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SOVEREIGN RISK, MONETARY POLICY AND FISCAL MULTIPLIERS: A STRUCTURAL MODEL-BASED ASSESSMENT

by Alberto Locarno†, Alessandro Notarpietro† and Massimiliano Pisani†

This paper briefly reviews the literature on fiscal multipliers and then presents results for the Italian economy obtained by simulating a dynamic general equilibrium model that allows for the possibility (a) that the zero lower bound may be binding and (b) that the initial public debt-to-GDP ratio may affect the financing conditions of the public and private sectors (sovereign risk channel). The results are the following. First, the public consumption multiplier is in general less than 1. Second, it goes above 1 only under extremely strong assumptions, namely the constancy of the monetary policy rate for an exceptionally long period (at least five years) and there is full time-coincidence between the fiscal and the monetary stimuli. Third, when the sovereign risk channel is active the government spending multiplier is much lower. Finally, in all cases tax multipliers are lower than government consumption multipliers.

Abstract

JEL Classification: E32, E52, E62.
Keywords: fiscal multiplier, monetary policy, zero lower bound, sovereign risk.

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1 Introduction[1]

Until the 2007 financial crisis there was a broad consensus that discretionary fiscal policy was ineffective in stabilizing aggregate demand and fighting recessions. This position was justified by the fact that the lags in implementing fiscal policy were typically too long for it to successfully combat cyclical downturns; and it was reinforced by the econometric evidence that the fiscal multiplier was generally low, especially when the fiscal stimulus was ultimately tax-financed. The crisis shattered these beliefs. When monetary policy interest rates hit the dreaded zero lower bound in several countries, it became abundantly clear that the axiom of the ineffectiveness of discretionary fiscal policy was incorrect.

This paper reconsiders the effectiveness of fiscal policy as a demand-management tool, evaluating the fiscal multiplier under various macroeconomic conditions. The question is whether an increase in government consumption leads to more than a one-for-one increase in output,[2] with special attention to the reasons for supposing that the fiscal multiplier is higher in Depression-like circumstances and to the potential importance of the initial stock of public-sector debt. Our contribution is twofold. First, we survey the main theories on the size of the fiscal multiplier and discuss the empirical evidence for and against the competing views on the effectiveness of government spending. Then, using the Bank of Italy's dynamic stochastic general equilibrium (DSGE) model, we estimate the fiscal multiplier in Italy under differing assumptions concerning the monetary policy stance, the financing of the fiscal expansion and the role of sovereign risk.

We are mainly concerned with the short-term impact of fiscal expansions, but we also give an assessment of their long-term effects. Our main conclusions are the following. First, short-run fiscal multipliers are typically less than 1; in particular, tax multipliers are lower than public consumption multipliers. The latter come closer to 1 if a large share of households are liquidity-constrained. Second, public consumption multipliers are substantially greater than 1 only under highly constrictive assumptions, i.e. the constancy of the monetary policy rate for an exceptionally long period (at least five years in our simulations) and full time-coincidence between the fiscal and monetary stimuli. Third, under conditions similar to those now prevailing in the

[1] We thank Fabio Canova, Francesco Nucci and participants at Villa Mondragone International Economic Seminar 2013 for useful comments. The views expressed in this paper are those of the authors and do not necessarily represent those of the Bank of Italy.

[2] Government spending is treated as pure waste in the analysis, in order to focus on the pure macroeconomic effects of fiscal policy as a determinant of aggregate demand in the short run. So it does not directly affect households' welfare or firm's productivity.

euro area, in countries with high public debt the stimulus produces a deterioration of the public finances and hence a rapid increase in the sovereign risk premium, which in turn substantially reduces the multiplier and the effectiveness of fiscal policy. Fourth, and symmetrically, the short-run contractionary effects of fiscal consolidation can be mitigated by a lowering of the risk premium.

The rest of the paper is organized as follows. Section 2 reviews the literature on fiscal multipliers and the related empirical evidence. Section 3 presents the model and elaborates on model calibration. Section 4 illustrates the simulation exercises and shows the results for fiscal multipliers under different macroeconomic scenarios. Section 5 concludes.

2 Theory and evidence on the effects of government spending

Government spending can boost economic activity only if it increases the employment of labour: as the capital stock cannot instantaneously adjust and technical progress is unresponsive to fiscal stimulus, in the short run output can increase only if more hours of labour are used in production. Thus, the value of the fiscal multiplier is closely linked to the effect of government spending on number of hours worked, though the channels posited differ according to whether the perspective is Keynesian or Neoclassical (i.e. real-business cycle). The value of the fiscal multiplier depends on (i) the duration of the stimulus; (ii) how the budget slippage is financed; (iii) whether the monetary policy responds or not (e.g. because the binding zero lower bound (ZLB) keeps the policy rate well above the desired level); (iv) the country's initial conditions (i.e. the volume of resources idles due to lack of aggregate demand and the size of the public debt). Each of these factors must be taken properly into account in order to derive a reliable assessment of the macroeconomic impact of a change in the discretional component of government spending.

2.1 Neoclassical approaches

In the neoclassical paradigm, a debt-financed increase in government purchases - unexpected but known immediately to be permanent - has a negative wealth effect on households, related to the expected payment of higher taxes in the future. Individuals respond by reducing consumption and leisure, as long as both are normal goods.[3] Because the increase in the labour input shifts the marginal product schedule for capital upward, investment rises and remains higher than in the no-stimulus scenario; it stops increasing only when the pre-shock capital-labour ratio is restored. In response to the jump in labour supply, the real wage declines and the rental rate of capital increases symmetrically; these factor-price movements are temporary, however, and the accumulation of capital eventually restores the original situation. According to Baxter and King (1993), the long-run fiscal multiplier is 1.16, corresponding to a 0.2 percentage-point decrease in consumption and a 0.3-point increase in investment;[4] welfare is unambiguously lower, as the representative agent consumes less and works more. When the increase in government spending is temporary, the results are sharply different.[5] As before, agents, who suffer a negative wealth shock, save and work more; now, however, investment falls, due to the increased government absorption of resources. On impact, output increases, though less than in the previous case. After T years, when public spending is back to the pre-stimulus level, investment goes above its long-run level and gradually declines thereafter; consumption and leisure remain below the steady-state equilibrium level and so does output. Eventually, all variables revert to their steady-state level and the original equilibrium is restored. When the fiscal stimulus is withdrawn, output falls below the pre-shock level, reducing the growth rate of the economy, and stays there indefinitely.

Government purchases financed by distortionary taxes have a radically different effect, lessening rather than expanding output. The mechanism is as follows. First, the increase in tax rates creates a gap between marginal productivity and (net) factor compensation and so reduces individuals' incentives to work and invest. Second, the fall in labour supply and capital accumulation compresses the tax base and calls for higher tax rates to balance the budget. Third, the heavier tax burden depresses output even more and forces the government to procure additional revenues. The resulting downward spiral drive output well below the pre-shock level. According to Baxter and King (1993), the fiscal multiplier may go as low as -2.5, implying that private-sector spending is completely crowded out and tax distortions discourage work and investment.

[3]The most-cited reference on this regard is Baxter and King (1993). The numbers for the fiscal multipliers quoted in this section refer to their paper. Under fairly general conditions, there is no difference between a debt-financed and a tax-financed fiscal stimulus, provided the latter is based on lump-sum taxes. Baxter and King (1993) consider a fiscal expansion financed by lump-sum taxes.

[4]As for the change in government spending, variations in consumption and investment are measured in terms of units of output.

[5]Once again it is assumed that the increase in government spending is unexpected but that it is immediately known to last for T years.

