases initially in all scenarios in both models before declining below the non-consolidation case, though there are important differences regarding both the magnitude of the initial increase and the timing of the decline below the baseline. In the NAWM, where in the baseline scenario the government debt-to-GDP ratio falls below the non-consolidation case in year two, success on this dimension is only achieved in year three and four with an increased share of liquidity constrained households or in the presence of a financial accelerator, while with both of these features in place the decline takes place only during year five. In the QUEST III model, the decline of the debt-ratios decline below the non-consolidation case takes place between one and two years later across the four scenarios we consider.

The adverse GDP effects of fiscal consolidation raise the question of whether the fiscal multipliers of individual fiscal instruments associated with the scenarios we consider are reasonable. Table 2 reports the 8 and 20 quarter cumulative multipliers from changes of individual fiscal instruments with an ex-ante effect on the deficit of 1% for the "worst case" scenario considered above, i.e. an increased share of liquidity constrained households and the presence of a financial accelerator. The table also reports results from a recent metaregression analysis of fiscal multiplier estimates from Gechert and Rannenberg (2014), who analyze empirical fiscal multiplier estimates from 89 papers and find that government expenditure multipliers are systematically higher during downturns. The table reports their estimate of the 8 quarter cumulative multiplier for such states. Furthermore, we report results from the seminal contribution of Auerbach and Gorodnichenko (2012), as well as Callegari et al. (2012), which report results specifically for the Euro Area. It turns out that with the exception of the government investment multiplier in the QUEST III model, none of the model multipliers are much higher the reported estimates. Even the investment multiplier in QUEST III has some empirical support, as shown by the results from Auerbach and Gorodnichenko (2012).

Table 2: Cumulative fiscal multipliers during downturns

	Horizon	
	8 quarters	20 quarters
Government consumption		
Auerbach and Gorodnichenko (2012)		1.5
Callegari et al. (2012) (general expenditure)	2.5	
Gechert and Rannenberg (2014)	1.8	
QUEST III worst case	1.8	1.7
NAWM worst case	2.0	1.8
Government investment		
Auerbach and Gorodnichenko (2012)		3.4
Gechert and Rannenberg (2014)	1.9	
QUEST III worst case	3.9	4.0
NAWM worst case	1.9	1.8
Transfers		
Gechert and Rannenberg (2014)	2.6	
QUEST III worst case	1.0	1.0
NAWM worst case	1.4	1.2
Taxes		
Auerbach and Gorodnichenko (2012)		0.3
Gechert and Rannenberg (2014)	0.4	
Consumption/labor tax multipliers		
QUEST III worst case	0.5/0.2	0.5/0.3
NAWM worst case	1.0/0.3	0.9/0.3

4.4 Fiscal consolidation and the Euro Area recession

In order to put the above results into perspective, we now investigate the degree to which, according to our simulations, the Euro Area's fiscal consolidation may have caused or added to the weak growth performance of the Euro Area economy over the 2011-2013 period. Figure 7 displays a simple estimate of the deviation of the output gap in the Euro Area from its value in 2010Q4, as well as the simulated output effect of the Euro Area's fiscal consolidation in the two models under the various scenarios considered. According to our estimate, the Euro Area's output gap had declined by almost 6 percentage points by the end of the recession's last quarter, marked by the black vertical line. Under the baseline scenario, fiscal consolidation would explain more than one third (in the NAWM) or one half (in QUEST III) of the deterioration of the output gap during the recession. In the presence of a financial accelerator, this fraction increases to almost two thirds (NAWM) and more than 80% (QUEST III), respectively. With both an increased

Table 3: Short run costs and benefits of the fiscal consolidation, NAWM/QUEST III

	Cum. GDP loss 2011-2013	Cum. multiplier 2011-2013	Debt-GDP ratio starts falling in year
Baseline	6/9	0.7/1.0	2/4
Financial accelerator	10/12	1.1/1.3	4/6
Higher share of ROT	8/9	0.9/1.0	3/4
FA plus ROT share=0.48	12/12	1.3/1.3	5/6

Table 4: Short run costs and benefits of the fiscal consolidation in the absence of the zero lower bound, NAWM/QUEST III

	Cum. GDP loss 2011-2013	Cum. multiplier 2011-2013	Debt-GDP ratio falls in year
Baseline	1.4/1.2	0.2/0.1	1/1
Financial accelerator	2.5/1.4	0.3/0.2	1/1
Higher share of ROT	2.4/1.1	0.3/0.1	1/1
FA plus ROT share=0.48	3.7/1.4	0.4/0.1	1/1

share of rule of thumb households and a financial accelerator, the output gap decline reproduced by the NAWM increases to 80% as well. Hence, it seems that if we assume a plausible degree of financial frictions, the Euro Area's fiscal consolidation would be largely responsible for the weak growth performance over the 2011-2013 period.

The potentially high cost of fiscal consolidation raises the question of whether the output loss could have been reduced if the fiscal consolidation had been postponed to a period of robust economic recovery where the central bank would have been no longer constrained by the zero lower bound. As is shown in Table 4, across all scenarios, the simulated GDP loss would only be a fraction of the effect obtained under constrained monetary policy. The reason is that unlike in our baseline and its extensions, the central bank follows its interest feedback rule and thus lowers both the nominal and the real interest rate in response to the decline in inflation associated with the fiscal consolidation, which stabilizes private consumption and investment. By contrast, with constrained monetary policy, the inflation decline causes an increase in the real interest rate.

