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The monetary and fiscal framework of the EMU in times of high debt and constrained interest rates

Abstract: This paper looks at the monetary and fiscal interaction in the European Monetary Union and how the two arms of macrostabilisation policy are affected by high levels of sovereign debt and short-term interest rates at, or around, their lower bound. Using the National Institute's Global Econometric Model it shows that when one arm of policy is constrained then the other must do more work to act as a partial, yet imperfect substitute. With both binding fiscal constraints and short-term interest rates near the lower bound, monetary intervention in sovereign debt markets offers a channel by which to ease the monetary stance and simultaneously relax the fiscal budget constraint. When only a subset of the monetary union is fiscally constrained, a domestic fiscal expansion by the remaining unconstrained members can provide a cross-country intra-union offset that makes all member states better off than they otherwise would be.

Authors:[1]
Ian Hurst, NIESR[2]
Iana Liadze, NIESR[3]
Jack Meaning, NIESR[4]

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[2] i.hurst@niesr.ac.uk
[3] i.liadze@niesr.ac.uk
[4] J.meaning@niesr.ac.uk

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1 Introduction

The design of the European Monetary Union (EMU) is such that there exists a single monetary authority with responsibility for stabilising prices at the union-wide aggregate level alongside multiple fiscal authorities, each setting policy with regards to the domestic policy objectives of their own government. When both of these arms of macroeconomic stabilisation policy are unconstrained, the framework allows for monetary policy to respond to symmetric and homogeneous shocks across the currency union, and even partially to respond to asymmetric shocks which are large enough to move the union-wide aggregate. This last option will, however, be imperfect for all member states involved as the policy move will be insufficient to optimally stabilise some economies and too strong for others. Fiscal policy is then able to offset asymmetric elements of any shocks which afflict a particular member state, which in a well-designed currency union should anyway be relatively small. The two elements complement each other as a fiscal policy which keeps the economic cycles of member states closely aligned allows for a more effective setting of monetary policy. Similarly, a consistently set and active monetary policy should limit the work that fiscal policy needs to do, allowing it to focus just on the specific concerns of the domestic economy.

When one or both of these arms of policy become constrained though, these well-defined roles of monetary and fiscal policy begin to break down. Monetary policy, for instance, has found its traditional instrument of choice, the short-term nominal interest rate, constrained by a lower bound which limits the extent to which it can be reduced. Fiscal policy can become constrained for a number of reasons; it may be a legal/regulatory constraint such as those imposed on the EMU member states by the Maastricht Agreement and the Growth and Stability Pact; it may also be a market-imposed constraint as capital markets will either refuse to lend further, or may only do so at prohibitively high rates of interest.

In the recent history of the EMU, both of these constraints, monetary and fiscal, have been found to bind for many member states. The levels of debt-GDP in many EMU economies are far in excess of the thresholds laid out in the Growth and Stability Pact, as are many budget positions. This has limited the extent to which the governments of EMU member states have been able to respond to the various crises and persistent economic malaise with expansionary fiscal policy. In fact, in some cases there has been a substantial consolidation at a time of contracting or stagnant economic output, implying procyclical rather than countercyclical fiscal policy. On a different occasion this may have been able to have been countered somewhat by additionally expansive monetary policy, but the European Central Bank's (ECB) primary policy instrument, the Main Refinancing Operations (MRO) rate, has been at or close to its lower bound for much of this period and unable to respond.

This paper views these policy issues through the lens of the National Institute's Global Econometric Model (NiGEM), a large-scale semi-structural model of the world economy. Sections 2 and 3 provide some context before section 4 gives an exposition of the model. Sections 5 to 10 then explain the analysis undertaken and present the results. We find that when one of the arms of policy is constrained, the other has to work harder to stabilise the economy, but that the two elements are imperfect substitutes for one another, leading to a worse outcome for the EMU as a whole. The effects of a fiscal constraint in one subset of economies can be ameliorated somewhat by more expansionary fiscal policy in member states which are not constrained. Lastly, monetary purchases of the sovereign debt of member states can address a number of the policy issues associated with high debt and constrained interest rates by directly targeting longer-term interest rates in the markets of particular sovereigns. This does, however, bring to the floor the difficulty of coordination while maintaining the independence of multiple sets of policymakers.

2 The fiscal-monetary framework of the EMU

The macroeconomic policy framework of the European Monetary Union (EMU) is based on two distinct arms; monetary policy is set by an operationally independent central bank with a mandate to stabilise price inflation at the EMU-wide aggregate level, while fiscal policy remains largely, though not entirely, the domain of individual member states.

This framework has academic foundations. Gali and Monacelli (2008) show that in a monetary union it is optimal for monetary policy to concern itself with price stability at the union-wide aggregate level, leaving fiscal policy to smooth any idiosyncratic developments in a particular member state.[5] Such idiosyncrasies can arise due to an asymmetry in the nature, size and timing of the shocks that affect member states or, even assuming perfect homogeneity of the underlying shocks, due to an asymmetric transmission of those shocks through each economy as a result of structural differences between member states. For instance, Palek (2015) introduces financial heterogeneity to a New Keynesian model of a currency union and finds that this can drive dynamics which support the findings of Gali and Monacelli (2008). Importantly, the theoretical literature on optimal currency areas would suggest that in a well-formed currency union these asymmetries should be small, Mundell (1961). The correct inference is then that the larger the asymmetries and the more divergent the economic cycles among member states, the larger the burden on fiscal policy relative to monetary, and vice versa.

In a monetary union such as the EMU, the fiscal decisions of one member state are not without consequence for the rest of the union. Should a fiscal authority outside of a currency union over-extend its debt position, assuming it has issued debt in its own currency it has the option to print more of that currency to meet its obligations. In a monetary union however, each member state is unable to directly control the supply of currency in this way. What is more, the high level of economic and financial integration a monetary union fosters between its member states means that a fiscal default or even financial turmoil in the sovereign debt markets of one member state could spill over into those of other members, Alcidi et al (2015). Lastly, the interconnected nature of EMU members, and the shared burden of being the ultimate backstop of a single currency created an implicit view of risk-sharing between member states. This meant, for instance, that markets viewed sovereign bonds issued by all members as broadly equivalent to those issued by Germany, which lead to a convergence of bond yields. As long rates fell substantially for periphery sovereigns, this could induce an excessive loosening of the fiscal constraint in the periphery relative to the core which could lead periphery sovereigns to overextend their borrowing.

To counter this difficulty, the Maastricht Treaty that formed the basis of the EMU specified a requirement to avoid excessive fiscal deficits (Article 126, TFEU). This was further augmented by the Stability and Growth Pact which introduced formal multilateral surveillance alongside measures designed to prevent excessive deficits occurring and then to enforce corrective policy action if they do.

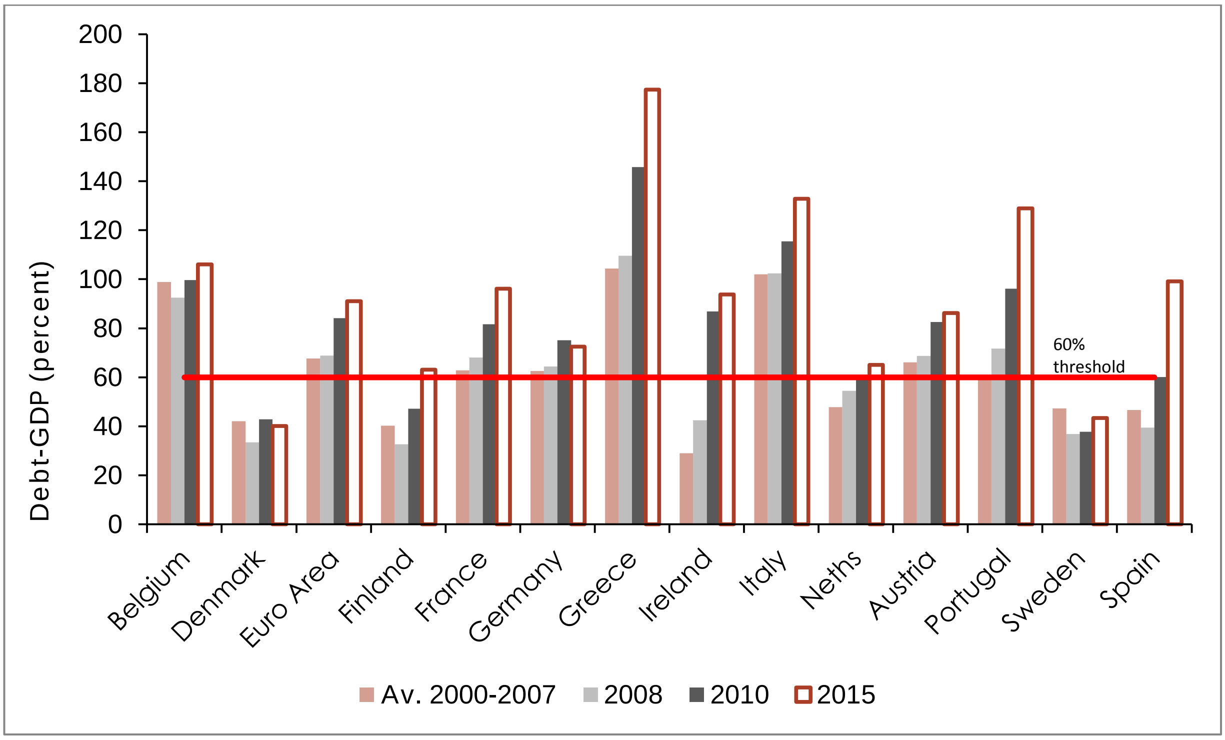
3 Times of high debt and constrained interest rates

The preventative element of the Stability and Growth Pact has been largely unsuccessful. By the start of 2008, almost all of the EMU member states had debt-GDP ratios in excess of the 60 per cent limit, figure 1. The financial crisis of 2008-9 exacerbated the problem, leading to budget deficits in excess of 3 per cent even in many of the economies that had previously met their budget targets, figure 2. By the time the

[5] A recent paper by Cole et al (2016) provides some evidence from a New Keynesian DSGE model that there exist benefits to coordination of fiscal policies between member states as well.

European Sovereign Debt Crisis took hold in 2010, the debt and budget positions of the vast majority of the EMU economies breached both thresholds laid out by the Stability and Growth Pact.