In the case of a tax-financed fiscal "stimulus" that lasts for T years, temporarily low after-tax factor rewards induce households and firms to increase leisure and to postpone investment. Output declines and remains below baseline for as long as the measure is in effect. When the "stimulus" ends (and tax rates return to their normal level), hours worked and capital accumulation immediately increase, pushing output slightly above baseline. Eventually, the initial equilibrium is restored. To summarize, the neoclassical theory provides three main insights: (1) permanent changes in government purchases have a multiplier greater than 1;[6] (2) temporary fiscal stimulus is less effective, even in terms of the impact multiplier, which tends to be less than 1;[7] (3) financing decisions are crucial, as they can not only reduce the size of the multiplier but even change its sign.

2.2 Keynesian approaches

Keynesian analysis focuses on situations in which the binding constraint on production and employment is aggregate demand. The essential policy implication is that any increase in aggregate spending, whatever the source, will make induce firms to expand production and draw workers into employment without requiring any change in wages or prices. Under the assumptions that (i) the economy is closed, (ii) there is no capital, (iii) monetary policy does not respond to the fiscal stimulus, and (iv) government spending is debt-financed, then the multiplier corresponding to a permanent increase in government purchases is equal to the reciprocal of the marginal propensity to save. Allowing for foreign trade or for a monetary policy response reduces the size of the output expansion; taking capital accumulation into account has the opposite effect. Even if the fiscal stimulus is tax-financed, the multiplier remains positive and large, as the Haavelmo theorem shows.[8] If instead it is temporary, the size remains the same but it falls to zero as soon as the government stops spending. Accordingly, a temporary fiscal stimulus simply shifts aggregate demand from one period to another: first it provides a boost to growth, then it subtracts from it.

New Keynesian models generate predictions that are in between those consistent with the neoclassical and the Keynesian theories. Since New Keynesian models add sticky prices and other frictions to the real business cycle theory, neoclassical features tend to mute the Keynesian

[6] A short-run multiplier greater than 1 is also possible if the labour supply is highly elastic.

[7] The finding that temporary stimulus is less effective than permanent is not trivial. Barro (1981) and Hall (1980) reach opposite conclusions.

[8] See Haavelmo (1945).

multiplier. Galí et al. (2007) show, however, that the traditional Keynesian predictions can be restored if two ingredients are added, namely: (1) a sufficiently high proportion of rule-of-thumb consumers, which helps by increasing the marginal propensity to consume;[9] and (2) an elastic labour supply, which makes workers willing to offer as many hours as firms demand.[10] Both assumptions, however, ultimately make the models heavily dependent on non-optimizing behavior and so are not entirely appealing.

2.3 ZLB, hysteresis and (other) initial conditions

Monetary policy ordinarily reacts to demand shocks that increase output and drive inflation up; thus in normal times the value of the fiscal multiplier is low, as the fiscal stimulus is largely offset by the response of the central bank. In severely depressed economies, in which the policy interest rate is well above the desired level because of the zero lower bound (ZLB), this is no longer the case. A stream of the literature has recently resumed the Keynesian argument that government spending is likely to boost aggregate demand much more substantially in recession than in expansion, especially when the monetary policy rate is stuck at the ZLB (see Christiano et al. (2011), Eggertsson (2001) and Woodford (2011), among others). The sequence is as follows. When the ZLB is strictly binding, an increase in government spending leads to a rise in output, marginal costs and expected inflation; with the nominal interest rate stuck at zero, higher expected inflation decreases the real interest rate, which stimulates private spending; the increase in spending leads to a further rise in output, marginal cost, and expected inflation and a further decline in the real interest rate. The net result is a large rise in output: the increase in government consumption counteracts the deflationary spiral associated with the ZLB state. The value of the government-spending multiplier depends on how long the ZLB is expected to be binding. Christiano et al. (2011) also respond to the practical objection that using fiscal policy to counteract a contraction associated with the ZLB state is not feasible, as spending increases are

[9] Rule-of-thumb consumers are non-Ricardian. They consume just what they earn, regardless of the impact of government spending on the inter-temporal budget constraint. The larger the share of these non-optimizing agents, the smaller the (negative) impact of wealth effects on consumption and the higher the multiplier.

[10] (u_l) must be equal to the (real) wage rate (w) times the marginal utility of consumption (u_c), i.e. $u_l = wu_c$.Households' labour-supply decision is driven by the intra-temporal equilibrium condition, which states that the marginal utility of leisure (u) must be equal to the (real) wage rate (w) times the marginal utility of consumption (u), i.e. u wu . Because of the negative wealth effect of additional government spending, consumption falls and its marginal utility increases; to restore the equilibrium, either leisure has to diminish (i.e. hours worked have to increase) and/or the real wage has to fall. In the standard Neo-classical (i.e. real business cycle model) both things happen. By preventing the real wage to change, all the adjustment is born by the labour supply, that accordingly has to increase more, boosting the output response to a fiscal stimulus.

subject to long lags. They argue that the case for fiscal stimulus while the constraint binds applies only where the increased government purchases will be terminated as soon as the constraint ceases to bind.[11] Christiano et al. (2011) also provide estimates of the size of the fiscal multiplier, obtained with a DSGE model: assuming government spending that lasts for 12 quarters and a constant nominal interest rate, the impact multiplier is roughly 1.6 and reaches a peak value of about 2.3. However, the high estimates of the spending multiplier implicitly depend on the assumption that non-standard monetary policy measures cannot stimulate aggregate demand and prevent a deflationary spiral.

Another possible factor is hysteresis, especially in the labour market. The concept of hysteresis, borrowed by economists from its original application to physical systems, is that transitory causes may have permanent effects. First used by Blanchard and Summers (1986), it has been revived by DeLong and Summers (2012), who argue that in a depressed economy hysteresis is important and once it is taken into account, the impact of additional government purchases on output can become so strong as to be self-financing. They define a depressed economy as one in which many workers are jobless for an extended period of time, undermining both their skills and their morale.. A depressed economy is marked by low investment, slow if any accumulation of capital, and little entrepreneurial exploration. These factors can affect potential output, which means that a temporary shortage of aggregate demand may permanently reduce aggregate supply. Any policy that averts this outcome is therefore worth being pursued; in particular, a temporary increase in government spending can not only raise output significantly and help end the recession but can also ensure permanent output gains at no financial cost.[12] As Blanchard and Leigh (2013) note, hysteresis characterizes the transmission of fiscal impulses in general and is particularly marked during severe downturns.

Besides the business cycle, other initial conditions also matter, in particular the public finances and debt. Blanchard (1990) proposes a model in which the size of the fiscal multiplier may be inversely related to the ratio of debt to GDP. A budget consolidation affects expectations, hence consumption, in two ways. First, the inter-temporal redistribution of taxes from the future to the present is likely to increase the tax burden of current taxpayers and reduce their

[11] Woodford (2011) adds an additional condition, namely that the tax increase required to finance the budget deficit also lasts only as long as the constraint binds.