5 The sovereign risk channel

It has recently been argued that fiscal consolidation has less adverse effects in the presence of a so-called "sovereign risk channel", i.e. a positive link between the government's debt-to-GDP ratio and deficit, government bond yields and the private sector's cost of external finance (Corsetti et al. 2013). Such a link might be considered particularly relevant for the Euro Area during the period we consider, as financial markets were questioning the solvency of some member states (Schoder 2014). Laubach (2010) provides cross-sectional evidence that the government debt-to-GDP ratio and the deficit had positive effects on

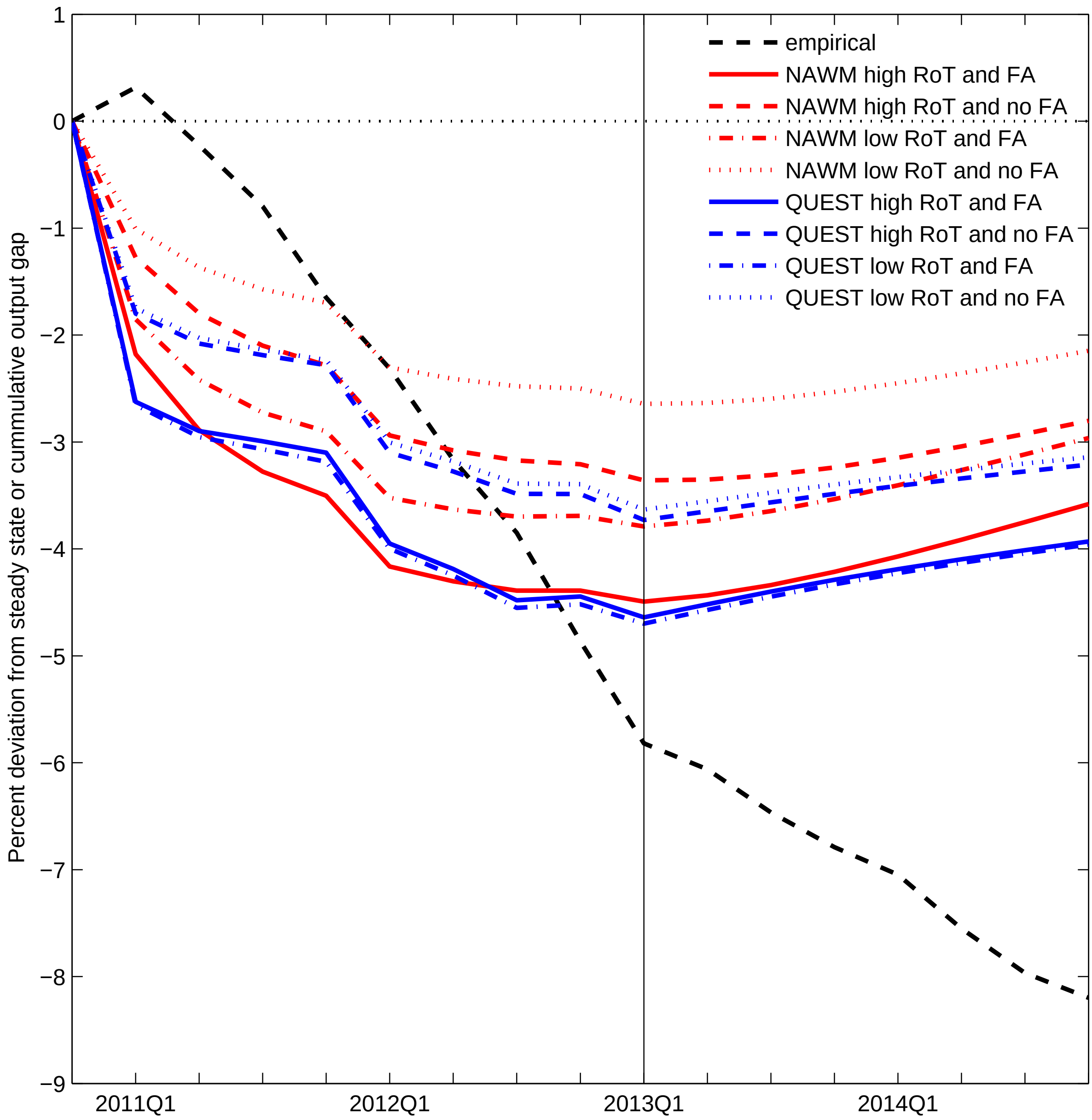

Figure 7: Output gap in the two models in the baseline setup and in the Euro Area (dashed line) since 2011Q1. We assume that the output gap in the data evolves as $GAP_t - GAP_{t-1} = g_t^y - g^{yp}$, where g_t^y and g^{yp} denote actual and potential quarterly GDP growth, respectively. We set g^{yp} equal to the average quarterly GDP growth rate over the pre-crisis (i.e. 1999-2007) period, i.e. 0.6%. The vertical line denotes the end of the last quarter of the EA's recession.