Figure 1. Debt-GDP ratio of EMU economies (per cent)



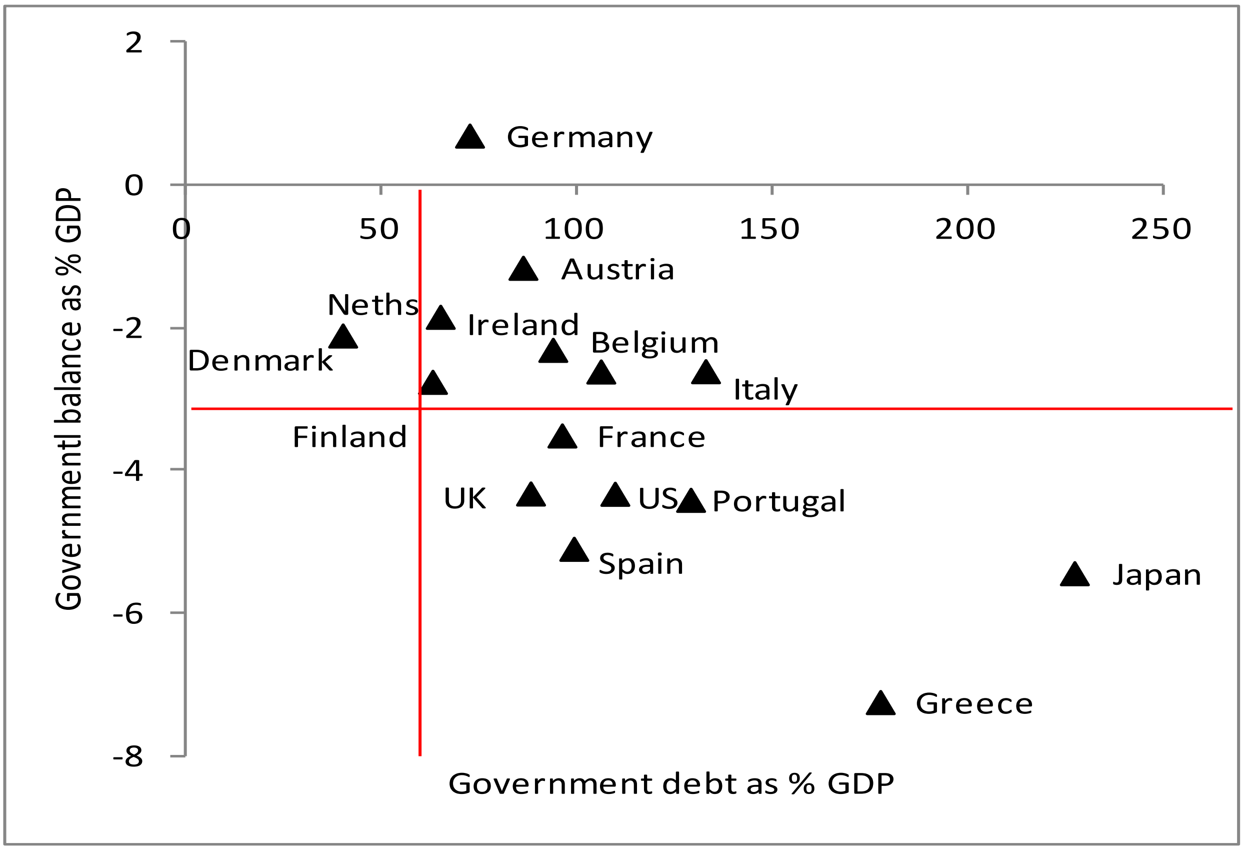
Source: NiGEM database

Figure 2. Government budget deficit ratio of EMU economies (per cent of GDP)

Source: NiGEM database

What this has meant in practice is that EMU sovereigns have been unable to respond to the prolonged period of relatively subdued growth with expansionary fiscal policy. In fact, a number of EMU members have had to undertake a fiscal consolidation as part of the corrective procedures designed to bring their debt and deficits to more sustainable levels.

Figure 3. Evidence of the lack of fiscal space in the EMU



Source: NiGEM database

Note: Shows debt –GDP ratio and government budget ratio for the year 2015

What is more, the monetary arm of macroeconomic stabilisation has also been faced with its own constraint. The ECB responded to the financial crisis by cutting its main policy rate significantly, although at first, not as aggressively as its counterparts in the United Kingdom and the United States. As the Sovereign Debt Crisis weighed on economic growth, and inflation remained below the ECB's mandated target, the main refinancing operations rate was cut further and now stands at zero percent, while the ECB overnight deposit rate has actually been set in negative territory since June 2014 and now stands at -0.4 per cent.

The combination of simultaneously binding constraints on both fiscal and monetary policy faced by many EMU economies at the current juncture is especially problematic. Ordinarily, when a fiscal constraint binds, or when there is a need for a fiscal consolidation which will withdraw demand from an economy, monetary policy is able to offset this somewhat by loosening over and above what it would otherwise do. This has never fully been the case in the EMU as monetary policy responds to aggregate targets and so will not fully offset a shock in a particular economy, unless it is perfectly mirrored in all other member states. If monetary policy is constrained by the lower bound, there is a large amount of evidence, both theoretical and empirical that fiscal policy can take up some of the slack, and in fact that under these conditions, fiscal multipliers are particularly strong.

These are the issues which the remainder of this paper will investigate through the lens of the National Institute's Global Econometric Model. The following section will present the broad mechanics of that model to give context to the work that follows.

4 The National Institute Global Econometric Model (NiGEM)

NiGEM is a large estimated quarterly model of the UK and the world economies which is intended to be theoretically coherent and quantified by means of empirical estimation over recent historical experience. It includes complete demand and supply sides, as well as extensive monetary and financial sectors. Domestic demand, aggregate supply, and the external sector are linked through the wage-price system, income and wealth, the financial sector, the government sector, and competitiveness. The external sector links each domestic economy to the rest of the world. In the model framework agents can be forward looking, but nominal rigidities, namely sticky prices and adjustment costs, slow down the adjustment to the long-run equilibrium.

It provides a plausible benchmark for estimating the effects on the economy of different policy decisions as well as other types of shocks and is a useful lens through which to view issues on almost all areas of the domestic and international economy. In contrast to many small theoretical models of the economy, its complete specification ensures that important features of the economy are not omitted from the analysis.

This section will outline some of the sectors with particular relevance for the themes of this paper, but the theoretical structure and the relevant simulation properties of NiGEM are described in more detail in Barrell et al. (2001, 2004).

4.1 The demand side

4.1.1 Household consumption

Consumption decisions are presumed to depend on real disposable income and real wealth in the long run, and follow the pattern discussed in Barrell and Davis (2007). Total wealth is composed of both financial wealth and tangible (housing) wealth where the latter data is available.

$$\ln(C_t) = \alpha + \beta \ln(RPDI_t) + (1-\beta)\ln(RFN_t + RTW_t) \tag{1}$$

where *C* is real consumption, *RPDI* is real personal disposable income, *RFN* is real net financial wealth and *RTW* is real tangible wealth. The dynamics of adjustment to the long run are largely data based, and differ between countries to take account of differences in the relative importance of types of wealth and of liquidity constraints.

4.1.2 Investment

Business investment is determined by the error correction based relationship between actual and equilibrium capital stocks, where the speed of adjustment, for instance in the US, depends on Tobin's Q. Government investment depends upon trend output and the real interest rate in the long run. All investment flows on to the relevant capital stock, which then aggregates to form the total capital stock in the economy's production function.

4.1.3 The external sector

International linkages come from patterns of trade, the influence of trade prices on domestic prices, the impacts of exchange rates and patterns of asset holding and associated income flows. The structure of the trade block ensures overall global consistency of trade volumes by imposing that the growth of import volumes is equal to the growth of export volumes at the global level. Trade volumes and prices are linked by Armington matrices, based on 2010 trade patterns. The volumes of exports and imports of goods and services are determined by foreign or domestic demand, respectively, and by competitiveness as measured by relative prices or relative costs.

$$\Delta XVOL = \alpha_1 - \lambda\left[XVOL_{-1} - S_{-1} + \beta_1 \frac{PXNCOM}{CPX}_{-1} + \beta_2 \frac{PXNCOM}{DPX}_{-1}\right] + \\ + \beta_3 \Delta S - \beta_4 \Delta \frac{PXNCOM}{CPX} - \beta_5 \Delta \frac{PXNCOM}{DPX} \quad (2)$$

where XVOL is a volume of exports of goods and services, S is export market size, PXNCOM is export prices of non-commodities, CPX is a weighted average of competitor's export prices, and DPX is a weighted average of consumer prices in the exporting country's export markets.

$$\Delta MVOL = \alpha_1 - \lambda\left[MVOL_{-1} - 1.24 TFE_{-1} + \beta_1 RPM_{-1}\right] + \beta_2 \Delta TFE - \beta_3 \Delta RPM \quad (3)$$

where MVOL is a volume of imports of goods and services, TFE is total final expenditure and RPM is relative import price. We impose a common demand elasticity across all countries of 1.24, based on panel estimations reported in Barrell and Dees (2005).

The export demand variable (S) is constructed as a weighted sum of other countries' imports, which ensures approximate balance, and any discrepancy is allocated to exports in proportion to the country's share of world trade.

$$S_j = \sum \beta_i XMVOL_i \quad (4)$$

where β_i is given by (exports from country j to country i)/(total imports in country i). $XMVOL_i$ is imports of goods and services in country i, calculated in 2011 US$.

Import prices depend on a weighted average of global export prices, and this ensures that the ratio of the value of exports to the value of imports remains at around its historical level.

$$RPM = PM / (CED / (1 + ITR)) \quad (5)$$

where PM is an import deflator (goods and services), CED is a consumer expenditure deflator and ITR is indirect tax rate.

It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices. The overall current balance depends upon the trade balance and net property income from abroad, which comprises flows of income onto gross foreign assets and outgoings on gross foreign liabilities. World flows of property income balance because all assets are matched by liabilities, while revaluations of liabilities match those of assets and income flows match payment flows.

4.2 The supply side

For each country we have an underlying CES production function which constitutes the theoretical background for the specification of the factor demand equations and provides a measure of capacity utilisation which then feeds into the price system. A CES production function that embodies labour augmenting technological progress (denoted λ) with constant returns to scale, can be written as:

$$Q_t = \gamma\left\{\left[s(K_t)^{-\rho} + (1-s)\left(L_t e^{\lambda t}\right)^{-\rho}\right]^{-\frac{1}{\rho}}\right\}^{\alpha} M_t^{1-\alpha} \tag{6}$$

where Q is real output, K is the total capital stock, L is total hours worked, t is an index of labour-augmenting technical progress and M is oil input. This constitutes the theoretical background for the specifications of the factor demand equations, forms the basis for unit total costs and provides a measure of capacity utilization, which then feeds into the price system.

Barrell and Pain (1997) show that the elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. Demand for labour and capital are determined by profit maximisation of firms, implying that the long-run labour-output ratio depends on real wage costs and technical progress, while the long-run capital-output ratio depends on the real user cost of capital:

$$\ln\left(\frac{L_t}{Y_t}\right) = \alpha - (1-\sigma)\lambda t - \sigma \ln\left(\frac{w_t}{p_t}\right) \tag{7}$$

$$\ln\left(\frac{K_t}{Y_t}\right) = \delta - \sigma \ln\left(\frac{c_t}{p_t}\right) \tag{8}$$

where α and δ are constant terms related to the other parameters in the model, *w/p* is the real wage and *c/p* is the real user cost of capital. The user cost of capital is influenced by corporate taxes, depreciation (consumption of fixed capital) and risk premia and is a weighted average of the cost of equity and debt finance. The weights vary with the size of equity markets as compared to the private sector capital stock. Business investment is determined by the error-correction based relationship between actual and equilibrium capital stocks. It is the response of firms that is one of the main drivers of any boost to aggregate demand. Firms anticipate the expansion of the labour force and aggregate incomes and hence invest to raise the level of capital stock to a new equilibrium in order to maintain their desired capital-output ratio. This shift raises demand through an increase in investment: the accelerator effect. This is not an immediate response but rather a gradual shift to a new equilibrium, due to such factors such as adjustment costs for implementing additional investment. Government investment depends upon trend output in the long run. Prices are determined as a constant mark-up over marginal costs in the long term.

Within NiGEM, core prices are determined as the solution to a cost minimization problem, which assumes that firms choose factor inputs to minimize the cost of producing at the desired level of output. Core prices are driven by import prices and by the total cost of production, where the latter is constructed from the wage per person hour and the nominal user cost of capital per unit of capital. We incorporate an endogenous markup, which we model as a function of the output gap. This core price variable is used in the determination of consumer prices and hence of the rate of inflation. The price equations, and the wage equations that they depend upon, are dynamically and statically homogenous.

Capacity utilisation also affects price setting and depends on actual as opposed to potential output. If output is above capacity, prices rise more rapidly than their determinants (foreign prices, costs, expectations) would suggest, and the reverse is the case if the economy is below capacity. If prices fall relative to baseline because the economy is below capacity then real financial wealth rises, and competitiveness improves, and both help raise capacity utilisation through higher domestic demand and exports. These effects stabilise the economy slowly.