[12] DeLong and Summers (2012) provide an example: an incremental $1.00 of government spending raises future output permanently by $0.015 if (1) the fiscal multiplier is 1.5; (ii) the average income tax rate is 33 percent; (iii) the real interest rate on long-term government debt is fixed at 1 percent.

consumption. This is the conventional effect, and its strength depends on how far the economy departs from the benchmark of Ricardian equivalence. Second, by taking measures today, the government avoids larger, more disruptive adjustments in the future, which averts the danger of low output and thus increases consumption. Third, consolidation may be associated with a substantial reduction of uncertainty, which should decrease precautionary saving and lower the option value of waiting by consumers to buy durables and by firms to invest. The last two mechanisms are unconventional and may explain non-Keynesian effects of tighter fiscal policies. Symmetrically, if an increase in government purchases is perceived as threatening the sustainability of the public finances, it may have very little or even a negative effect on output. Sutherland (1997) presents a model that shows how the power of fiscal policy to affect consumption can vary with the level of the public debt. At moderate levels of debt, fiscal policy has the standard Keynesian effects: current consumers discount future taxes because they may not live until the next debt stabilization. But when debt reaches extreme values, current consumers know that they are very likely to be present for the next stabilization programme, and in these situations a fiscal deficit can have a contractionary effect on consumer spending. Nickel and Tudyka (2013) provide empirical evidence on the negative correlation between the fiscal multiplier and the level of public debt. As indebtedness rises the private sector has increasingly Ricardian features: for low debt ratios, consumers and firms ignore the government's inter-temporal budget constraint, but for higher debt ratios they appear to internalize the tax burden that is inevitably associated with an expansion of government spending.

2.4 Empirical evidence on the size of the fiscal multiplier

Pre-crisis estimates of the multiplier

Until recently, it was widely agreed that the government-spending multiplier was not much greater than 1. Hall (2009) holds that in the US the multiplier is between 0.7 and 1.0, while Ramey (2011a) estimates it at closer to 1.2.[13] In both studies the estimates are obtained by using structural VAR models, which suffer from serious identification problems.[14] Moreover, studies

[13]Leigh et al. (2010) present estimates for 15 developed countries, including the US. However, they consider not the standard government-purchases multiplier but average multipliers, referring to fiscal packages consisting of a mixture of transfers, taxes and purchases. They find that on average a fiscal consolidation equal to 1 percentage point of GDP reduces output after 2 years by half a point and increases the unemployment rate by 0.3 points.

[14]The critical issue is to distinguish variations in government spending that represent real changes in the fiscal policy stance from those due to economic events. One solution is to focus on military buildups, on the assumption that this type of spending is the least likely to respond to economic events. Nevertheless, as Ramey (2011b) points out, there is always the possibility that the events that lead to these buildups – e.g. the onset of World

using aggregate data measure what happens on average when government spending changes: to assess the effect of a deficit-financed stimulus, one needs either to focus on periods in which taxes did not change significantly or to control for tax effects, which is no simple matter, given that the estimates of tax multipliers range from -0.5 to -5.0.[15]

Similar evidence is obtained with DSGE models: in standard new-Keynesian models the government-spending multiplier can be somewhat above or below 1 depending on the exact specification of agents' preferences, while in frictionless real-business-cycle models this multiplier is typically less than 1.[16] Accordingly, due to its limited fire-power, lags in implementation and financing costs, until just a few years ago fiscal policy was viewed as a poor tool for aggregate demand management. Things have changed since the 2007-2008 financial crisis, owing among other things to the perceived impotence of monetary policy, stuck at the ZLB.

Recessions, depressions and the ZLB

The evidence on the size of the multiplier when monetary policy is at the ZLB derives both from calibrated DSGE models and from more standard (and data-based) econometric techniques. Christiano et al. (2011) use a DSGE model whose parameters match the response of ten US macro variables to (i) a neutral technology shock, (ii) a monetary impulse, and (iii) a capital-embodied technology shock. They find, first, that when the central bank follows a Taylor rule the government spending multiplier is less than 1, in line with most of the literature; second, when the nominal interest rate does not respond to the rise in spending the multiplier is much larger;[17] third, the value of the multiplier depends critically on how much of the government spending comes during the period when the nominal interest rate is constant. The evidence cited by Christiano et al. (2011) has been criticized for improperly linearizing around the steady-state for a case study – the effects of fiscal policy when interest rates are at the ZLB – that is necessarily

War II or the Cold War – could have other effects on the economy, apart from those on government spending, that could bias the estimates of the multiplier. For example, during World War II a surge of patriotism could have expanded the labour supply by more than would have been predicted by economic incentives alone, increasing the multiplier. By contrast, rationing and capacity constraints could have held it down.

An additional factor complicating identification is that government spending shocks are most often anticipated, implying that the econometrician does not have all the information that economic agents may have. That is, individual agents' expectations may not be based just on past information from the variables in the empirical model. So errors of expectation or forecasting cannot be the residuals of the econometrician's model and the shocks to be studied may not be forecast errors and may be non-fundamental. See Ramey (2011b) and Perotti (2011).

[15] Ramey (2011b) lists a number of studies dealing with this issue.

[16] See e.g. the evidence in Cogan et al. (2010) and Coenen et al. (2012).

[17] For example, for a 12-quarter increase in government spending the impact multiplier is roughly 1.6, with a peak value of about 2.3.

some distance from the steady-state. According to Braun et al. (2012), this mistake accounts for about half of the estimated size of the fiscal multiplier. Auerbach and Gorodnichencko (2012) use regime-switching models and find large differences in the values of spending multipliers between recessions and expansions: the response in expansions never rises above 1 and soon falls below 0, whereas in recessions it rises steadily to peak at more than 2.5 after 20 quarters.[18] Some aspects of their analysis are unconvincing, however, and cast a shadow over their results: first, the peak of the GDP response is reached 20 periods after the shock, at the end of the forecasting window, when output is apparently gaining further momentum; second, the government shock is still 1 percentage point of GDP higher than in the baseline after 20 periods, suggesting that the shock is permanent rather than transitory; third, the output and tax responses in expansions are quite implausible: at period 4, with taxes 1.5 percentage point of GDP below and government spending 2 points above baseline, output is by and large unchanged.

The evidence in Ramey (2012) does not support the thesis that the multiplier is higher when there is slack in the economy or when interest rates are at the ZLB. For the period 1933-1951, characterized by very low interest rates and very high unemployment rates, she estimates the following regression on monthly data:

$$\frac{\Delta Y_t}{Y_{t-1}} = \beta_0 + \beta_1 \frac{\Delta G_t}{Y_{t-1}} + \beta_2 \frac{\Delta Y_{t-1}}{Y_{t-2}} + I_t \left[\beta_3 + \beta_4 \frac{\Delta G_t}{Y_{t-1}} + \beta_5 \frac{\Delta Y_{t-1}}{Y_{t-2}} \right] + \varepsilon_t$$

where Y_t is output, G_t government spending and I_t a dummy variable equal to 1 in periods with high unemployment rates (i.e. larger than 7 percent) and zero otherwise. Unlike Auerbach and Gorodnichencko (2012), she finds that $\beta_4 \simeq 0$. Evidence reported in Ramey (2012) is supported by Owyang et al. (2013), who estimate essentially the same model but use (i) a longer sample period and (ii) a "news" variable (*viz.* the change in the expected present value of government spending in response to military events) rather than G_t: the multiplier is always below unity and, if anything, is slightly lower during the high unemployment state. Owyang et al. (2013) estimate the same model also on Canadian data, finding this time results that are closer to those of obtained by Auerbach and Gorodnichencko (2012).

More recently, an article by Blanchard and Leigh in the IMF's October 2012 World Economic Outlook, presents evidence that the fiscal multiplier in the advanced economies may be considerably greater than had been assumed when fiscal austerity was instituted in most economies in

[18]Note that none of the recessions in their sample (except possibly the last) qualifies as a depression, in which the policy interest rate is at (or close to) the zero lower-bound.