the Euro Area government bond yield spreads in 2010. However, the relationship between the effect of fiscal consolidation on sovereign bond yields and output on the one hand and "fiscal stress" on the other is not straightforward. Cottarelli and Jaramillo (2012) investigate the determinants of 5-year Credit Default Swap (CDS) spreads across a sample of 31 advanced economies in 2011 and find that while the governments primary deficit and the debt-to-GDP ratio both have a positive effect on the spread, GDP growth

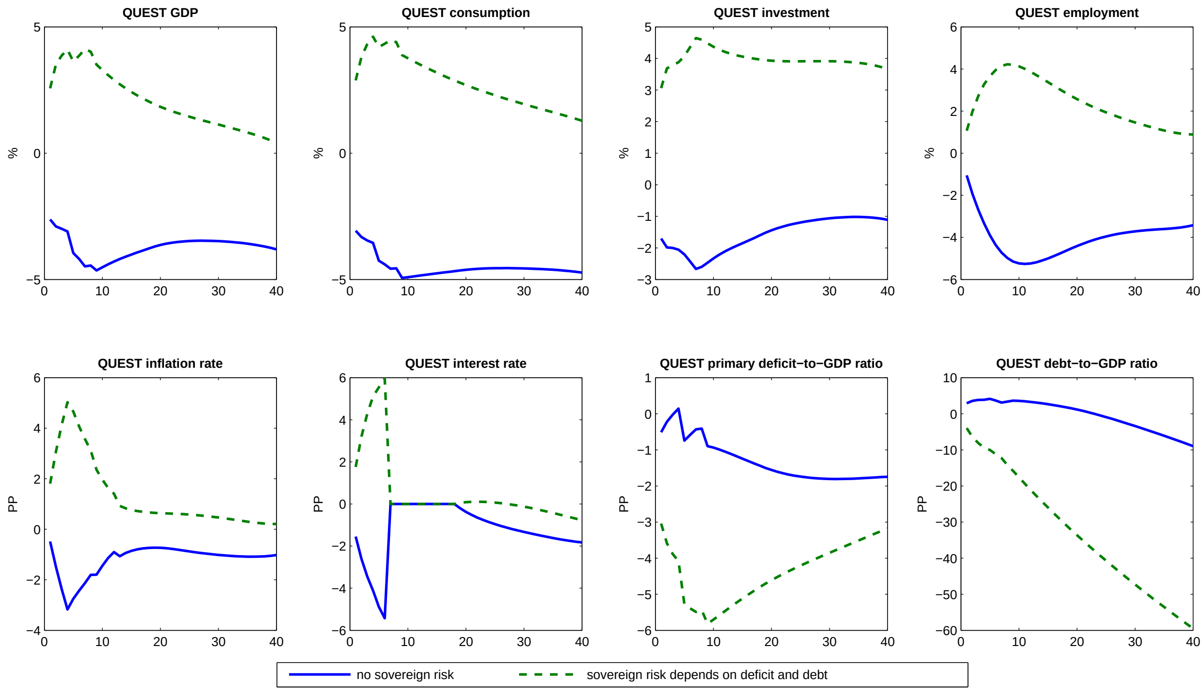

Figure 8: Responses of selected variables of the EA to the consolidation measures implemented in the EA between 2011 and 2013 for QUEST III excluding and including the sovereign risk channel.

has a negative effect. Therefore, if one assumes even a fairly modest multiplier of 0.7 and a government debt-to-GDP ratio of 100%, the spread does not decline in response a fiscal tightening. Furthermore, both the results of Laubach (2010) and those of Cottarelli and Jaramillo (2012) are based on cross-sectional evidence alone and thus do not necessarily imply that, in any individual country, an increase in the government debt-to-GDP ratio or deficit over time implies an increase in the sovereign risk spread. Indeed, during the downturn associated with the financial crisis of 2007-2009, the government's deficit and debt-to-GDP ratio increased in many economies without sovereign risk spreads increasing as well. Recent evidence based on a dynamic panel suggests that the relationship between fiscal austerity, economic activity and sovereign risk may not be in line with the conventional view. Born et al. (2014) estimate a Smooth Transition VAR (STVAR) model on a panel of advanced and emerging economies, and find that in times of fiscal stress, cuts to government consumption actually cause bigger output declines and, at least in the short term, an increase in the sovereign risk premium.

In spite of these caveats, we attempt to investigate the implications of the presence of a sovereign risk channel on our results by modeling the the Euro Area sovereign risk spread in a fashion similar to Laubach (2010), i.e.

$$i_t - i_t^{CB} = spr_{Def} * (Def_t - Def) + spr_{Debt} * (Debt_t - Debt) \tag{2}$$

where i_t^{CB} denotes the central bank interest rate, i_t the interest rate faced by households and financial intermediaries, Def_t the primary deficit-to-GDP-ratio and $Debt_t$ the debt-to-GDP ratio. We set $spr_{Def} = 0.2$ and $spr_{Debt} = 0.008$ as estimated by Laubach (2010). If we add this specification to the two models, the algorithm we use to impose the constant interest rate does not converge in the NAWM. For the QUEST III model, we report results for the specification with an increased share of liquidity constrained households and a financial accelerator. Fiscal consolidation becomes expansionary under this specification (Figure 8), due to the fact that even in the absence of a sovereign risk channel fiscal consolidation lowers the primary deficit, which has a negative effect on both the current and the future sovereign risk spread, and in the medium run lowers the government debt-to-GDP ratio as well, which lowers future sovereign risk spread. However, the caveats listed above apply to these results.