4.3 Financial markets

We generally assume that exchange rates are forward-looking and 'jump' when there is news. The size of the jump depends on the expected future path of interest rates and exchange rate risk premia, solving an uncovered interest parity condition, so that the expected change in the exchange rate is given by the difference in the interest earned on assets held in local and foreign currencies.

$$e_t = e_{t+1}\left(\frac{1+r_t^*}{1+r_t}\right)(1+rp_t) \tag{9}$$

where e_t is the bilateral exchange rate at time t (defined as domestic currency per unit of foreign currency), r_t is the short-term nominal interest rate at home set in line with a policy rule, r_t* is the interest rate abroad and rp_t is the exchange rate risk premium.

Interest rates are determined by policy rules adopted by monetary authorities as discussed in Barrell et al. (2006). Nominal short-term interest rates are set in relation to a standard forward-looking feedback rule[6].

Forward-looking long-term interest rates (LR) are a forward convolution of expected short-term interest rates:

$$(1+LR_t) = \prod_{j=1}^{T}(1+r_{t+j})^{1/T} + TPREM_t \tag{10}$$

This forward convolution is taken over 40 quarters and is, in essence, the 10-year sovereign bond rate. Importantly long-term interest rates are also subject to a premium which in our benchmark specification is fixed unless exogenously shocked.

We assume that equity markets are also forward-looking, with equity prices determined by the discounted present value of expected profits, adjusted by an equity risk premium.

4.4 Policy

4.4.1 Fiscal policy

The specification of the fiscal sector in NiGEM is one of the most developed areas of the model. Policy instruments are disaggregated to a fine level, both on the expenditure and taxation side of the sovereign balance sheet. We model corporate (*CTAX*) and personal (*TAX*) direct taxes and indirect taxes (*MTAX*) on spending, along with government spending on investment and on current consumption, and separately identify transfers and government interest payments. Each source of taxes has an equation applying a tax rate to a tax base (profits, personal incomes or consumption). As a default we have government spending on investment (*GI*) and consumption (*GC*) rising in line with trend output in the long run, with delayed

[6] Our default rule follows a 'two-pillar' strategy, targeting a combination of inflation and a nominal aggregate.

adjustment to changes in the trend, and are re-valued in line with the consumers' expenditure deflator (*CED*). Government interest payments (*GIP*) are driven by a perpetual inventory of accumulated debts and the prevailing interest rate. Transfers to households (*TRAN*) are determined by the number of the working-age population not in employment and the population above working age. Adjusted spending minus receipts gives us the budget deficit (*BUD*):

$$BUD = CED*(GC+GI)+TRAN+GIP-TAX-CTAX-MTAX \quad (11)$$

We have to consider how the government deficit (*BUD*) is financed. We allow either money (*M*) or bond finance (*DEBT*), so that the debt stock is related to historical deficits:

$$BUD_t = \Delta M_t + \Delta DEBT_t \quad (12)$$

rearranging gives:

$$DEBT_t = DEBT_{t-1} + BUD_t - \Delta M_t \quad (13)$$

In all policy analyses, unless otherwise specified, we use a tax rule to ensure that governments remain solvent in the long run (Barrell and Sefton, 1997). This ensures that the deficit and debt stock return to sustainable levels after any shock. A debt stock target can also be implemented. The tax rate equation is of the form:

$$TAXR = f(\text{target deficit ratio} - \text{actual deficit ratio}) \quad (14)$$

If the Government budget deficit ratio is greater than the target, (e.g. -3 per cent of GDP and target is -1 per cent of GDP) then the effective income tax rate is increased. This feedback rule ensures fiscal solvency, so the tax rate on household incomes adjusts to return the government balance to baseline in the medium term[7].

Fiscal multipliers in response to direct and indirect tax adjustments are smaller compared to the multipliers arising from adjustments in government spending, as part of the movement in personal sector income driven by adjustment in taxes is offset by temporary adjustments in the saving rate while government spending instruments, such as government consumption or government investment, are part of the income identity and affect output directly.

4.4.2 Monetary policy

Within NiGEM, monetary policy operates predominantly through the setting of the short-term nominal interest rate. This is done with reference to a simple feedback rule, for which there are multiple options. Unless otherwise stated, the default rule used is a 2-pillar strategy defined as

$$r_t = \gamma * r_{t-1} + (1-\gamma) * \left[\alpha * ln\left(\frac{nom_t^*}{nom_t}\right) + \beta * (inf_{t+1} - inf_{t+1}^*)\right] \quad (15)$$

Where r is the nominal short rate, nom is the aggregate nominal output of the EMU, nom*: is a specified target for EMU nominal GDP, inf is inflation expectations and inf*is a target for inflation at the EMU-aggregate level.

[7] By medium term we refer to a time span of around 5 years.

The transmission of changes in this rate operate through standard interest rate channels, lowering the long-term interest rate through the term structure, reducing financing costs for firms, households and governments and changing the intertemporal incentives for consumption and investment.

5 Endogenising sovereign premia: introducing default risk to NiGEM

One element the NiGEM model has lacked to-date is an endogenous process for the premium associated with longer-term sovereign bond yields. The long-term nominal sovereign bond rate is defined as

$$LR_t = \sum_{t=0}^{N} i_t + TPREM_t \tag{16}$$

$$TPREM_t = TPREM_{t-1} \tag{17}$$

Where i_t is the short-term nominal interest rate and $TPREM$ is a premium that follows a simple random walk.

Although this allows for an exogenous movement of the sovereign risk premium, there is no feedback from developments in the economy, or policy choices on to the premium itself. This is of particular importance when contemplating the issues with which this paper is concerned.

To deal with this we augment the standard model to include a government bond premium which is itself a positive function of the debt-GDP ratio, equations 18 and 19.

$$LR_t = \sum_{t=0}^{N} i_t + GPREM_t \tag{18}$$

Where

$$GPREM_t = \beta * GDR_t \tag{19}$$

This structure can be motivated by a large theoretical and empirical literate on the determinants of sovereign bond yields.[8] Theoretically, the argument can be made that the debt-GDP ratio is a helpful proxy for the sustainability of the fiscal position, and as such, default risk. The numerator is the liability owed, while the denominator is the resource available to meet that liability. A similar theoretical argument derives from the imperfect substitutability of assets which implies a less than perfectly elastic demand curve for bonds. This means that changes in the supply of bonds, as captured by the numerator of the debt-GDP ratio, will have consequences for prices and yields.

To calibrate β we build on the empirical estimates of Baker et al (2016) who use pooled-mean group estimation to identify the long-run relationship between 10-year sovereign bond yields in the EMU and the level of debt-GDP, controlling for interest rate expectations. In essence, they estimate equation 20 for ten EMU economies.

$$\Delta y_{it} = \alpha_i^1 \Delta O_{it} + \alpha_i^2 \Delta GDR_{it} + \delta_i [y_{it-1} - \beta^1 O_{it-1} - \beta^2 GDR_{it-1}] + \varepsilon_{it} \tag{20}$$

[8] See for example De Grauwe and Ji (2012)

with β^2 the equivalent parameter to β in equation 19. Their results are presented in Table 1 and suggest that for each percentage point increase in debt to GDP, the premium on 10 year government bonds increases by around 1.2 basis points. This is consistent with the wider empirical literature. For instance, Poghosyan (2012) finds that across a panel of 22 advanced economies a percentage point increase in the debt-GDP ratio raises long-term yields by around 2 basis points. The results of Bernoth and Erdogan (2012), who use time-varying parameter techniques, also imply around a 2 basis point impact on long-rates, while Laubach (2009) who uses the Congressional Budget Office's projections of future federal government deficits and debt to analyse driver of long-horizon forward rates in the US finds a slightly stronger impact of around 3-4 basis points per percentage point increase in debt-GDP. Both Faini (2006) and Ardagna el al (2007) find significant non-linearities in the relationship between debt and sovereign bond yields. In the former case they show sensitivities to changes in debt-GDP increases above a given threshold (they use 100 per cent of GDP), whilst in the latter accounting for the non-linearity increases their estimates of the impact of a percentage point increase in debt-GDP to between 2 ½ and almost 4 basis points. Lastly, Barrel et al (2012) undertake similar work to the current authors using NiGEM and find a coefficient of around 4 basis points per percentage point of debt-GDP.

Table 1. Estimates of the relationship between debt-GDP and EMU sovereign bond yields

Long Run	
L.ois	1.015***
	(0.000)
L.gdr	0.0120*
	(0.053)

	Austria	Belgium	Greece	Finland	Spain	France	Germany	Netherlands	Italy	Portugal	Ireland
ec	-0.272***	-0.185**	-0.0908	-0.299***	-0.132*	-0.365***	-0.640***	-0.362***	-0.119*	-0.0963*	-0.0594
	(0.004)	(0.020)	(0.133)	(0.004)	(0.059)	(0.001)	(0.000)	(0.003)	(0.081)	(0.053)	(0.442)
D.ois	0.818***	0.774***	-0.648	0.913***	0.663***	0.892***	1.026***	0.959***	0.473**	0.681*	1.097***
	(0.000)	(0.000)	(0.523)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.028)	(0.075)	(0.004)
D.gdr	0.0219**	0.0142	0.0918*	0.0213**	0.0631	0.0666***	0.00315	0.0244**	-0.00983	0.131**	-0.0176
	(0.047)	(0.397)	(0.075)	(0.040)	(0.195)	(0.001)	(0.802)	(0.022)	(0.801)	(0.016)	(0.578)
_cons	-0.174	-0.128	0.374	-0.119	0.0163	-0.273	-0.619*	-0.196	0.0190	-0.0233	0.121
	(0.302)	(0.386)	(0.447)	(0.302)	(0.880)	(0.258)	(0.085)	(0.291)	(0.881)	(0.901)	(0.473)
N	429										
Hausman p value 0.44											

*Note: p-values in parentheses. * p<0.10; ** p<0.05; *** p<0.01*

Source: Baker et al (2016)

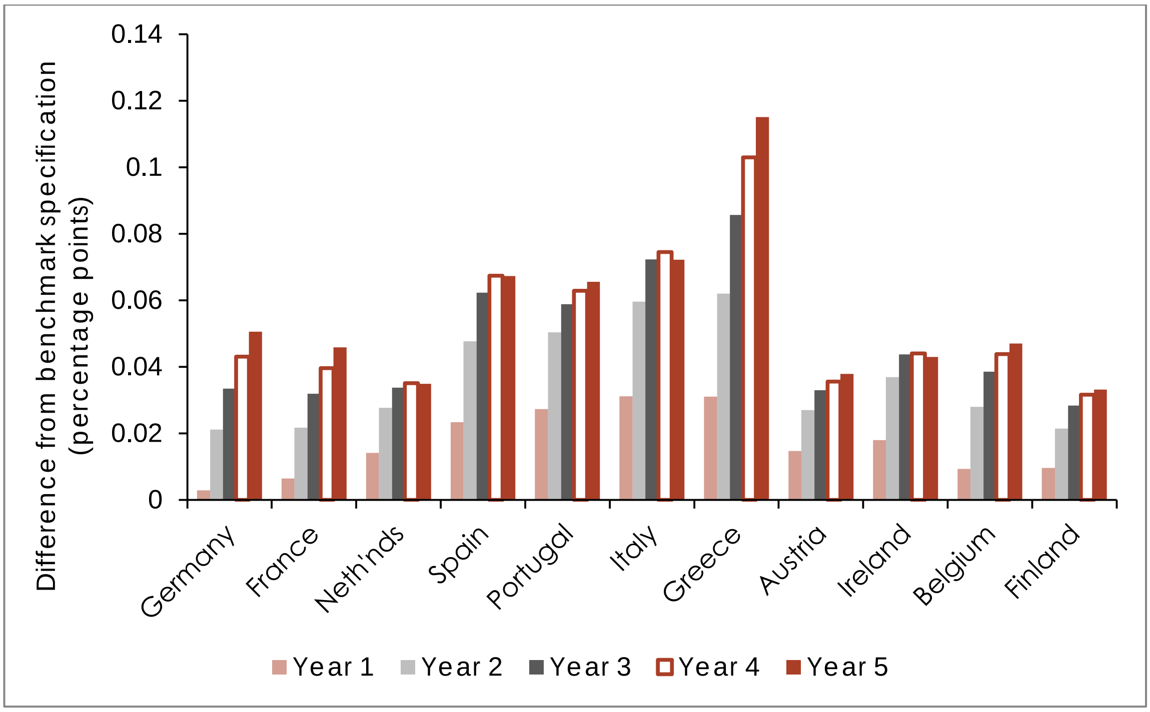
As an illustration of the impact this innovation has on the dynamics of the model, figures 4-6 show the response of term premia, long rates and government interest of a number of EA economies following a negative shock to the EMU economies in both the original and updated frameworks.[9] What they show is that in both cases, as domestic demand weakens and the automatic stabilisers kick in, the fiscal position deteriorates. However, with the premia in sovereign bond yields endogenised, the resulting increase in the

[9] The shock itself is a permanent 5 per cent increase in the nominal GDP target within the ECB's policy rule. This leads to a monetary tightening of around 1 percentage point which adversely affects the economy.

level of debt-GDP serves to push up premia, and therefore bond yields by more. It is worthy of note here that the introduction of endogenous term premia allows for deviation in the reaction of government bond yields between economies which previously was uniform by assumption. As each EMU sovereign reacts differently, the changing fiscal stance leads to heterogeneous responses in term premia and thus in bond yields, despite the homogenous nature of the underlying shock.