2010.[19] Using a sample including 28 advanced economies, Blanchard and Leigh regress the forecasting error for real GDP growth during 2010-11 on forecasts of fiscal consolidation for 2010-11 that were made in early 2010. Under rational expectations, and assuming that the forecasting model is the right one, the coefficient for planned fiscal consolidation should be 0. Blanchard and Leigh instead find it to be large, negative, and significant: the baseline estimate suggests that a planned consolidation of 1 percent of GDP is associated with a growth forecasting error of about 1 percentage point (the estimates range from 0.4 to 1.2 points). As the multipliers underlying the growth forecasts made in early 2010 were about 0.5, these results indicate that the multipliers have actually been between 0.9 and 1.7. Blanchard and Leigh's study drew a good deal of attention and criticism. First, the estimates seem to depend significantly on the results for Greece and Germany. Second, the results were presented as general, but are limited to the specific time period chosen: the 2010 forecasts of deficits are not good predictors of errors in growth forecasts for 2010 or 2011 when the years are analyzed individually; and the 2011 forecasts are not good predictors of anything.[20] Third, the fiscal consolidation efforts assumed by the IMF in early 2010 were smaller than the measures actually implemented. Fourth, the correlation between growth forecast errors and changes in the fiscal stance breaks down when increases in sovereign bond yields are included in the regression.[21] Fifth, the analysis does not distinguish between budget expansions (in place in 2010) and fiscal tightenings (mostly enacted in 2011): usually the former are temporary, while the latter are permanent. The European Commission (2012a) estimates the same regression as the IMF for consolidating countries only and finds no correlation between growth forecast errors and changes in the fiscal stance. Sixth, multipliers differ greatly across countries and take different values depending on the credibility of the consolidation effort and on the response of sovereign risk premia.[22]

Blanchard and Leigh (2013) respond to these criticisms partially but not fully. They argue that their results are extremely robust and in particular do not depend on the inclusion of Germany and Greece; moreover, they assert that it is no surprise that estimating their model in different periods yields inconsistent results, as economic theory itself predicts that the fiscal multiplier depends on business cycle conditions and on the monetary policy stance; finally, they

[19] In this case the fiscal multiplier does not refer to government purchases but measures the output response to all the fiscal consolidation measures on both the revenue and the expenditure sides adopted in the sample countries.

[20] On these two points, see Financial Times (2012).

[21] On the third and fourth point, see European Commission (2012a).

[22] See European Central Bank (2012).

posit that sovereign risk premia respond to growth prospects, not to the fiscal stance, and accordingly consolidation measures, by weakening aggregate demand and economic activity, raise the cost of borrowing for governments and increase the multiplier.

Hysteresis

The evidence on hysteresis is scanty at best. With respect to DeLong and Summers (2012) it is worth stressing that while the magnitude of the hysteresis effects they assume – just $0.015 for each dollar of additional temporary government purchases – may seem small, actually it is not. In their example, the gains from fiscal stimulus are permanent and their present value, with a discount rate equal to the real interest rate they use for US long-term bonds, is 1.5, which is larger than the shock itself.

Fiscal multipliers in high-debt countries and the sovereign risk channel

The evidence on the relevance of a country's debt/deficit position to the size of the fiscal multiplier is mostly casual. The sovereign debt crisis has clearly shown that the leeway for governments in setting the fiscal policy stance is limited: any action that is perceived as jeopardizing debt sustainability immediately triggers a punitive response by the financial markets. In particular, for countries with dangerously weak finances it is to be expected that any attempt to increase public expenditure may spark a jump in the risk premium on their debt, reducing the output response to the fiscal stimulus, while the contrary is likely to happen for fiscal consolidation attempts.

The studies of Perotti (1999) and Corsetti et al. (2012b) are worth mentioning, however. Perotti (1999) lays out a simple model where government expenditure shocks have a positive, Keynesian correlation with private consumption in normal times and a negative, non-Keynesian correlation in bad times. Symmetrically, tax shocks have a negative, Keynesian correlation in normal times and a positive, non-Keynesian correlation in bad times. What is needed to rationalize state-dependent fiscal multipliers of the type described above is a model in which the correlation between private consumption and shocks to government expenditure and revenues changes, depending on the initial conditions. The empirical model uses a 30-year panel of 19 OECD member countries and distinguishes good periods and bad periods by the size of the cyclically-adjusted public debt and the probability of re-election of the incumbent government.

The empirical evidence supports the thesis that expenditure shocks have Keynesian effects at low levels of debt and non-Keynesian effects at high levels. The evidence of a similar switch in the effects of tax shocks is less strong. Corsetti et al. (2012b), on a sample of 17 OECD countries for the period 1975-2008, investigate the determinants of government spending multipliers, inquiring into the way in which the fiscal transmission mechanism depends on the economic environment. The conditioning factors considered are on the exchange rate regime, the level of the public debt and deficit, and the occurrence of a financial crisis. They obtain four principal findings: (1) multipliers are virtually 0 under normal conditions; (2) the exchange rate regime matters; (3) the fiscal multiplier increases markedly during financial crises, rising from 2.3 on impact to 2.9 at peak; (4) fiscal strains may take the multiplier into negative territory (the cumulative effects over the first 2 years are strongly negative but weaken over longer horizons). The study is subject to the usual caveat about cross-country studies with small samples. Moreover, the finding on the impact of financial crises may be due to reverse causality; that is, it may simply reflect the fact that in times of financial crisis both output and government spending fall. Finally, the response to a crisis should differ substantially internationally, as larger countries have more fiscal leeway for counter-cyclical policies.

While it is clear that in some circumstances an increase in spending (or a reduction in taxation) may not only boost aggregate demand but also raise borrowing costs, thus lowering the fiscal multiplier, the evidence on this link is limited. Most empirical studies focus on countries with negligible default risk and postulate linear relationships, as if the initial stock of public debt were irrelevant. For the United States Laubach (2009) finds that a 1-percentage-point increase in the projected ratio of deficit (debt) to GDP raises long-term yields on Treasury bonds by 20-30 (3-4) basis points. Gruber and Kamin (2012) obtain similar results for OECD countries but find no support for the hypothesis that changes in fiscal balances affect yields through their effect on perceived default risk. Attinasi et al. (2010), for the pre-2010 period, estimate even lower responses of euro-area sovereign spreads to anticipated changes in government deficit and debt. Belhocine and Dell'Erba (2013) find a greater elasticity of sovereign risk premia to public finance conditions; for 26 emerging countries they estimate the response of the yield to maturity of sovereign bonds to changes in the primary budget balance (ratio to GDP), allowing the response to depend on the level of the debt. They find that for countries whose debt is greater than 45 percent of GDP, a 1- point worsening of the primary balance from its debt-stabilising level increases the cost of borrowing by 53.69 basis points.

3 The model

We have seen the findings of the previous literature on fiscal multipliers. In particular, their size depends on the monetary policy stance and the response of credit spreads to changes in the public debt and deficit. To further assess the role of these channels, we will show the fiscal multipliers obtained by simulating a DSGE model of the Italian economy. Its main features are illustrated here.

We model a world economy composed of three regions: Italy, the rest of the euro area (REA) and the rest of the world (RW). In each region there is a continuum of symmetric households and symmetric firms. Italian households are indexed by $j \in [0; s]$, REA households by $j^* \in (s; S]$, RW households by $j^{**} \in (S; 1]$.[23]

Italy and the REA have the same currency and monetary authority, which sets the nominal interest rate according to euro-area-wide variables. The presence of the RW allows us to assess the role of the nominal exchange rate and extra-EA trade in transmitting shocks. In each region there are households and firms. Households consume a final good, which is a composite of intermediate non-tradable and tradable goods. The latter are either domestically produced or imported. Households trade a one-period nominal bond, denominated in euro. They also own domestic firms and use another final good (different from the final consumption good) to invest in physical capital. The latter is rented to domestic firms in a perfectly competitive market. All households supply differentiated labour services to domestic firms and act as wage setters in monopolistically competitive labour markets by charging a markup over their marginal rate of substitution between consumption and leisure.