6 Concluding remarks

Between 2011 and 2013, the Euro Area countries have implemented spending cuts and tax increases accumulating to about 4% of the Euro Area GDP (European Commission 2012b). This paper gauges the impact of this policy employing variants of two DSGE models used for policy analysis by the ECB (the NAWM) and the European Commission (QUEST III). We find that, first, the simulated effect of the Euro Area's fiscal consolidation strongly depends on one's view regarding the expected persistence of the measures. If households expect the measures to be permanent, consolidation might even have been expansionary, depending on the model used. With very persistent but temporary measures, however, GDP contracts in both models, with the cumulative multiplier of the fiscal consolidation amounting to 0.7 and 1.0, respectively. Similarly, the government debt-to-GDP ratio declines below the non-consolidation case after one or three years. However, as it is plausible to assume that households and firms did not expect the enacted consolidation measures to be permanent, and are subject to some degree of myopia, we use this specification as our baseline. Furthermore, the financial frictions facing households and non-financial firms matter as well. We consider two plausible enhancements of the degree of financial frictions. First, we add a reasonably parameterised financial accelerator. As a result, the contraction becomes considerably bigger, and the time the government debt-to-GDP ratio remains above the non-consolidation case longer. Second, we allow for plausible crisis-related increase of the share of liquidity constrained households. In the presence of both the financial accelerator and the increased share of liquidity constrained households, the debt-to-GDP ratio increases for 4 or 5 years relative to the non-consolidation case. The cumulative multiplier over the 2011-2013 period equals 1.3.

These results would imply that, in our baseline scenario, fiscal consolidation is responsible for between one third (NAWM) and one half (QUEST III) of the decline of the Euro Area's output gap from the beginning of 2011 until the end of the EA's recent recession in 2013, with the share rising to about 80% in the presence of both a financial accelerator and an increased share of rule of thumb households. Moreover, most of the output costs of fiscal consolidation could have been avoided if it had been postponed until the zero lower bound constraint on monetary policy was no longer binding, and under such conditions the government debt-to-GDP ratio could have been reduced much more quickly.

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A Financial accelerator

We introduce a financial accelerator mechanism along the lines of Queijo von Heideken (2009) and Gelain and Kulikov (2011). Capital is owned by risk-neutral entrepreneurs instead of Ricardian households. The investment decision is made by perfectly competitive capital producers. At the end of period t, an entrepreneur j buys capital K_t^j for price $P_t Q_t$ from the capital producers. In period $t+1$, the entrepreneur rents his capital stock to monopolistically competitive retailers, i.e. intermediate goods firms, at a rental rate $P_{t+1} r_{t+1}^k$ (optimally choosing the utilization rate U_t if modelled) and then sells the non-depreciated capital stock at price $P_{t+1} Q_{t+1}$ to the capital producers who purchase investment goods subject to adjustment costs and add to the capital stock. The entrepreneur's return to capital is given by

$$R_t^K = \Pi_t \frac{\left(1-\tau_t^K\right)\left(r_t^k U_t - a\left(U_t\right)\right) + \tau_t^K \delta P_t^I + Q_t\left(1-\delta\right)}{Q_{t-1}} \tag{3}$$

where τ_t^K denotes the tax rate on rental income from capital and $a(U_t)$ the cost of capital utilization. It implies for the optimal rate of capital utilization that

$$r_t^k = a'\left(U_t\right) \tag{4}$$

To fund the acquisition of the capital stock, the entrepreneur uses his own net worth $P_t N_t^j$ and a loan $P_t L_t^j = P_t\left(Q_t K_t^j - N_t^j\right)$ from the banking sector. At the beginning of period $t+1$, the entrepreneur pays the bank $R_t P_t\left(Q_t K_t^j - N_t^j\right) + P_t BC_t^j Q_t K_t^j$, where $P_t BC_t^j$ denotes the average cost arising from the bankruptcy of some entrepreneurs at the beginning of period $t+1$ due to idiosyncratic uncertainty, specified as a fraction of the value of the capital stock:

$$BC_t^j = f\left(\phi_t^{e,j} - \phi^e\right) + BC^f \tag{5}$$

with

$$\phi_t^{e,j} = \frac{Q_t K_t^j}{N_t^j}. \tag{6}$$

denoting entrepreneurial leverage and $f\left(0\right)=0$, $f'\left(0\right)=0$, $f''\left(0\right)>0$. $BC^f \geq 0$ is a constant. Hence, as in BGG, we assume that the bank passes all costs associated with bankruptcy to the entrepreneurial sector, implying that it always earns the risk free rate R_t. The bank has no equity of its own and returns all interest income to its depositors, i.e. Ricardian households.

After the realization of R_{t+1}^K, entrepreneurs die with a fixed probability $1-\gamma$. Dying entrepreneurs consume their equity V_t. This assumption ensures that entrepreneurs never become fully self-financing. The fraction $1-\gamma$ of entrepreneurs who have died are replaced by new entrepreneurs in each period who receive a transfer W^e from households, which under our calibration is very small.