Higher bond yields increase the burden of government interest payments, and leads to a further deterioration of the fiscal position. Even in our relatively conservative example here, the small variations in sovereign bond premia are enough to add as much as EUR250 million a year to the interest burden. As should be expected, the issue is acuter in economies with large debt stocks as the small interest rate differential is amplified when applied to a larger quantity of debt. This means as an economy's debt stock increases, this feedback becomes increasingly important.

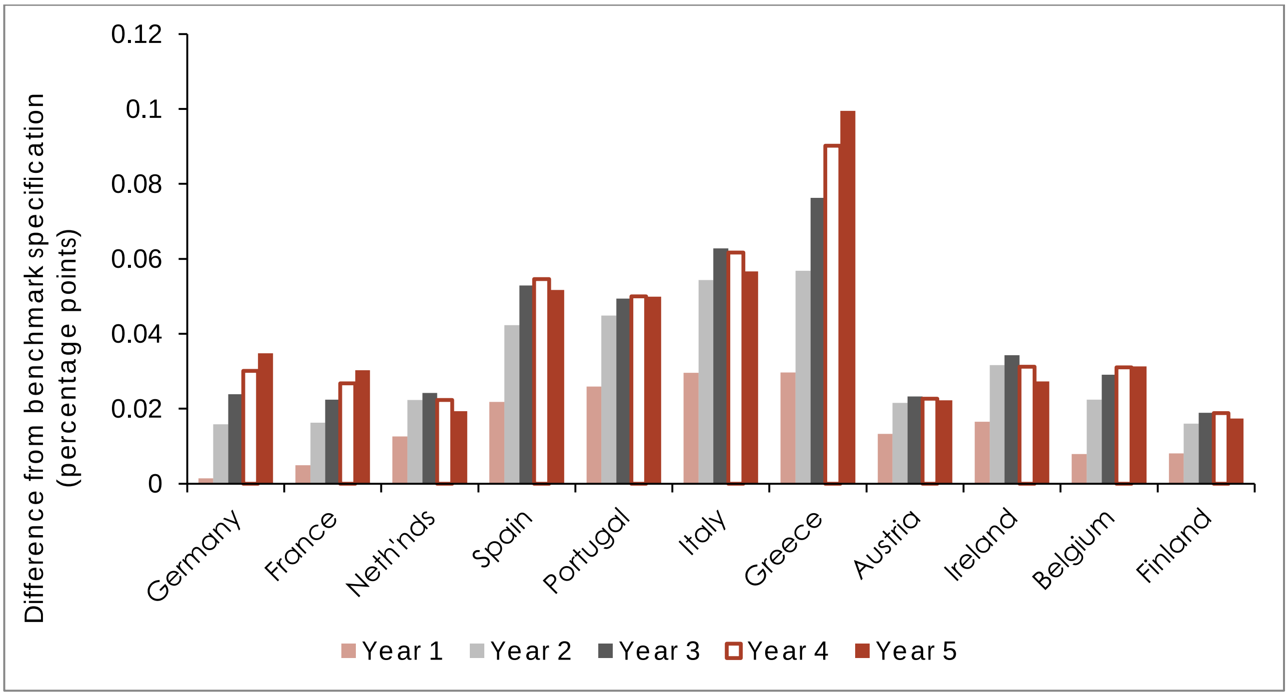
Figure 4. Endogenous sovereign term premia



Source: NiGEM simulations

Note: Shows the difference in the evolution of term premia in response to negative shock when the premium in long-term government bond rates is endgenised compared with them being held fixed. The shock is a permanent 5 per cent increase in the nominal GDP target within the ECB's policy rule

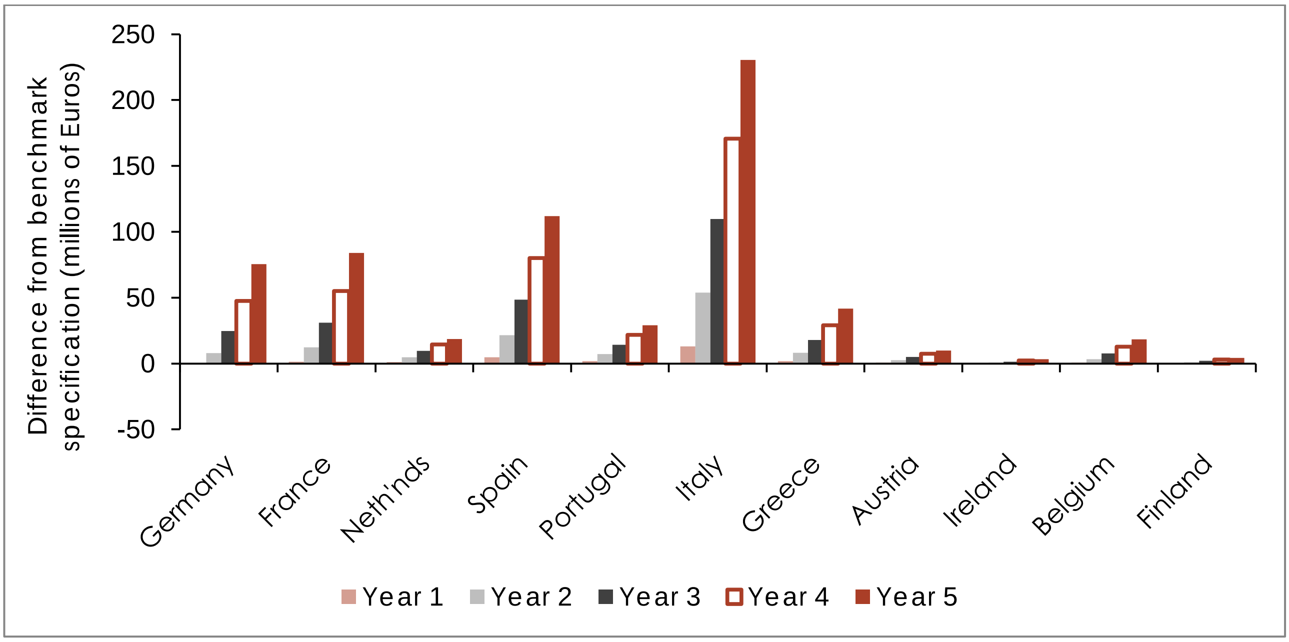
Figure 5. The impact of an endogenous sovereign bond premium on 10-year bond yields



Source: NiGEM simulations

Note: Shows the difference in the evolution of long-term sovereign bond yields in response to negative shock when the premium in long-term government bond rates is endgenised compared with them being held fixed. The shock is a permanent 5 per cent increase in the nominal GDP target within the ECB's policy rule

Figure 6. The impact of an endogenous sovereign bond premium on government interest payments



Source: NiGEM simulations

Note: Shows the difference in the evolution of long-term sovereign bond yields in response to negative shock when the premium in long-term government bond rates is endgenised compared with them being held fixed. The shock is a permanent 5 per cent increase in the nominal GDP target within the ECB's policy rule

6 A crisis shock

To begin our analysis, we first construct a synthetic crisis in the EMU by introducing a series of shocks to the NiGEM model. In doing this we follow the European Banking Authority's latest adverse macro-financial scenario, used for the 2016 EU-wide banking stress test (ESRB, 2016). At the heart of this scenario is an increase in spreads on the borrowing rates of sovereigns, firms and households, falls in equity markets and a reduction in consumer sentiment/confidence. The full list of shocks applied, and their calibration can be found in Appendix B. The EBA provide a comprehensive narrative to motivate the design of the scenario which in this case centres on 4 key elements;

1. an abrupt reversal of compressed global risk premia, amplified by low secondary market liquidity;
2. weak profitability prospects for banks and insurers in a low nominal growth environment, amid incomplete balance sheet adjustments;
3. rising of debt sustainability concerns in the public and non-financial private sectors, amid low nominal growth;
4. prospective stress in a rapidly growing shadow banking sector, amplified by spillover and liquidity risk.

The EBA also publish a profile for the impact on GDP in EMU and other economies. For the purposes of this analysis we are interested in introducing only the drivers of the shock and then allowing the model to determine the endogenous response of output. That is why, although very close, the exact deviations in GDP do not match exactly with those of the published scenario.

Also unlike the EBA specification, in this baseline case we allow a monetary policy reaction to the crisis. The monetary authority responds by setting the short-term nominal interest rate consistent with a simple feedback rule. In the case of the ECB this is a function of variables at the EMU-wide aggregate level, equation 21.

$$r_t = \gamma * r_{t-1} + (1-\gamma) * \left[\alpha * ln\left(\frac{nom_t^*}{nom_t}\right) + \beta * (inf_{t+1} - inf_{t+1}^*)\right] \quad (21)$$

By default the simulations presented here are conducted using forward-looking, rational expectations formation. For a point of comparison, we also run our benchmark simulation allowing expectation formation to be backward-looking and adaptive. The results are presented in Appendix C, but are fundamentally little changed from those presented in the body of the paper.

The result of our crisis scenario is that the level of GDP in the EMU is 1.8 per cent lower than the baseline in the first year, 4.0 per cent in the second and 5.9 per cent in the third before gradually returning to base after the fifth year. The unemployment rate increases by 1½ percentage points by the third year, and the annual rate of inflation is as much as 5 percentage points lower.

By design, some economies are more affected than others, introducing an element of asymmetry into the shocks. For instance, the impact on German GDP is relatively muted and short-lived, while the reaction of the Greek economy is significantly worse.