On the production side, there are perfectly competitive firms that produce the two final goods (consumption goods and investment goods) and monopolistic firms that produce the intermediate goods. The two final goods are sold domestically and are produced combining all available intermediate goods by a constant-elasticity-of-substitution (CES) production function. The two resulting bundles can differ in composition. Intermediate tradable and non-tradable goods are produced by combining domestic capital and labour, which are assumed to be mobile across sectors. Intermediate tradable goods can be sold both domestically and abroad. Because

[23] The parameter s is the size of the Italian population, which is also equal to the number of firms in each Italian sector (final non-tradable, intermediate tradable and intermediate non-tradable). Similar assumptions hold for the REA and the RW.

intermediate goods are differentiated, firms have market power and restrict output in order to create excess profits. We also assume that the markets for tradable goods are segmented, so that firms can set three different prices, one for each market. Like other DSGE models of the euro area (e.g. Christoffel et al. 2008 and Gomes et al. 2012), our model includes adjustment costs on real and nominal variables, ensuring that consumption, production and prices respond gradually to shocks. On the real side, habit preferences and quadratic costs prolong the adjustment of households' consumption and investment, respectively. On the nominal side, quadratic costs make wages and prices sticky.[24]

In the following section we describe in detail the fiscal policy setup (the public sector budget constraint and the sovereign spread), the monetary policy setup, and households' problem in the case of Italy. Similar equations, not reported to save on space, hold for other regions. The only exception is the equation for the spread, which holds for Italy alone.[25]

3.1 The fiscal authority

Initially we report the budget constraint and the fiscal rule of the public sector, and subsequently the sovereign spread.

Budget constraint and fiscal rule

Fiscal policy is set at the regional level. The government budget constraint is:

$$\left[\frac{B_{t+1}^g}{R_t^H} - B_t^g\right] = (1+\tau_t^c)P_{N,t}C_t^g + Tr_t - T_t \tag{1}$$

where $B_t^g \geq 0$ is nominal public debt. It takes the form of a one-period nominal bond issued in the EA market and paying the gross nominal interest rate R_t^H. The variable C_t^g represents government purchases of goods and services, $Tr_t > 0$ (< 0) are lump-sum transfers to (lump-sum taxes on) households. Consistent with the empirical evidence, C_t^g is fully biased towards the intermediate non-tradable good. Hence it is multiplied by the corresponding price index $P_{N,t}$.[26]

We assume that the same tax rates apply to every household. Total government revenues T_t

[24] See Rotemberg (1982).
[25] The rest of the model is set out in the Appendix.
[26] See Corsetti and Mueller (2006, 2008).

from distortionary taxation are given by the following identity:

$$T_t \equiv \int_0^s \left(\tau_t^\ell W_t(j) L_t(j) + \tau_t^k \left(R_t^k K_{t-1}(j) + \frac{\Pi_t^P}{s} \right) + \tau_t^c P_t C_t(j) \right) dj - \tau_t^c P_{N,t} C_t^g \qquad (2)$$

where τ_t^ℓ is the tax rate on individual labor income $W_t(j) L_t(j)$, τ_t^k on capital income $R_t^k K_{t-1}(j) + \Pi_t^P/s$ and τ_t^c on consumption $C_t(j)$. The variable $W_t(j)$ represents the individual nominal wage, $L_t(j)$ is individual hours worked, R_t^k is the rental rate of existing physical capital stock $K_{t-1}(j)$, Π_t^P stands for dividends from ownership of domestic monopolistic firms (they are equally shared across households) and P_t is the price of the consumption bundle.

The government follows a fiscal rule defined on a single fiscal instrument that serves to bring the ratio of public debt to GDP, $b^g > 0$, into line with its target $\bar{b}^g$ and to limit the increase in the ratio of public deficit to GDP (b_t^g/b_{t-1}^g):[27]

$$\frac{i_t}{i_{t-1}} = \left(\frac{b_t^g}{\bar{b}^g} \right)^{\phi_1} \left(\frac{b_t^g}{b_{t-1}^g} \right)^{\phi_2} \qquad (4)$$

where i_t is one of the five fiscal instruments (three tax rates $(\tau_t^\ell, \tau_t^k, \tau_t^c)$ and the two expenditure items (C_t^g, Tr_t)). Parameters ϕ_1, ϕ_2 are less than 0 when the rule is defined on an expenditure item calling for a reduction in expenditures whenever the debt level is above target and/or there is a positive change in the debt. They are greater than 0 when the rule is on tax rates.

Sovereign spread

The interest rate paid by the Italian government and Italian households is determined as a spread over the EA risk-free nominal interest rate (set by the ECB). In the spirit of Corsetti et al. (2012a) the spread reflects the default risk, and any policy measure that changes public-sector deficit and debt affects the sovereign risk premium (whose response depends, among other things, on the size of the outstanding debt). We make two additional assumptions: (i) after the initial adjustment, the spread returns to its pre-shock value: the reversion is gradual and is completed when the fiscal stimulus (or consolidation effort) terminates; (ii) in case of permanent fiscal measures, households and firms do not fully anticipate the duration of the spread change.[28]

[27] The definition of nominal GDP is:

$$GDP_t = P_t C_t + P_t^I I_t + P_{N,t} C_t^g + P_t^{EXP} EXP_t - P_t^{IMP} IMP_t \qquad (3)$$

where P_t, P_t^I, P_t^{EXP}, P_t^{IMP} are prices of consumption, investment, exports and imports, respectively.

[28] This assumption is deliberately conservative, because it allows us to rule out large and counterfactual macroeconomic responses associated with perfect anticipation of permanent changes in the cost of borrowing. In this

These assumptions permit taking account, in our otherwise perfect-foresight framework, of the uncertainty surrounding the sustainability of public finances and the duration of the discretionary measures.

The assumption that even temporary changes in the fiscal stance affect the sovereign risk premium can be justified on the grounds that any deterioration or improvement in net borrowing pushes the economy closer to or further from the fiscal limit, i.e. the point at which taxes and spending can no longer adjust to stabilize debt and the government has no choice but to default on the debt: the closer the fiscal limit, the more likely it is that a recessionary shock will trigger a run on the sovereign debt.[29] The higher probability of default calls for an increase in the sovereign risk premium, which does not disappear until the stimulus is withdrawn and the economy is back to the original position.

Specifically, we formalize the spread as follows:

$$spread_t^H \equiv \begin{cases} f\left(b_t^g / b_{t-1}^g\right) & for\ t = 1 \\ \rho * spread_{t-1}^H & for\ t > 1 \end{cases} \tag{5}$$

where $b_t^g > 0$ is the Italian public debt-to-GDP ratio at the end of period t.

As such, the (gross) interest rate R^H paid by the Italian government is:

$$R_t^H \equiv R_t * spread_t^H \tag{6}$$

where R_t is the (gross) risk-free nominal interest rate. The spread also affects the intertemporal choices of Italian households through the standard Euler equation, as reported later.