Deciding on the leverage ratio, the objective of the entrepreneur is to maximize

$$E_t \left\{ R^K_{t+1} Q_t K^j_t - \left(Q_t K^j_t - N^j_t \right) R_t - Q_t K^j_t \left(f \left(\phi^{e,j}_t - \phi^e \right) + BC^f \right) \right\}$$

which can also be written as

$$E_t \left\{ R^K_{t+1} \phi^e_t - \left(\phi^e_t - 1 \right) R_t - \phi^e_t \left(f \left(\phi^e_t - \phi^e \right) + BC^f \right) \right\}.$$

Note that we can drop the j superscript as the objective depends only on $\phi^{e,j}_t$, implying that all entrepreneurs will choose the same leverage. The FOC is then given by

$$\begin{aligned} E_t R^K_{t+1} - R_t &= f \left(\phi^e_t - \phi^e \right) + BC^f + \phi^e_t f' \left(\phi^e_t - \phi^e \right) \\ &= BC^f + BC_t + \phi^e_t BC'_t \left(\phi^e_t \right) \end{aligned} \tag{7}$$

with

$$BC'_t \left(\phi^e_t \right) = f' \left(\phi^{e,j}_t - \phi^e \right) \tag{8}$$

Note that the steady-state external finance premium equals BC^f which we assume to be zero. Then linearizing this yields

$$\begin{aligned} R^K E_t \widehat{R}^K_{t+1} - R\widehat{R}_t &= f' \left(\phi^e - \phi^e \right) \phi^e \widehat{\phi}^e_t + f' \left(\phi^e - \phi^e \right) \phi^e \widehat{\phi}^e_t \\ &\quad + f'' \left(\phi^e - \phi^e \right) \left(\phi^e \right)^2 \widehat{\phi}^e_t \\ &= f'' \left(\phi^e - \phi^e \right) \left(\phi^e \right)^2 \widehat{\phi}^e_t \end{aligned}$$

We assume that $f \left(\phi^e_t - \phi^e \right) = \frac{\chi}{2\phi^e} \left(\phi^e_t - \phi^e \right)^2$, where $\chi \geq 0$ and ϕ^e are the parameter indexing the response of the cost of bankruptcy to entrepreneurial leverage and the steady state value of the entrepreneur's leverage, respectively. This implies that

$$R^K E_t \widehat{R}^K_{t+1} - R\widehat{R}_t = \chi \widehat{\phi}^e_t$$

Hence, up to the first order, our assumptions produce the same relationship between entrepreneurial leverage and the spread between the return on capital and the risk free rate as the BGG-financial accelerator, with the elasticity of the external finance premium with respect to entrepreneurial leverage given by χ.

Total entrepreneurial net worth at the end of period t consists of the fraction γ of entrepreneurial equity V_t not consumed by dying entrepreneurs and a transfer from Ricardian households to entrepreneurs W^e, which entrepreneurs need in order to be able to start operations:

$$N_t = \gamma V_t + W^e \tag{9}$$

Entrepreneurial equity and consumption C^e_t are given by

$$V_t = \frac{R^K_t Q_{t-1} K_{t-1} - \left(Q_{t-1} K_{t-1} - N_{t-1} \right) R_{t-1} - Q_{t-1} K^j_{t-1} BC_{t-1}}{\Pi_t} \tag{10}$$

$$C^e_t = \left(1 - \gamma \right) V_t \tag{11}$$

As a result, the models change in the following ways: Eq. (3) replaces the first order condition of Ricardian households with respect to capital. Eq. (4) is the new first order condition of capital utilization. Entrepreneural consumption C_t^e has to be added to the equation summing up total consumption in the economy. Overall, for each region where we add the financial accelerator, we have 7 new variables, namely R_t^K, BC_t, $BC_t'(\phi_t^e), \phi_t^e, N_t, V_t$ and C_t^e, and 7 new equations, namely (5) to (11).

B Effects of changes in single instruments

We analyze how each single fiscal policy instrument affects the economy of the EA in NAWM and QUEST III given our modifications of these models as discussed above. To make these measures comparable, the shocks are calibrated such that each of them has an ex-ante deficit effect of 1% of GDP. That means, the measure reduces the deficit by 1% of GDP and, in case of tax increases, the respective tax base is held constant.

For both NAWM and QUEST III, Figure 9 plots the responses of various macroeconomic variables to such ex-ante deficit-reducing shocks to selected fiscal policy instruments. The responses are deviations from the steady-state values. In line with earlier studies (e.g. Erceg and Lindé 2013), we find that changes to the government's demand for goods and services, i.e. changes to government consumption and investment, exceed the effects of increasing labor or consumption taxes. Cuts to government investment are especially harmful since they cause a successive decline in private sector productivity in each period they are in place. They thus increase marginal cost and inflation, implying a more restrictive monetary policy once the zero lower bound ends. This effect is especially strong in QUEST III, mostly because the elasticity of private sector output with respect to public capital equals 10%. In both models, the decline of GDP in response to a transfer cut is smaller than the response to a cut of government consumption, largely because the assumed marginal propensity to spend out of transfers is less than one, but also because the consumption decline associated with the transfer cut causes an expansion in non-Ricardian households labor supply and thus a decline in the real wage and inflation as compared to the paths associated with a cut in government consumption. Therefore, once it is no longer constrained, monetary policy is loosened more in response to a transfer cut.