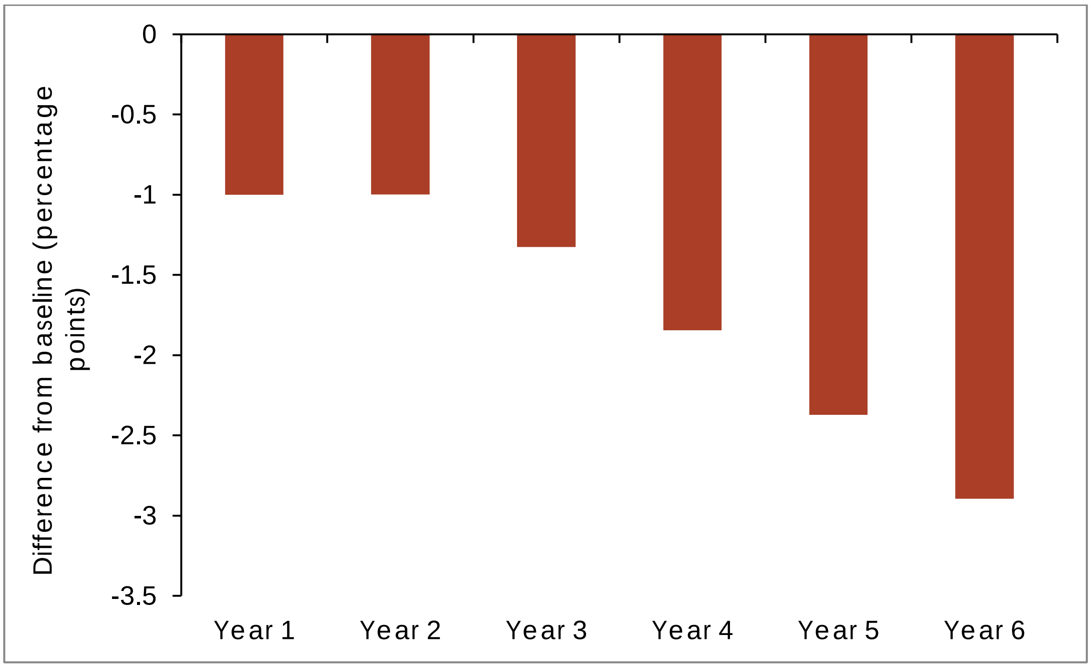
Table 2. Impact of synthetic crisis shock on GDP (per cent difference from base)

	Year 1	Year 2	Year 3	Av years 4-8
Austria	-0.6	-2.1	-4.4	-0.3
Belgium	-2.3	-4.7	-6.7	0.3
Euro Area	-1.8	-4.0	-5.9	0.6
Finland	-1.0	-1.6	-2.8	3.0
France	-3.7	-8.5	-12.0	-4.3
Germany	-0.4	-0.7	-1.2	2.0
Greece	-6.9	-16.2	-21.3	-7.1
Ireland	0.7	0.5	-2.1	-2.0
Italy	-1.0	-2.9	-4.6	2.6
Netherlands	-2.9	-5.6	-7.1	3.7
Portugal	-4.9	-10.3	-13.8	-2.9
Spain	-0.7	-2.5	-4.7	3.2

Note: Baseline case with active monetary and fiscal policy in the EMU. The short-term nominal interest rate is restricted to -1 per cent (lower bound).

The policy response to our crisis scenario includes both a monetary and a fiscal response, both of which are determined endogenously. The monetary authority responds by reducing the short-term nominal interest rate by as much as 3½ percentage points. This stimulates demand through the traditional interest rate channels, lowering the cost of investment and incentivising current expenditure and consumption.

Figure 7. Impact of synthetic crisis shock on ECB policy rate (percentage points difference from base)



Source: NiGEM simulations

Throughout the scenario, we allow the path of fiscal policy to be determined endogenously by the processes outlined in section 4.4.1.

Table 3 shows what these policy rules imply for the fiscal reaction to our crisis scenario. All EMU governments respond by borrowing more, relative to GDP, and increasing their debt-GDP ratio. The magnitude of these responses ranges from ¼ to 6 percentage points for the budgetary position and 6 to 120 percentage points for debt-GDP. This fiscal reaction emanates from a number of channels. First, the downturn lowers the tax base and reduces tax revenue while simultaneously increasing the burden associated with welfare spending and transfers to households. These can be thought of as the automatic stabilisers. In addition, the increased debt issuance leads to a higher probability of default and thus pushes up on the government bond premium, and thus the long-term bond rate. For a given level of debt, this increases the government's interest payments and worsens the fiscal position even further. There is an inherent monetary-fiscal interaction working to partially offset this second process as lower short-term nominal interest rates feed through the term structure and counter some of the effect of the increased government bond premium on long rates.

Table 3. Impact of synthetic crisis shock on government debt-GDP ratio (percentage points difference from base)

	Year 1	Year 2	Year 3	Av years 4-8
Austria	-0.3	1.4	6.6	10.7
Belgium	1.8	7.6	14.8	13.2
Euro Area	2.2	7.5	15.0	12.9
Finland	0.3	1.5	4.6	4.3
France	3.4	13.8	27.4	32.8
Germany	0.6	0.9	2.7	3.6
Greece	8.4	41.6	83.5	87.6
Ireland	-0.8	-1.3	2.7	12.3
Italy	0.6	7.2	20.3	20.4
Netherlands	1.9	6.8	11.9	2.9
Portugal	3.9	17.8	35.5	29.8
Spain	0.4	5.2	14.2	13.4

Source: NiGEM simulations

7 Monetary constraints

In response to the downturn generated by our crisis shock, the ECB significantly loosens the stance of monetary policy, cutting the short-term nominal interest rate by as much as 3 percentage points. This not only acts to stabilise the wider economy, but also has direct implications for the fiscal position.

With the ECB's marginal refinancing operations (MRO) rate currently set at zero, were such a shock to hit the EMU now, there exists little-to-no room for such a monetary stabilisation. To ascertain the impact of this lower bound constraint on monetary policy we run exactly the same set of shocks through the NiGEM model, but this time we hold the ECB's policy rate fixed at its baseline value, effectively rendering traditional monetary policy redundant. The results of this simulation are presented in table 4.

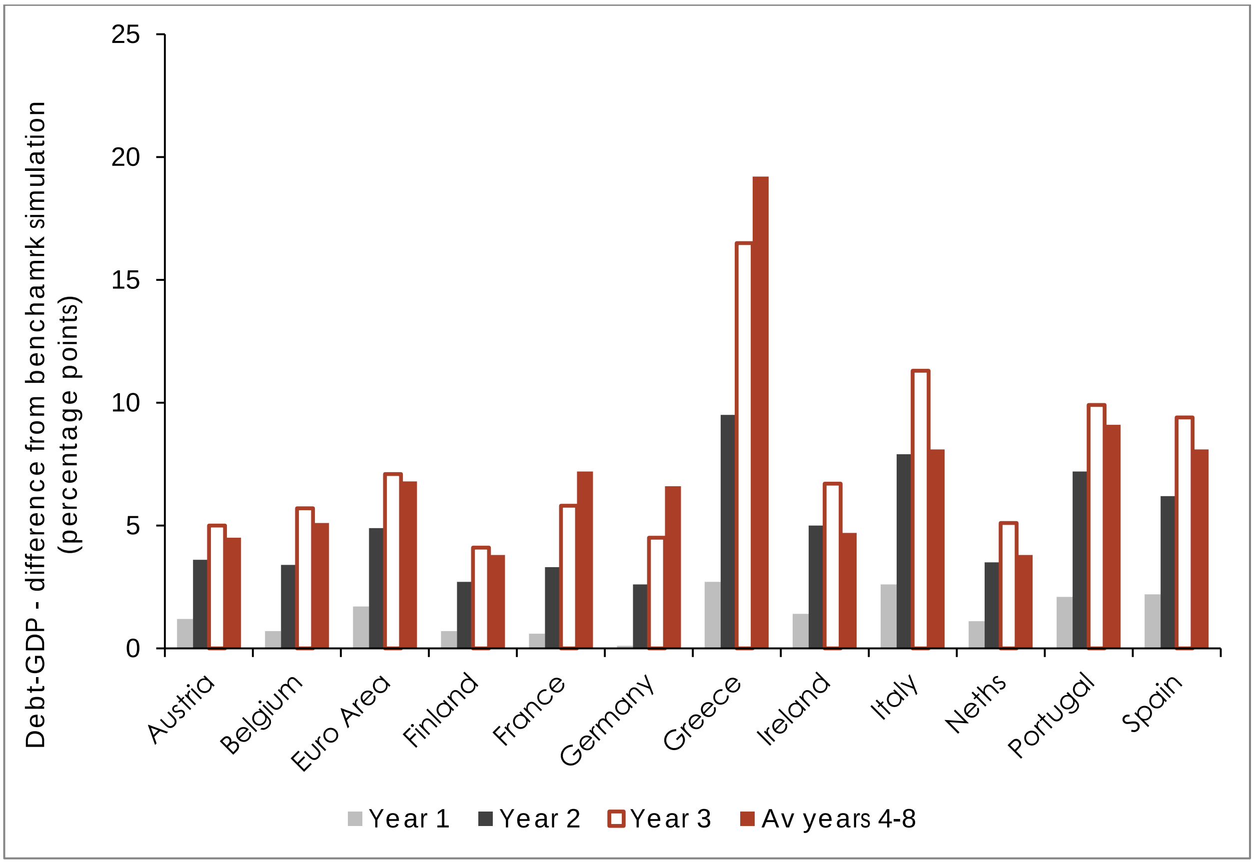
What we see is that in all EMU economies, the outcome is a deeper and more protracted contraction than when monetary policy is able to complement fiscal policy and actively stabilise the economy.

Table 4. Impact of synthetic crisis shock on GDP when monetary policy is held constant (per cent difference from base)

	Year 1	Year 2	Year 3	Av years 4-8
Austria	-1.5	-4.1	-6.6	-1.5
Belgium	-3.5	-7.1	-8.9	-0.4
Euro Area	-2.5	-5.7	-7.6	-0.2
Finland	-1.8	-3.4	-4.7	2.2
France	-4.4	-10.1	-13.7	-5.4
Germany	-1.0	-2.1	-2.8	1.2
Greece	-7.8	-18.2	-23.5	-8.6
Ireland	-0.6	-2.4	-5.0	-2.8
Italy	-1.6	-4.3	-5.9	2.1
Netherlands	-3.9	-7.7	-9.2	2.8
Portugal	-5.4	-11.6	-15.2	-4.3
Spain	-1.4	-4.3	-6.4	2.5

Source: NiGEM simulations

Figure 8. Additional fiscal burden from constraining monetary policy response to crisis shock



Source: NiGEM simulations

Note: shows difference in the change in debt-GDP ratio following a synthetic crisis shock between a scenario where monetary policy is active and unconstrained compared with one in which the short-term nominal interest rate is fixed.

What is more, in the absence of monetary policy, the stabilisation burden on fiscal policy is more extreme as it takes up as much of the slack as it can manage. This can be as much as an additional 20 percentage points on the debt-GDP ratio compared with the scenario where monetary policy is active, and the resultant path for output is still worse.

8 Fiscal constraints

In our benchmark crisis simulation, fiscal policy is set with reference to the endogenous processes described in Section 4.4.1, most notably the solvency condition. This amounts to a weak solvency constraint, requiring the fiscal authority to gradually adjust back towards its target level. In order to get a picture of what path fiscal policy would follow if it were to be truly unconstrained we modify our benchmark crisis simulation, removing the solvency condition for the first 4 years of the simulation.[10] Doing this provides an insight into how much the loose fiscal constraint that forms our default policy setting was weighing on the results of our previous simulations. Relaxing the fiscal constraint in this way improves the response of the EMU economy to the crisis shock by ½ per cent by the third year relative to the benchmark simulation, table 5. In Greece relieving the fiscal constraint increases the level of GDP by over 3 per cent in the third year compared with the benchmark crisis, although it obviously still falls significantly below the baseline.