3.2 Monetary authority

The monetary authority controls the short-term policy rate R_t according to a Taylor rule of the form:

$$\left(\frac{R_t}{\bar{R}}\right) = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} \left(\Pi_{EA,t}\right)^{(1-\rho_R)\rho_\pi} \left(\frac{GDP_{EA,t}}{GDP_{EA,t-1}}\right)^{(1-\rho_R)\rho_{GDP}} \tag{7}$$

The parameter ρ_R $(0 < \rho_R < 1)$ captures inertia in interest rate setting, while the term $\bar{R}$ represents the steady state gross nominal policy rate. The parameters ρ_π and ρ_{GDP} are respectively the weights of the euro-area CPI inflation rate $(\Pi_{EA,t})$ and GDP $(GDP_{EA,t})$. The CPI inflation

respect, the estimated contribution of the sovereign risk channel to our results should be taken as a lower bound.

[29] See for instance Leeper (2013).

rate is a geometric average of CPI inflation rates in Italy and the REA (respectively Π_t and Π_t^*) with weights equal to the correspondent country size (as a share of the EA):

$$\Pi_{EA,t} \equiv (\Pi_t)^{\frac{s}{s+S}} (\Pi_t^*)^{\frac{S}{s+S}} \tag{8}$$

The EA GDP, $GDP_{EA,t}$, is the sum of the Italian and REA GDPs (respectively GDP_t and GDP_t^*):

$$GDP_{EA,t} \equiv GDP_t + rer_t * GDP_t^* \tag{9}$$

where rer_t is the bilateral real exchange rate between Italy and REA, defined as the ratio of REA to Italian consumer prices. In some simulations, the interest rate will be held constant at its steady-state value for several periods, instead of following the Taylor rule (7), which eventually kicks in. In this way we can assess the role of the monetary policy stance for the size of fiscal multipliers.

3.3 Households

Households' preferences are additively separable in consumption and labor effort. The generic Italian household j receives utility from consumption C and disutility from labor L. The expected value of the lifetime utility is:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t(j) - hC_{t-1})^{1-\sigma}}{(1-\sigma)} - \frac{L_t(j)^{1+\tau}}{1+\tau} \right] \right\} \tag{10}$$

where E_0 denotes the expectation conditional on information set at date 0, β is the discount factor ($0 < \beta < 1$), $1/\sigma$ is the elasticity of intertemporal substitution ($\sigma > 0$) and $1/\tau$ is the labor Frisch elasticity ($\tau > 0$). The parameter h ($0 < h < 1$) represents external habit formation in consumption.

The budget constraint of household j is:

$$\begin{aligned} \frac{B_t(j)}{\left(1+R_t^H\right)} - B_{t-1}(j) \quad \leq \quad & (1-\tau_t^k)\left(\Pi_t^P(j) + R_t^K K_{t-1}(j)\right) + \\ & +(1-\tau_t^\ell)W_t(j) L_t(j) - (1+\tau_t^c)P_t C_t(j) - P_t^I I_t(j) \\ & +Tr_t(j) - AC_t^W(j) \end{aligned}$$

As is commonly assumed in the literature, Italian households hold a one-period nominal bond,

B_t, denominated in euro ($B_t > 0$ is a lending position). The short-term nominal rate R_t^H is paid at the beginning of period t and is known at time t.[30] We assume that government and private bonds are traded in the same international market. Households own all domestic firms and there is no international trade in claims on firms' profits. The variable Π_t^P includes profits accruing to the Italian households. The variable I_t is the investment bundle in physical capital and P_t^I the related price index, which differs from the consumer price index because the two bundles are different in composition.[31] Italian households accumulate physical capital K_t and rent it to domestic firms at the nominal rate R_t^k. The law of motion of capital accumulation is:

$$K_t(j) = (1-\delta) K_{t-1}(j) + \left(1 - AC_t^I(j)\right) I_t(j) \tag{11}$$

where δ is the depreciation rate. Adjustment cost on investment AC_t^I is:

$$AC_t^I(j) \equiv \frac{\phi_I}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)^2, \ \phi_I > 0 \tag{12}$$

Finally, Italian households act as wage setters in a monopolistic competitive labor market. Each household j sets its nominal wage taking into account labor demand and adjustment costs AC_t^W on the nominal wage $W_t(j)$:

$$AC_t^W(j) \equiv \frac{\kappa_W}{2}\left(\frac{W_t(j)}{W_{t-1}(j)} - 1\right)^2 W_t L_t, \ \kappa_W > 0 \tag{13}$$

The costs are proportional to the per-capita wage bill of the overall economy, $W_t L_t$.

The sovereign risk channel (see equation 6) affects households' choices via the interest rate R_H in the Euler equation (obtained by maximizing utility subject to the budget constraint with respect to bond holdings B_t):

$$(C_t(j) - hC_{t-1})^{-\sigma} = \beta E_t\left(R_t^H (C_{t+1}(j) - hC_t)^{-\sigma}\right) \tag{14}$$

The larger the spread, the higher the interest rate R_t^H and the greater the incentive for households to postpone consumption.

Similar relations hold in the rest of the euro area and the world, with two exceptions, in

[30] A financial friction μ_t is introduced to guarantee that net asset positions follow a stationary process and the economy converge to a steady state. Revenues from financial intermediation are rebated in a lump-sum way to households in the REA. See Benigno (2009).

[31] For details see the Appendix.

correspondence with two simplifying assumptions. First, the spreads paid by Italian households and government are rebated as a lump sum way to households in the REA. Second, neither the public sector nor the private sector in the REA and RW pay the spread on their borrowing. So what appears in the corresponding Euler equations is the riskless interest rate.

Finally, it is assumed that the bond traded by households and governments is in worldwide zero net supply. The implied market clearing condition is:

$$-B_t^g + \int_0^s B_t\left(j\right) dj - B_t^{g*} + \int_s^S B_t\left(j^*\right) dj^* - B_t^{g**} + \int_S^1 B_t\left(j^{**}\right) dj^{**} = 0 \qquad (15)$$

where B_t^{g*},$B_t^{g**} > 0$ are respectively the borrowing of the REA and RW public sectors, and $B_t\left(j^*\right)$ and $B_t^{**}\left(j^{**}\right)$ are respectively the per capita bond positions of their households.

3.4 Calibration

The model is calibrated at quarterly frequency. We set some parameter values so that steady-state ratios are consistent with the 2010 national accounts data, the latest and most complete available. For the remaining parameters we use previous studies and estimates.[32]

Table 1 gives the parameters that regulate preferences and technology. Parameters with "$*$"and "$**$" are related to the REA and the RW, respectively. Throughout we assume perfect symmetry between the REA and the RW, unless otherwise indicated. We assume that discount rates and elasticities of substitution have the same value in all three regions. The discount factor β is set to 0.9927, so that the steady-state real interest rate is equal to 3.0 per cent on an annual basis. The value for the intertemporal elasticity of substitution, $1/\sigma$, is 1. The Frisch labor elasticity is set to 0.5. The depreciation rate of capital δ is set to 0.025. Habit is set to 0.6.

In the production functions of tradables and non-tradables, the elasticity of substitution between labor and capital is set to 0.93. The bias towards capital in the production function of tradables is set 0.56 in Italy and 0.46 in the REA and in the RW. The corresponding values in the production function of non-tradables are 0.53 and 0.43. In the final consumption and investment goods functions the elasticity of substitution between domestic and imported tradable is 1.5, that between tradables and non-tradables 0.5. In the consumption bundle the bias to the domestic tradeable is 0.68 in Italy, 0.59 in REA and 0.90 in RW. The bias towards the composite tradeable is 0.68 in Italy and 0.5 in REA and RW. For the investment basket, the bias towards the domestic

[32]Among others, see Forni et al. (2009, 2010a, 2010b).

tradable is 0.50 in Italy, 0.49 in REA and 0.90 in RW. The bias towards the composite tradable is 0.78 in Italy, 0.70 in REA and RW. The biases towards the domestically produced good and composite tradable good are chosen to match the import-to-GDP ratios of Italy and REA.