Note that increasing employer's social security contribution increases GDP in all models. Increasing this tax has no direct effect on households' disposable income as it is borne by employers, but increases inflation and thus lowers the real interest rate as long as monetary policy is constrained. This increases the consumption of non-Ricardian households and investment spending.

Furthermore, we also single out government consumption to illustrate the effect of moving from one scenario to another for that important instrument (Figure 10). Clearly, the qualitative impact of moving from one scenario to another are the same as for the actually implemented fiscal consolidation.

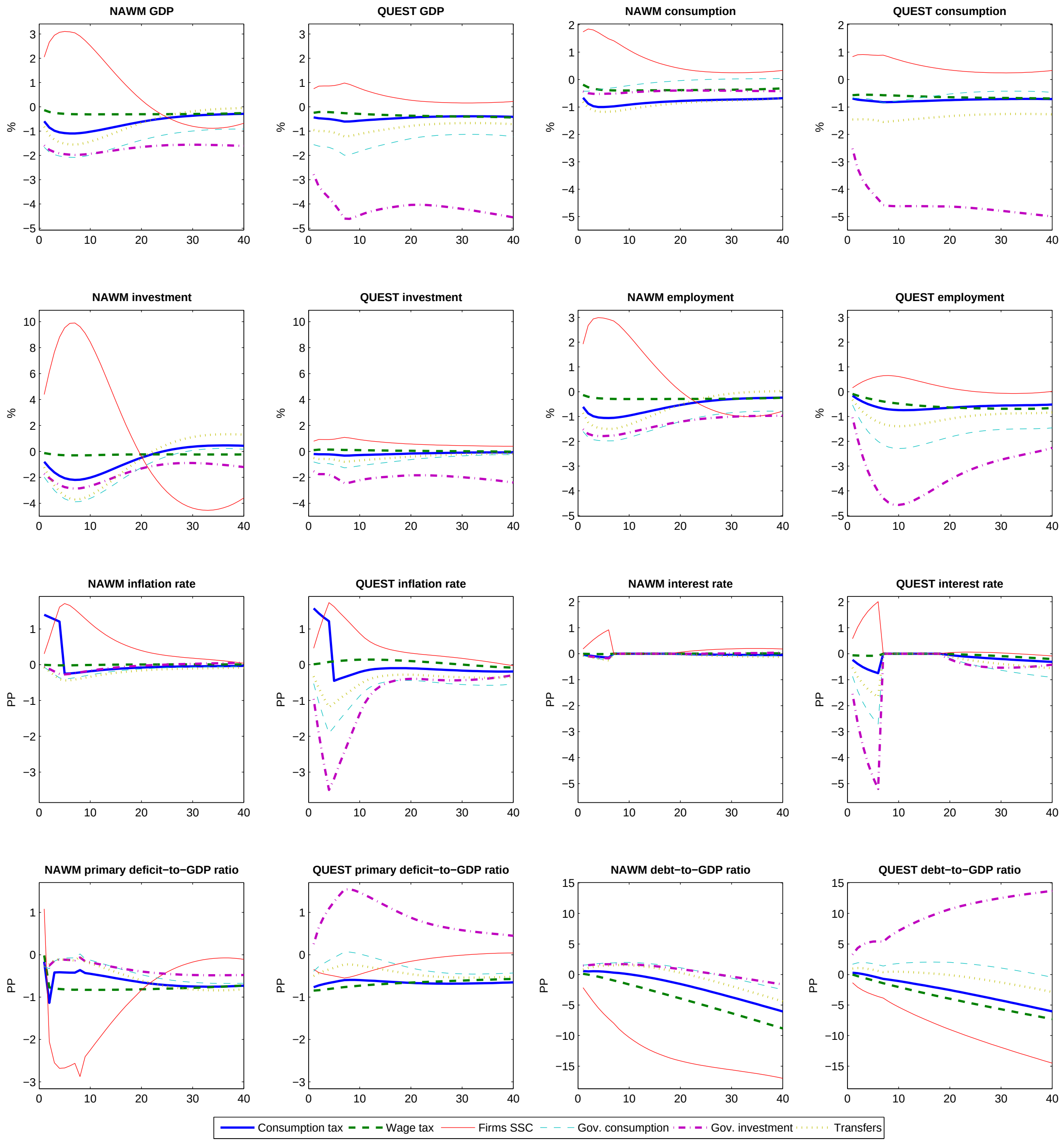

Figure 9: Responses of selected variables of the EA to shocks to single fiscal policy instruments with ex-ante deficit-reducing effects of 1% of GDP in baseline specification (phase-out after 60 quarters, zero lower bound for 20 quarters, Calvo wage parameter of 0.95, financial crisis conditions): consumption tax rate, labor tax rate, social security contribution tax rate, government consumption, government investment, and transfers.