Table 5. Impact of a synthetic crisis shock on GDP when there is no solvency constraint on fiscal policy (per cent difference from base)

	Year 1	Year 2	Year 3	Av years 4-8
Austria	-0.7	-2.1	-4.4	-0.3
Belgium	-2.3	-4.5	-6.3	0.4
Euro Area	-1.7	-3.9	-5.5	0.7
Finland	-1.0	-1.7	-2.9	2.9
France	-3.6	-8.0	-11.0	-4.0
Germany	-0.4	-0.8	-1.2	1.9
Greece	-6.5	-14.4	-18.0	-6.7
Ireland	0.7	0.4	-2.1	-1.9
Italy	-1.0	-2.9	-4.5	2.6
Netherlands	-2.9	-5.4	-6.6	3.9
Portugal	-4.8	-10.0	-12.8	-1.8
Spain	-0.7	-2.5	-4.5	3.3

Source: NiGEM simulations

In a similar exercise we look at the impact of increasing the aggressiveness with which the fiscal target is pursued. To do this we allow the default solvency condition to run as in our benchmark simulation, but this time we increase the parameter that controls the speed of adjustment to the target value by 25 per cent in all EMU economies, equation 14. Even with this small adjustment the more aggressive adherence to the fiscal target reduces the ability of fiscal policy to offset the shock, with all economies running smaller deficits than in the benchmark simulation and having reduced levels of debt-GDP. Monetary policy tries to

[10] The solvency condition is applied after this point as the model requires medium to longer run solvency to ensure a stable solution.

offset some of this effect, cutting rates by more and for longer, but still output contracts by more relative to the baseline than in the benchmark simulation for all EMU members, table 6.

Table 6. Impact of a synthetic crisis shock on GDP when there is a more aggressive solvency constraint on fiscal policy (per cent difference from base)

	Year 1	Year 2	Year 3	Av years 4-8
Austria	-0.7	-2.1	-4.5	-0.3
Belgium	-2.5	-5.0	-7.0	0.2
Euro Area	-1.8	-4.1	-6.0	0.7
Finland	-1.0	-1.7	-2.9	3.0
France	-3.8	-8.6	-12.2	-4.3
Germany	-0.4	-0.7	-1.3	2.0
Greece	-7.0	-16.6	-21.9	-6.9
Ireland	0.5	0.1	-2.4	-2.2
Italy	-1.0	-2.9	-4.6	2.8
Netherlands	-3.0	-5.7	-7.2	3.8
Portugal	-4.9	-10.3	-13.9	-2.7
Spain	-0.7	-2.5	-4.7	3.4

Note: parameter controlling speed of adjustment to the fiscal target increased from default of 0.2 to 0.25

These results raise a number of interesting points. First, they show that following a significant negative shock a constraint on the ability of fiscal policy to react is detrimental to the economic outcome of an economy. Second, given a deviation from a target level for the fiscal position, the more aggressively a government attempts to return to that target, the worse the economic outcome, both in depth and persistence.

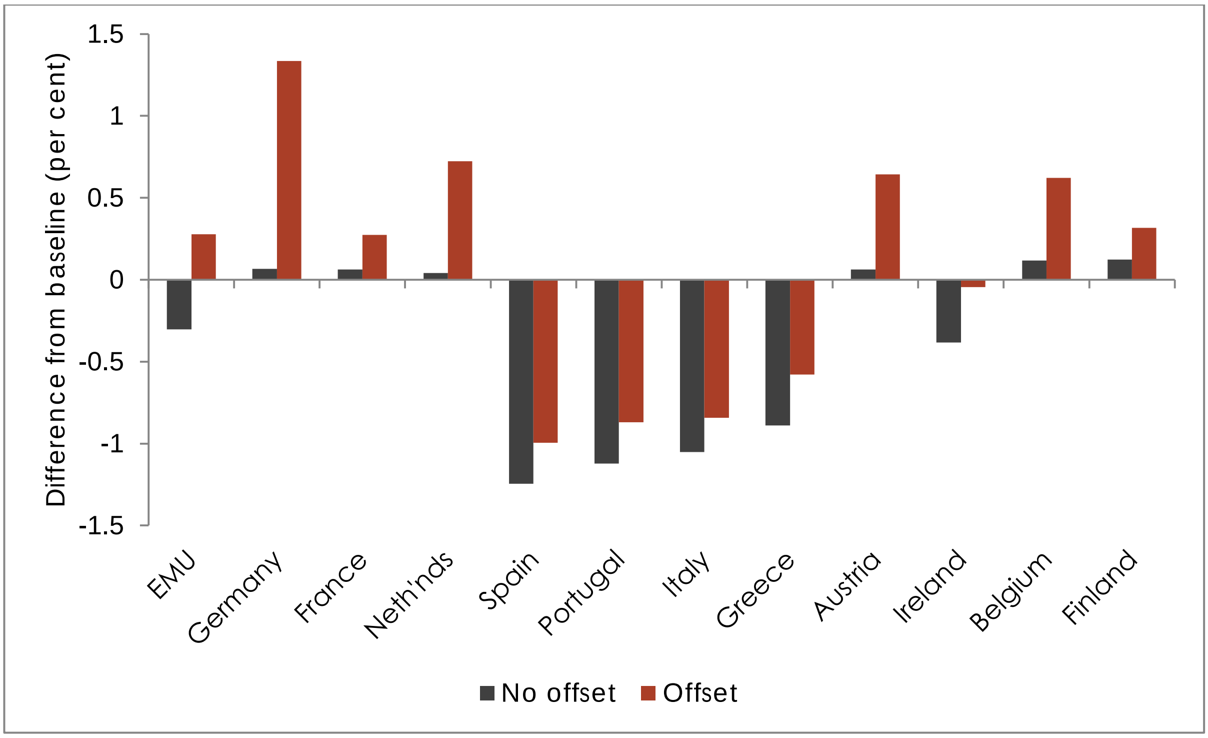
9 A cross-country fiscal offset

As it currently stands, when monetary policy is constrained for one EMU member state, it is constrained for all. This is not the case for fiscal policy. One member state may face a binding constraint which impairs its ability to respond to a negative shock, or even may be required to consolidate as part of a correction for excessive borrowing, while concurrently another member state may have plentiful fiscal space. Carreras et al (2016a, 2016b) discuss spillovers of fiscal policy choices and show that when all economies in the EMU consolidate simultaneously, the outcome for each is worse than if they were consolidating in isolation. What we ask here is; can a fiscal expansion in a fiscally unconstrained member state act to offset the negative consequences of a fiscal constraint in another? To do this we first simulate a fiscal consolidation in the GIIPS economies (Greece, Italy, Ireland, Portugal and Spain) equating to 2 per cent of GDP. This consolidation comes through reduced government consumption and as can be seen in Figure 9, lowers GDP in the GIIPS, but also in the rest of the EMU, lowering aggregate EMU GDP by 0.3 per cent after 2 years. Next we simulate the same consolidation, but this time we introduce an additional fiscal expansion in Germany, also of 2 per cent of GDP. Of course, the fiscal expansion in Germany more than offsets the otherwise mild impact that the GIIPS consolidation had on the German economy. In fact, it spurs significant additional growth. However, it also reduces the severity and duration of the downturn in the other EMU economies, suggesting there is scope for a cross-country, intra-EMU fiscal offset to asymmetric shocks when a subset of member states are fiscally constrained that benefits the union as a whole.

This simple simulation exercise neglects a number of important questions. Most obviously are the political economy considerations around one or several member states changing the stance of their own fiscal policy in order to pursue a union-wide objective rather than a purely domestic one. This is less of a concern in the current economic malaise where economic growth is subdued and most EMU economies have a degree of spare capacity to be absorbed. Under those circumstances, the fiscal expansion will aid the economy undertaking the policy by enabling them to close their output gap quicker, and would benefit the wider EMU, as demonstrated by the simulation above. However, if the unconstrained economy were to be in equilibrium or in danger of overheating, then such a policy move would be a much harder for a domestic audience to accept as prudent policy and the welfare loss of generating a significant positive output gap in one part of the EMU would need to be weighed against the loss of depressed output growth in another.

There is also the issue of how just the acknowledgement of such an option would affect the incentives for fiscal prudence of member states. Knowing that when they are close to their fiscal limit one of the other union members will effectively come to their aid may induce members to discount the welfare loss of approaching the constraint, and thus be more prone to reach it (see Thirion, 2016, Buti and van den Noord, 2004 and Dabrowski, 2015).

Figure 9. GDP impact of a fiscal consolidation in the GIIPS with and without an offsetting fiscal expansion in Germany



Source: NiGEM simulations

Note: The fiscal consolidation in GIIPS equates to 2 per cent of GDP. The fiscal expansion in Germany is also 2 per cent of GDP. The results shown are for the second year after the shock is applied

10 Unconventional monetary and fiscal policy interaction

Finding its traditional policy instrument constrained by the lower bound the ECB, like many of its international counterparts, has broadened its toolkit to include a series of new policy innovations. Of these, one in particular has significant fiscal consequences and therefore merits discussion in this paper. Since March 2015 the ECB has been making purchases of sovereign debt issued by member states through a policy known as the Public Sector Purchase Programme (PSPP). To-date it has bought just under EUR1 trillion of public sector securities under the PSPP. These purchases are made in the secondary bond market and are financed by the creation of new central bank reserves.

Although all monetary policy decisions have fiscal consequences[11] such a large-scale intervention in government debt markets brings the interaction to the fore.

In essence, quantitative easing aims to change the publicly available supply of bonds i.e. those available for the private sector to trade and hold. Of course, such a change in supply could also be effected by the fiscal authority itself, but as we will discuss below, there may be sound reasons to allow the monetary authority to share in the regulation of the publicly available supply of sovereign debt under certain conditions. Whichever arm of the macroeconomic stabilisation framework effects the change in supply, faced with a less than perfectly elastic demand curve for sovereign bonds, supply changes elicit a change in the price and similarly the yield on those bonds. Given that this can occur independently of the expected path of short-term interest, this effect is most commonly ascribed to the premium in the bond rate.[12]

10.1 Introducing quantitative easing into NiGEM

To model the impact of quantitative easing on bond rates in NiGEM, we augment the model further to include an channel akin to that described above. We adapt the equation for the nominal interest rate on 10-year government bonds so that it becomes a function of the forward convolution of short-term nominal interest rates, and a term premium. This term premium in turn encompasses the government premium defined previously, and a new variable, QE which is a random walk unless a deviation is imposed via an external shock.

$$LR_t = \sum_{t=0}^{N} i_t + TPREM_t \quad (22)$$

$$TPREM_t = GPREM_t + QE_t \quad (23)$$

$$QE_t = QE_{t-1} + \varepsilon_t \quad (24)$$

To demonstrate how asset purchases can then be viewed as operating through the economy we shock household consumption in each of the EMU economies to simulate a simple downturn that leads to an endogenous fiscal reaction that increases debt-GDP.[13] In the first scenario we do not allow any monetary response either through the short-term interest rate or QE. What we see is that the term premium increases, as shown for Germany and Greece in figure 10. What we see is that the risk premium increases

[11] see Kirby and Meaning (2015) for a discussion on this point

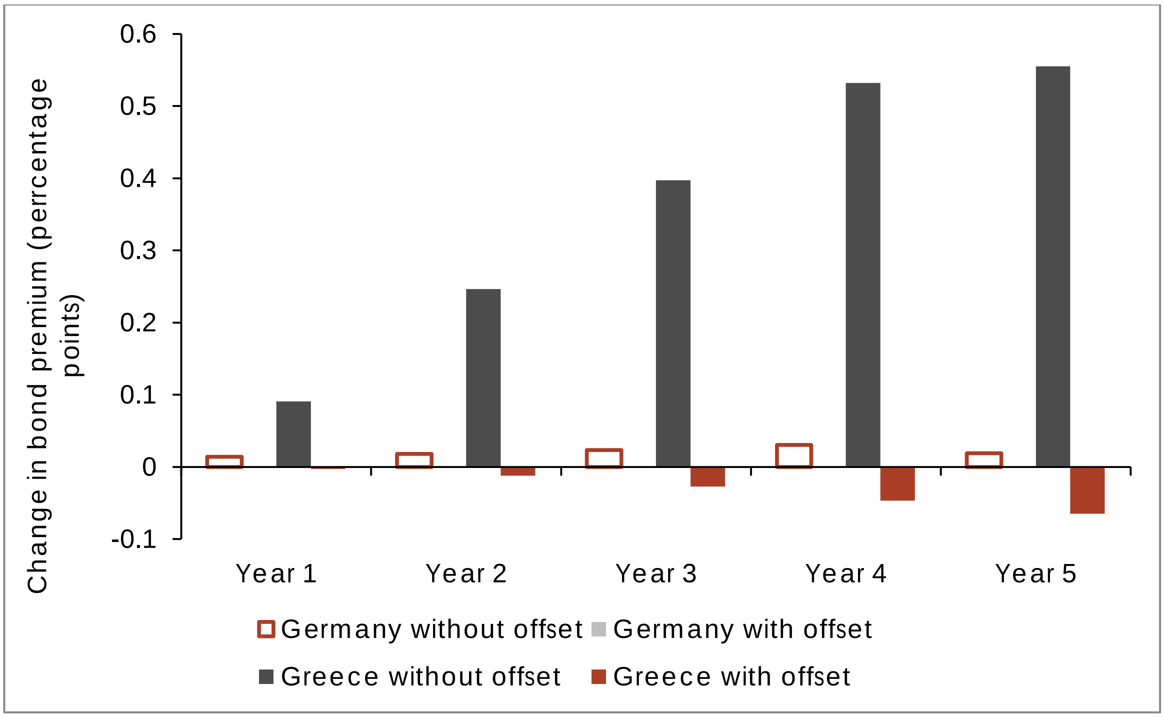
[12] This description focuses purely on the bond market reaction from a deliberately partial viewpoint. In practice such asset purchases are likely to also shape expectations and have an impact on elements of the wider macroeconomy, such as the exchange rate, some of which may feedback on bond rates. However, for the purposes of clarity we limit the discussion here to the classical bond premium arguments that have been at the heart of the literature on QE. For more on these additional channels see, among others, Eggertsson and Woodford(2003) and Gros et al (2015).