Table 2 reports gross markup values. In the Italian tradable and non-tradable sectors and in the Italian labour market the markup is set to 1.08, 1.30 and 1.60, respectively (the corresponding elasticities of substitution across varieties are set to 13.32, 4.44 and 2.65). In the REA these gross markups are respectively set to 1.11, 1.24 and 1.33 (the corresponding elasticities are set to 10.15, 5.19 and 4.00). Similar values are chosen for the corresponding parameters in the RW.

Table 3 gives the parameters that regulate the dynamics. Adjustment costs on investment change are set to 6. Nominal wage quadratic adjustment costs are set to 200. In the tradable sector, we set the nominal adjustment cost parameter to 300 for Italian tradables sold domestically and in REA; and to 50 for Italian goods sold in RW. The same parameterization is adopted for REA, while for the rest of the world we set the adjustment cost on goods exported to Italy and REA to 50. Nominal price adjustment costs are set to 500 in the non-tradable sector. The parameters are calibrated to generate dynamic adjustments for the euro area similar to those obtained with the New Area Wide Model (NAWM, see Christoffel et al. 2008) and Euro Area and Global Economy model (EAGLE, see Gomes et al. 2012). The two parameters regulating the adjustment cost to private agents on their net financial position are set to 0.00055 so that they do not greatly affect the model dynamics.

Table 4 reports the parametrization of the systemic feedback rules followed by the fiscal and monetary authorities. In the fiscal policy rule (4) we set $\phi_1 = \pm 0.05$, $\phi_2 = \pm 1.01$ for Italy and $\phi_1 = \phi_2 = \pm 1.01$ for the REA and the RW. Their sign is positive when the fiscal instrument in the rule is a tax rate, negative when it is expenditure. The central bank targets contemporaneous EA wide consumer price inflation (this parameter is set to 1.7) and the output growth (parameter 0.1). The interest rate is set in an inertial way, so its previous-period value enters the rule with a weight equal to 0.87. The same values hold for the corresponding parameters of the Taylor rule in RW.

Table 5 reports the actual GDP ratios and tax rates, which are matched in the steady state under our baseline calibration. We assume zero steady-state net foreign asset positions, which means that in each region the net financial position of the private sector is equal to the public debt. The Italian and REA GDPs are set to 3 percent and 17 percent, respectively, of world

GDP.

As for fiscal policy variables, the public consumption-to-GDP ratio is set to 0.20. The tax rate on wage income τ^ℓ is set to 42.6 per cent in Italy and to 34.6 in the REA. The tax rate on physical capital income τ^k is set to 34.9 in Italy and 25.9 in the REA, while the tax rate on consumption τ^c is equal to 16.8 in Italy and to 20.3 in the REA. The public debt-to-yearly GDP ratio is calibrated to 119 percent for Italy and to 0.79 for the REA. Variables of the RW are set to values equal to those of corresponding REA variables.

Finally, for Italy we calibrate the relationship between the fiscal policy stance and the spread on the sovereign debt (5). Absent operational estimates of the link between fiscal conditions and risk premia, we turn to the literature on this issue, in particular Belochine and Dell'Erba (2013), and posit that an increase in government spending of 1 percentage point of GDP maps into a 75-basis-point rise in the sovereign risk premium. The greater sensitivity of borrowing costs with respect to their estimates is justified by the fact that the Italian debt ratio is much higher than the threshold Belochine and Dell'Erba find for emerging economies. Moreover, in a way this value is consistent with market developments since June 2011. At that time the spread between Italian and German 10-year bond yields was about 180 basis points, close to the level reached in the aftermath of the Lehman crisis. During the summer it soared brusquely: the exacerbation of the euro-area sovereign debt crisis fuelled fears for the sustainability of the public finances in the peripheral countries. The political mishandling of the crisis further heightened market tensions, and by mid-November the spread had reached 553 basis points, 370 more than five months earlier.[33] It took three fiscal consolidation packages for a total of 4.8 percentage points of GDP to stop the escalation of borrowing costs. Hypothesizing that a budget adjustment of that size is what the financial markets expected to keep the re-pricing of Italian sovereign risk at just 370 basis points, we can gauge the cost (benefit) of increasing (reducing) the public-sector deficit by 1 percentage point of GDP at about 75 basis points.[34] This estimate is admittedly rough and highly tentative; and it fails to distinguish sovereign risk from redenomination risk. Even so it appears reasonable, more plausible than the alternatives. Furthermore, we carry out

[33]Spikes came immediately after the downgrade of Portugal in July, the release of the bail-in plan for Private Sector Involvement at the EU summit of 21-22 July, and the announcement of the Greek referendum on 1 November. Domestic events, i.e. the tensions generated by the uncertainty over the fiscal consolidation m also played some role. For a detailed account of the impact of news on the BTP-Bund spread between June 2011 and March 2012, see Pericoli (2012).

[34]The decrease in the spread in the initial months of 2012 and since August is not considered in the computation, as it most likely depends on monetary policy.

a robustness check, calibrating the initial spread increase according to the estimates of Borgy et al. (2011). A number of assumptions are required in order to map the observed variations in long-term government bond yields onto our model-based quarterly interest rate . We follow the common practice and take the return on 10-year government bonds as the most representative long-term market rate. We design a procedure to map a given change in that yield onto variations in R_t^H. We follow the common practice and take the return on 10-year government bonds as the most representative long-term market rate. We design a procedure to map a given change in that yield onto variations in R_t^H. For simplicity we assume that changes in the return on any given maturity are transmitted in equal measure to all maturities, so that the shape of the term structure is unchanged. Hence, a change in the yield on 10-year bonds corresponds simply to an upward or downward shift in the entire yield curve, with no effect on its slope. This reflects the implicit definition of the model-based long-term interest rate as a weighted average of expected future short-term rates, via the expectation hypothesis and the Euler equation. In our model an expected change in the short-term rate would affect the returns paid at different maturities equally, so that the shape of the term structure of interest rates would remain unchanged.

4 The Results

In what follows we simulate the model to assess the fiscal multipliers for Italy under standard monetary policy, constant monetary policy rate and alternative responses of the credit spread. All simulations assume perfect foresight: shocks are fully anticipated by households and firms, with the exception of the initial shock in the first period.

4.1 Benchmark fiscal multipliers

Table 6 shows the short-term (first and second year) results of increasing Italian public consumption by 1 percent of the pre-stimulus baseline GDP. For the permanent fiscal shock, the table also reports the long-run multipliers.[35] Monetary policy is conducted according to the Taylor rule (7), while public debt is stabilized by raising lump-sum taxes according to the fiscal rule (4).[36] After the end of the stimulus, public consumption returns immediately to its initial steady-state value.

[35] For temporary shocks the long-run multiplier is 0.

[36] The implications of distortionary taxation for the spending multiplier are considered below.