C The algorithm used to impose the constant interest rate

We conduct our simulations in Dynare. To impose the constant interest rate, we use a very simple algorithm, which is illustrated here using a simple New Keynesian model

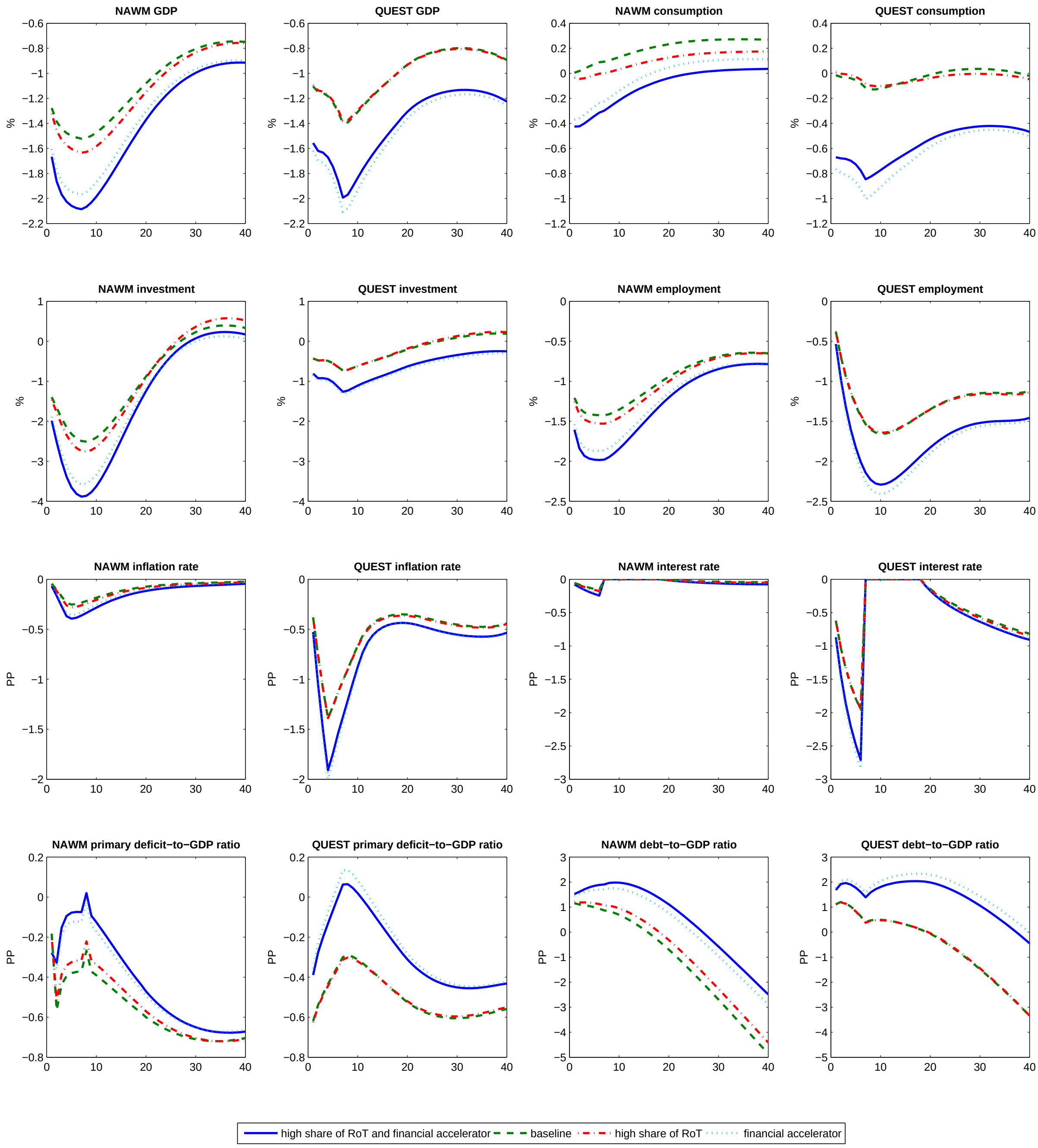

Figure 10: Responses of selected variables of the EA to a shock to government consumption with an ex-ante deficit-reducing effect of 1% of GDP for the baseline specification (low share of non-Ricardian households, no financial accelerator), the baseline with a high share of non-Ricardian households, the baseline with a financial accelerator, and the baseline with both a high share of non-Ricardian households and a financial accelerator.

where the economy is described by a consumption Euler equation, a Phillips curve, a law of motion for government spending and a monetary policy rule, expressed here in linearized form

$$c = \psi_c * c(+1) + (1 - \psi_c) * c(-1) - 1/\sigma * (i - \pi(+1))$$

$$\pi = \kappa * y + \psi_{lead} * \pi(+1) + \psi_{lag} * \pi(-1)$$

$$g = \rho_g * g(-1) + epsinorm$$

$$y = c * (1 - govsh) + g$$

$$i = (1 - \rho_i) * (\phi_\pi * pi + \phi_y * y) + \rho_i * i(-1) - i_{corr}$$

with ψ_c, σ, κ, ψ_{lead}, ψ_{lag}, ρ_g, ρ_i, ϕ_π, ϕ_y, $\rho_i > 0$, $1 > govsh > 0$ and c, π, g, y and i denoting private consumption, inflation, government spending, GDP, and the nominal interest rate, respectively, and *epsinorm* denoting a (normalized) shock with variance of one. i_{corr} matters if we want to induce a constant interest rate for a fixed number of quarters. It is determined by

$$i_{corr} = coef_1 * epsinorm + coef_2 * epsinorm(-1) + \ldots + coef_j * epsinorm(-j + 1)$$

with j being the number of quarters for which the interest rate is supposed to be constant. Our algorithm iterates over the parameters $coef_1, coef_2, \ldots, coef_j$ until $i = 0$ for exactly j periods. This is done by calculating an impulse response, adjusting $coef_1, coef_2, \ldots, coef_j$ based on the values of i_1 to i_j, calculating another impulse response, adjusting $coef_1, coef_2, \ldots, coef_j$ again and so on until $i_1 = i_2 = ... = i_j < 10^{-8}$. An example of the code applied to the simple model is available upon request.