[13] This shock is designed to proxy for a change in confidence that leads to an increased propensity to save.

substantially more in Greece as a result, inter alia, of the increased stock of debt and therefore amplified debt-premium feedback.

The second scenario varies in that a QE shock is calibrated to offset the movement in the government risk premium. As a result we see that TPREM is left unchanged. For Germany, the impact on output is minimal, however, for Greece it is as much as 1 ½ per cent of GDP, figure 11. It should be noted here that the monetary authority here is only offsetting the increased government risk premium and so holding the monetary stance constant from the point of view of long rates. Were it to carry out more QE than is assumed it, it could lower long rates further and impart a net stimulus to the economy, offsetting some of the other effects of the shock.

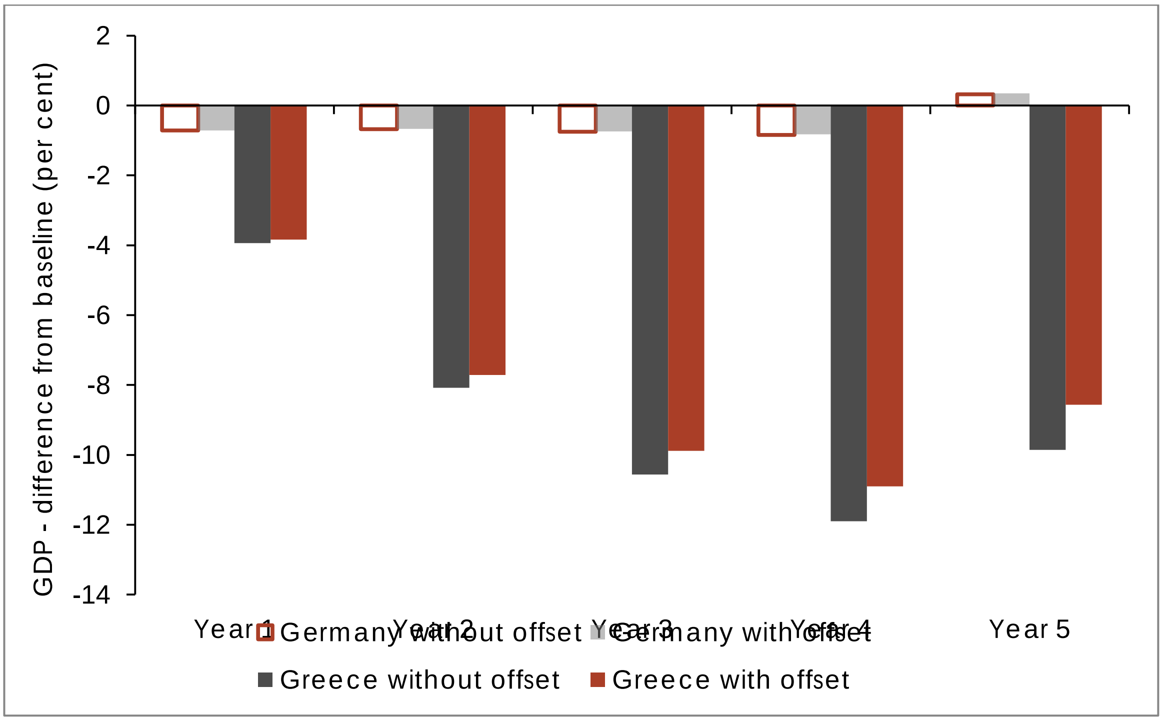
Figure 10. Impact on the government bond premium following a negative demand shock with and without a QE offset



Source: NiGEM simulations

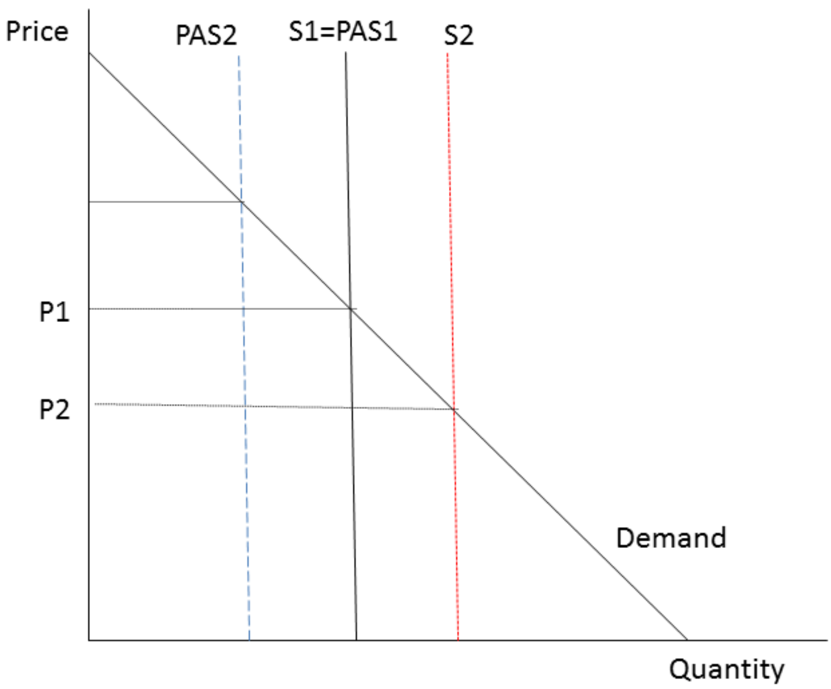
We can display the underlying mechanism graphically, figure 12. With a downward sloping demand curve for sovereign bonds, as the fiscal authority shifts out supply from S1 to S2 to meet its own objective and to facilitate the automatic stabilisers, the price of bonds falls from P1 to P2. This implies a rise in the rate of interest that bonds must pay. However, were the central bank to make purchases and remove debt from the publicly available market then the supply would fall back to PAS1 and the price would be held stable and the prevailing interest rate on government bonds unchanged. Similarly, should the monetary objective require a lower long-term interest rate then the central bank can make purchases in excess of the debt being issued by the fiscal authority and all else equal, would lower the publicly available supply (PAS2) and the prevailing interest rate, easing the monetary stance.

Figure 11. Impact on GDP following a negative demand shock with and without a QE offset



Source: NiGEM simulations

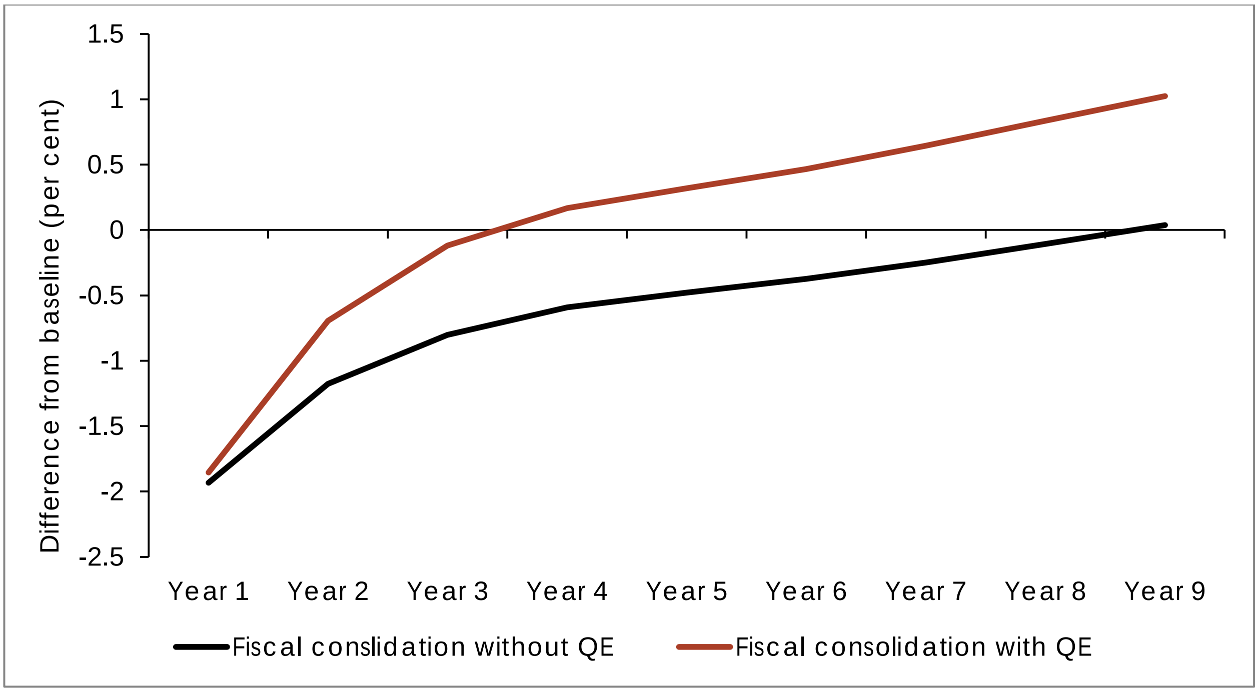
Figure 12. QE in a supply and demand framework



In this way quantitative easing can directly address two of the major constraints on macroeconomic stabilisation policy in a monetary union with high debt and a lower bound constraint.

First, they can allow for a monetary offset to changes in the fiscal stance, even when the short-term interest rate is constrained. By lowering longer term interest rates they can stimulate the economy long after the short-term nominal interest rate reaches the lower bound. Should the fiscal policy stance react to a downturn with increased fiscal spending in order to impart stimulus, central bank asset purchases can help the private market to absorb the increased level of debt without detrimentally impacting on yields and leading to a contractionary monetary stance. We can see this in figure 12. Should the fiscal policy response be to consolidate the fiscal position, then by lowering interest rates in this way asset purchases can offset some of the resultant negative macroeconomic effects associated with a fiscal contraction. This is demonstrated by figure 13 that compares the same fiscal consolidation but in one case allows for a simultaneous expansion of QE that lowers long rates by 75 basis points. The time taken for recovery from the negative effects of the fiscal consolidation is significantly reduced.[14]

Figure 13. GDP impact of fiscal consolidation with and without a QE offset



Source: NiGEM simulations

Second, unlike the short-term nominal interest rate, purchases of sovereign debt can be focussed on specific markets in order to offset idiosyncratic shocks. Should there be a need for larger policy intervention in one economy, or should the economic cycles and policy prescriptions deviate within the monetary union, the weight of purchases can be skewed in order to reflect and react to that fact. The need for such an asymmetric monetary response is likely to be especially acute in times of high sovereign debt, or with particularly large asymmetric shocks, when the fiscal authority's response function is constrained.

Central bank asset purchases are far from a panacea though. As should be obvious from the analysis above, large-scale monetary intervention in fiscal markets raises significant questions around independence and

[14] The initial impact of the shock is broadly similar because of the transmission lags of asset purchases.

coordination. These have been studied in detail by Greenwood et al (2015) and Meaning (2015), and are part of an ongoing research agenda by one of the authors of this piece, but a detailed exposition is beyond the scope and remit of this paper.

11 Conclusion

The balance and interaction between fiscal and monetary policy is always complex. It is made more so in the EMU by the institutional frameworks and the fact that monetary policy is set at an aggregate level with fiscal policy set predominantly nation by nation. In addition to this, the current macroeconomic landscape of high levels of debt and short-term nominal interest rates at their lower bound acutely highlights the extent to which the two arms of macroeconomic stabilisation policy can work together, offset one another, or indeed, act as substitutes for each other.

Looking at these issues through the lens of the National Institute's Global Econometric Model we can see that with both arms of policy unconstrained, the EMU economy is better able to respond to shocks than if one or both arms are impaired. In response to a synthetic crisis both fiscal and monetary authorities loosen the stance of policy, increasing debt-GDP ratio and cutting short-term interest rates. However, under the same shock, if there is no monetary response, the fiscal authority would have to run significantly larger deficits and accumulate substantially more debt as it takes up the burden of stabilising the economy. Even with this additional fiscal stimulus, the path for the economy is a more severe and protracted downturn. Similarly, if fiscal policy is constrained either by market discipline or explicit rules, then the monetary authority has to do more work, cutting interest rates by a larger amount for longer.

Were both arms of policy to be constrained, this leaves little scope for stabilisation. However, unconventional monetary policies offer one channel by which policy can still be effective. Purchases of longer term government debt by the central bank can act to reduce long-term bond yields and provide monetary stimulus while also reducing the funding costs for the fiscal authority and relaxing their budget constraint. What is more, they can be targeted to bonds of a specific member state, and even specific areas of the bond market, and so allow for an asymmetric monetary response that would otherwise be the preserve of the fiscal authority. Finally, our simplistic simulation work suggests potential for an intra-EMU cross-country fiscal offset by which a fiscal expansion in a fiscally unconstrained EMU member can alleviate some of the welfare loss of binding fiscal constraints in other EMU member states.

In general, the work here is expositional of the mechanisms at the heart of the fiscal and monetary framework of the EMU when debt is high and traditional monetary policy is constrained. There remains significant work to be done on both the empirical testing of the mechanisms shown here, and ultimately, on the optimal macroeconomic stabilisation framework of the EMU.

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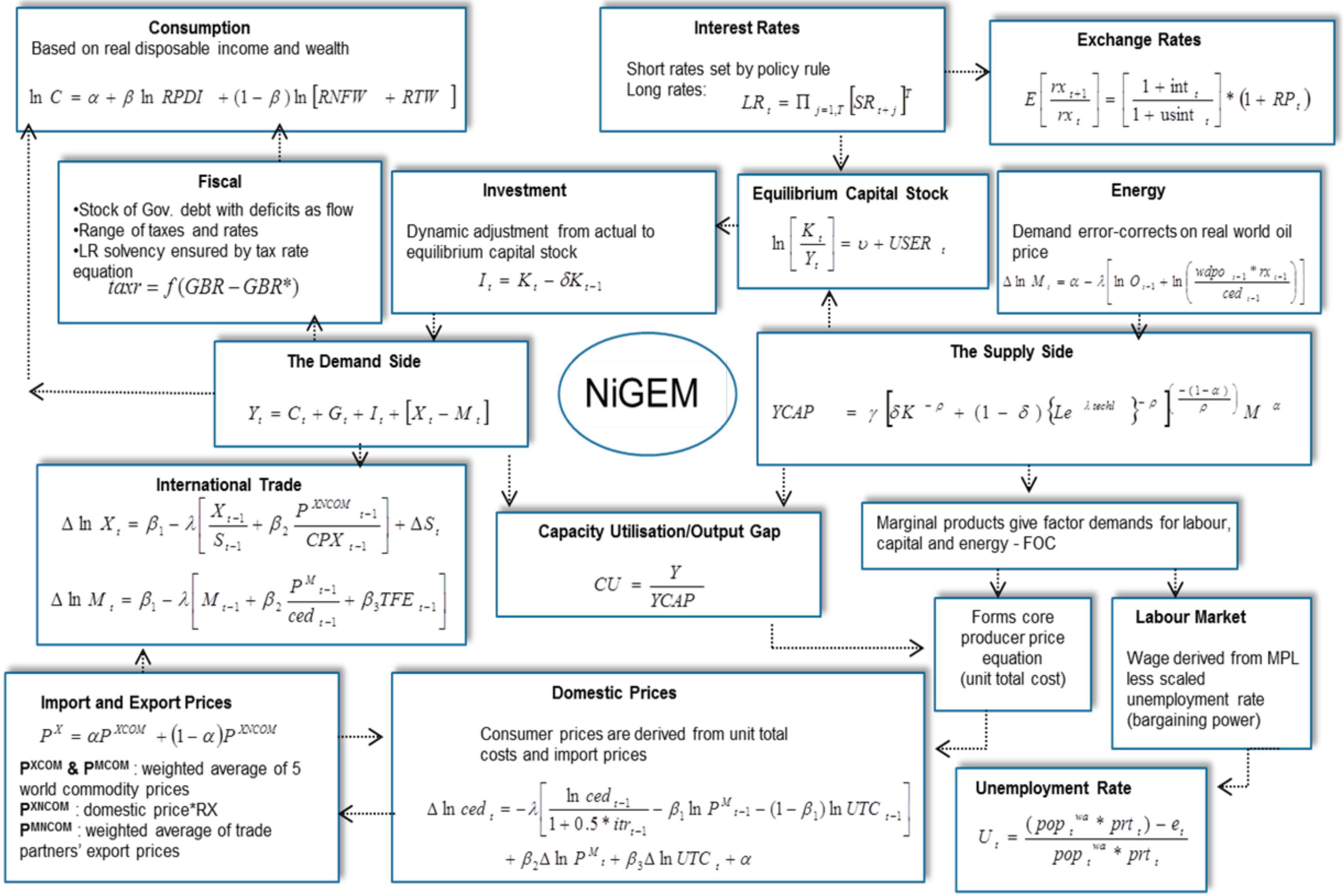
Appendix A: NiGEM schematic



Appendix B: Crisis shocks

Table A1. Term-premium shocks (percentage point)

	Year 1	Year 2	Year 3
Belgium	0.63	0.75	0.61
Bulgaria	0.64	0.83	0.69
Czech Republic	0.79	0.80	0.72
Denmark	0.56	0.67	0.53
Germany	0.44	0.67	0.53
Ireland	0.81	0.87	0.74
Greece	2.34	1.62	1.48
Spain	0.98	1.00	0.87
France	0.55	0.73	0.60
Italy	1.07	1.02	0.89
Latvia	0.56	0.76	0.63
Lithuania	0.62	0.72	0.59
Hungary	2.10	1.60	1.60
Netherlands	0.54	0.70	0.57
Austria	0.55	0.72	0.58
Poland	1.65	1.58	1.46
Portugal	1.21	1.11	0.97
Romania	1.19	1.24	1.15
Slovenia	0.95	1.00	0.86
Finland	0.52	0.70	0.57
Sweden	0.66	0.80	0.64
Slovakia	0.60	0.76	0.63
UK	0.50	0.59	0.47
US	2.00	2.50	2.00
Brazil	2.00	2.50	2.00
India	2.00	2.50	2.00
Indonesia	2.00	2.50	2.00
South Africa	2.00	2.50	2.00
Turkey	2.00	2.50	2.00
Russia	2.00	2.50	2.00
China	2.00	2.50	2.00
Japan	1.15	0.45	0.47
Canada	2.00	2.50	2.00
Norway	2.00	0.00	0.00
Australia	2.00	2.50	2.00
New Zealand	2.00	2.50	2.00
Hong Kong	2.00	2.50	2.00
Mexico	2.00	2.50	2.00

Note: Shocks are applied exogenously to each quarter of the year.

Table A2. Equity price shocks (per cent)

	Year 1	Year 2	Year 3
Belgium	-0.26	-0.24	-0.16
Bulgaria	-0.10	-0.12	-0.08
Czech Republic	-0.23	-0.21	-0.14
Denmark	-0.20	-0.22	-0.15
Germany	-0.25	-0.26	-0.17
Estonia	-0.14	-0.17	-0.11
Ireland	-0.26	-0.25	-0.17
Greece	-0.26	-0.24	-0.16
Spain	-0.26	-0.25	-0.17
France	-0.28	-0.27	-0.18
Italy	-0.29	-0.25	-0.17
Latvia	-0.10	-0.10	-0.07
Lithuania	-0.12	-0.15	-0.10
Hungary	-0.17	-0.20	-0.13
Netherlands	-0.26	-0.26	-0.17
Austria	-0.31	-0.25	-0.17
Poland	-0.19	-0.20	-0.13
Portugal	-0.24	-0.20	-0.14
Romania	-0.19	-0.22	-0.15
Slovenia	-0.10	-0.12	-0.08
Finland	-0.23	-0.25	-0.17
UK	-0.24	-0.25	-0.16
Slovakia	-0.11	-0.13	-0.09
UK	-0.25	-0.25	-0.16
US	-0.25	-0.25	-0.16
China	-0.25	-0.25	-0.16
Australia	-0.25	-0.25	-0.16
Japan	-0.25	-0.25	-0.16
Canada	-0.25	-0.25	-0.16

Note: Shocks are applied exogenously to each quarter of the year.

Table A3. Investment premium shock (percentage point)

Year 1	Year 2	Year 3
0.330	0.230	0.060

Note: Shocks are applied exogenously to all countries in NIGEM with investment premium modelled to each quarter of the year.

Table A4. Oil price shock (per cent)

Year 1	Year 2	Year 3
-48	-44	-44

Note: Shocks are applied exogenously to each quarter of the year.

Finally to bring the impact of a combined shock on GDP in line with the table 5 from EBA scenario, country-specific endogenous shocks were applied to private consumption/ domestic demand in EU and non-EU countries.[15]

Appendix C: Backward-looking expectations formation

Table A5. Impact of synthetic crisis shock on GDP with backward-looking expectation formation (per cent difference from base)

	Year 1	Year 2	Year 3	Av years 4-8
Austria	-2.2	-5.6	-8.6	-2.2
Belgium	-4.0	-8.4	-10.9	-0.2
Euro Area	-3.0	-6.9	-9.3	-0.5
Finland	-2.7	-5.0	-6.5	2.0
France	-4.7	-11.0	-15.4	-6.5
Germany	-1.6	-3.4	-4.2	0.7
Greece	-7.3	-17.7	-23.9	-4.4
Ireland	-1.0	-3.6	-6.8	-3.8
Italy	-2.1	-5.4	-7.8	2.2
Netherlands	-4.8	-9.9	-11.8	3.5
Portugal	-5.5	-11.9	-16.0	-3.1
Spain	-1.9	-5.5	-8.5	1.7

Note: Baseline case with active monetary and fiscal policy in the EMU. Short-term nominal interest rate is restricted at -1 per cent (lower bound).

[15] There are two types of shocks that can be introduced in NiGEM: an exogenous shock shifts a variable by the predetermined value and the equation for this variable is switched ‘off’ for the duration of the shock period; an endogenous shock is applied to the residual component of the equation and equation for this variable continues to operate allowing for feedbacks from the rest of the model to impact upon this variable.