D Estimation results for QUEST III model from 2009 to 2014

To see how nominal wage and price rigidities have changed during the time of economic stagnation, we have re-estimated restricted versions of the QUEST III model for the period 2009 to 2014. In particular we have considered three specifications imposing different numbers of parameter restrictions which are required due to the low number of observations. Restricted parameters are calibrated close to the estimation results of Ratto et al. (2009) and Gelain and Kulikov (2011). In the most restrictive specification, only the following variables are estimated: the standard errors of the innovations, the auto-regressive coefficients of the shock processes, the share of non-Ricardian households, the probability of survival of entrepreneurs and the effect of an increase in entrepreneurial leverage on the cost of external finance χ as well as the share of workers resetting their wage in a given period and the wage adjustment cost scaling parameter. The second specification additionally estimates the share of price-adjusting firms and the price adjustment cost parameter. In the final and least restrictive specification, we additionally re-estimate the parameters affecting rigidities in import and export prices.

Estimation results for the structural parameters are reported in Table 5 and compared to the estimates of Ratto et al. (2009) and Gelain and Kulikov (2011), respectively. We find the following: The posterior means of $\chi$and the share of surviving entrepreneurs are roughly in line with the findings of Gelain and Kulikov (2011). The scaling parameter of the wage adjustment cost increases from 1.29 in the initial calibration to somewhere between 20.36 and 26.74, respectively. The share of wage-adjusting workers increases from 77.4% to 87.9% in the most restrictive specification but decreases to 60.5% and 50.9% in the second and third specification, respectively. Regarding price setting, the adjustment cost parameter decreases from 61.44 to 49.34 and 52.95, respectively, but the share of re-adjusting firms decreases as well and considerably from 87.1% to 37.9% and 43.2%, respectively. The adjustment cost parameters for export and import prices increase from 26.13 to 54.60 and from 1.68 to 4.20, respectively. The share of re-adjusting firms decreases from 91.8% to 70.2% and from 73.6% to 46.6%, respectively. These results suggest that nominal rigidity increased during the period. In our simulation, we account for this feature by increasing the degree of nominal wage rigidity, for the following reasons. First, simply using the parameter estimates in our simulation is not sufficient to make our constant interest rate algorithm converge. Furthermore, the estimation results are to be interpreted with caution, as the number of observation is very limited and the estimation does not take into account the presence of the zero lower bound. The latter affects the quantitative and qualitative effect of shocks on the economy and their relation to the degree of nominal rigidity. For instance as we discuss in the main text, in the presence of the zero lower bound, higher nominal flexibility tends to increase the effect of demand shocks on output, the opposite of what is typically true in the absence of the zero lower bound, as well as on inflation. An estimation taking into account the zero lower bound might therefore lead to higher estimates of the degree of nominal rigidity.

Table 5: Results for structural parameters of the re-estimations of restricted specifications of the QUEST III model.

		Specification 1			Specification 2			Specification 3			G10/ RRI09
	prior	post.	90% HPD interval		post.	90% HPD interval		post.	90% HPD interval		
χ	0.03	0.007	0.000	0.016	0.032	0.001	0.058	0.032	0.021	0.050	0.027
s_{ENT}	0.9	0.998	0.994	1.000	0.995	0.992	1.000	0.999	0.999	1.000	0.978
s_{LC}	0.5	0.687	0.629	0.752	0.504	0.322	0.693	0.381	0.363	0.394	0.351
γ_W	30	22.372	8.590	32.430	20.362	6.185	33.676	26.744	26.726	26.763	1.292
s_W	0.5	0.879	0.787	0.970	0.605	0.320	0.891	0.509	0.494	0.524	0.774
γ_P	30				49.343	21.345	75.229	52.954	52.939	52.974	61.441
s_{FP}	0.5				0.379	0.198	0.553	0.432	0.403	0.456	0.871
γ_{PM}	30							4.200	4.152	4.224	1.678
s_{FPM}	0.5							0.466	0.449	0.497	0.736
γ_{PX}	30							54.600	54.578	54.624	26.129
s_{FPX}	0.5							0.702	0.687	0.718	0.918

Notes: χ is the bankruptcy cost scaling parameter. s_{ENT} is the share of surviving entrepreneurs. γ_W, γ_P, γ_{PM}, γ_{PX} are the scaling parameters of the adjustment costs for wages, prices, import prices and export prices, respectively. s_X is the share of agents able to adjust the respective price X in a given period. GK11 and RRI09 stand for Gelain and Kulikov (2011) and Ratto et al. (2009), respectively.