The first two columns of Table 6 report multipliers of Italian public consumption when it is increased for one year. In the first year GDP increases by 0.86 percent of its baseline value. Household consumption and investment decrease slightly. The nominal policy rate does not increase, because it is set at the euro-area level and reacts to EA-wide inflation and output, which are not significantly affected by the increase in Italian GDP and even less by the rise in the CPI. With the small increase in Italian prices, the real exchange rates of Italy against the REA and the RW appreciate slightly, so Italy's terms of trade vis-à-vis those areas improve slightly. Accordingly, tradables produced in the REA and in the RW become cheaper than those produced in Italy. Italy's net exports diminish (gross exports decrease and gross imports increase).[37] Spillovers towards the REA and RW are small, given Italy's small share of the world economy and the relatively strong home bias in the REA and RW consumption and investment baskets.[38]

The remaining columns of Table 6 report the multipliers for the first two years for two-year, five-year and permanent fiscal stimuli (for the last, the long-run multiplier is also reported). In the first year GDP increases by 0.80, 0.78 and 0.69 percent, respectively; in the second, by 0.67, 0.56 and 0.52. In the case of a permanent fiscal stimulus, the long-run multiplier is 0.59. The responses of the output components change with the scenario. The longer the duration of the stimulus, the larger the decrease in private consumption and the smaller the decrease in private investment; the latter increases when the stimulus lasts for five years or longer. Differences in household demand responses are associated with the strength of the negative wealth effect of current and expected public spending. The more resources appropriated to public consumption, the larger the negative wealth effect, the more households cut consumption and increase labour supply. The increase in labour supply makes capital more productive and induces investment and capital accumulation. Accordingly the aggregate supply can match the persistently higher public consumption demand.

For comparison, Table 7 reports the values of the public consumption multipliers when both public spending and labour income taxes are increased. The increase in the labour tax rate is such that the corresponding revenues are equal to 1 percent of pre-stimulus GDP, so that the

[37] This is true for bilateral exports and imports to and from REA and RW (not reported for space reasons). Exports decrease more towards the RW, as their prices increase by more than those of the exports towards the REA (the former are more flexible than the latter).

[38] REA and RW consumption and investment (not reported) fall slightly to finance the increase in Italian borrowing associated with the fiscal stimulus and the consumption smoothing of Italian households.

fiscal stimulus is ex ante revenue-neutral. The multiplier is now lower than in the case of higher lump-sum taxes. There is less incentive to increase labour effort than in the previous case, as the increase in distortionary labour taxes reduces the net real wages. The differences are large for the second year, in particular for long-lasting stimuli.

The foregoing simulations have shown the multipliers associated with public consumption spending. Table 8 reports the multipliers associated with stimuli consisting in lowering tax rates on labour income, capital income and consumption. The reduction in tax revenues is 1 percent of pre-stimulus GDP and lasts for either one, two, five years or permanently. After the stimulus, the public debt is stabilized by increasing lump-sum taxes according to the fiscal rule (4); public consumption is held constant at its pre-stimulus level. In the short run tax multipliers are less than 1 and lower than public consumption multipliers; they are larger in the second year than in the first (the only exception is consumption tax), because household consumption and investment react smoothly, given the assumptions of habit persistence and adjustment costs on investment. Finally, in the case of labour and capital income taxes, the longer the duration of the stimulus, the larger the multipliers, because households have more incentive to increase labour effort, the more long-lasting the decrease in taxes on their labour or capital income. In particular, in the long run the GDP multiplier associated with a permanent reduction in the capital tax rate is greater than 1.

Figure 1 shows the dynamic response of the main macroeconomic variables in the benchmark case of a public consumption increase financed by lump-sum taxes. Figure 2 reports the responses to the labour tax cut. In both cases the stimulus lasts for one year. Interestingly, the increase in public consumption raises GDP immediately, whereas the labour tax cut does so only gradually, as consumption and investment increase smoothly because of external habit formation in consumption and adjustment costs for investment.

Overall, the results suggest that fiscal multipliers are less than 1 and that for short-lived shocks the multipliers associated with taxation are lower than those associated with public spending, as public consumption affects aggregate demand directly while the negative wealth effects on consumption are rather muted. By contrast, in the case of permanent measures the wealth effects become large, implying that in the long run, when private spending fully adjusts to a given shock, the taxation multiplier is larger than the public consumption multiplier.

4.2 Constant monetary policy rate

So far we have assumed that monetary policy follows the Taylor rule (7). Now we assume instead an accommodative monetary policy stance. Table 9 reports the results for increases in public consumption by 1 percent of GDP for one, two, and five years and on a permanent basis when the nominal policy rate is constant during the fiscal stimulus; for the permanent stimulus, the accommodative stance lasts for five years.[39] After the stimulus, monetary policy is standard (the Taylor rule kicks in). As in previous simulations the public debt is stabilized by increasing lump-sum taxes according to rule (4).

In the case of one- and two-year stimuli the GDP multiplier is comparable to that under the standard monetary policy stance (Table 6). The multiplier increases to well above 1 when the stimulus lasts for five years. It is 1.37 in the first year and 1.13 in the second. The monetary policy rate is similar in all scenarios, as we see by comparing Tables 6 and 9. For the standard stance, it increases by a few basis points. In the case of the five-year fiscal stimulus and accommodative monetary policy, in conjunction with the Italian fiscal stimulus inflation increases substantially in Italy and in the rest of the euro area (not reported). The implied reduction in the real interest rate favors the crowding-in of private demand and thus enhances the effectiveness of the stimulus.

When the fiscal stimulus is permanent and monetary policy is accommodative for five years (Table 9), the lack of full overlap between monetary and fiscal policy implies that the multiplier is only slightly greater than under standard monetary policy (0.79 and 0.62 in the first two years vs. 0.69 and 0.52). The results are qualitatively in line with those reported in Woodford (2011), who finds that both fiscal stimulus and accommodative monetary policy have to be retained for an exceptionally long period in order to generate large multipliers, as inflation expectations need to be high enough to reduce the ex ante real interest rate. Note also that the 5-year mix of expansionary Italian fiscal policy and constant EA policy rate affects the REA activity and inflation positively, through trade spillovers. When the interest rate is constant for a sufficiently long time and there is full overlap with the fiscal stimulus, the inflation expectations of REA households become high enough to reduce the ex ante real interest rate significantly, stimulating household consumption and investment demand. This favours Italian exports, partially offsetting

[39] In what follows, we assume that the central bank does not or cannot steer the short-term nominal interest rate of the monetary union for a certain amount of time. Unlike much of the literature (see for example Corsetti et al. 2012a), we do not posit an exogenous recessionary shock that takes the monetary policy rate down to the ZLB. The reason is that the ZLB holds at EA level and so can be taken as exogenous with respect to changes in Italian economic conditions.

the loss of competitiveness due to the appreciation in the real exchange rate.

Table 10 reports the results under the assumption that the policy rate remains constant for half as long as the fiscal stimulus (2.5 years in the case of the 5-year and permanent fiscal stimuli). Multipliers are lower than in Table 9, as the monetary policy now accommodates the public consumption shock to a lesser extent. If the shock lasts 5 years, the multipliers are 0.88 in the first year and 0.65 in the second (instead of 1.37 and 1.13).

Table 11 reports the results for tax-rate multipliers. For 1- and 2-year stimuli, assuming constant interest rate, the multipliers are similar to those under standard monetary policy (Table 8). For 5-year and permanent stimuli the capital income and consumption tax multipliers are higher under no monetary-policy response than under standard monetary policy. In particular, the capital income tax multiplier rises above 1. On the other hand, the labour income tax multiplier decreases in the case of 2- and 5-year stimuli, because of the large initial positive response on the supply side, which lowers inflation expectations and, given the absence of monetary policy response, raises the real interest rate. Consumption and investment fall accordingly, as monetary policy is no longer accommodative.

Overall, the public consumption multiplier is well above 1 only when monetary policy remains accommodative for a very long time; otherwise the multipliers do not differ greatly from the case of standard monetary policy response and remain generally below 1.

4.3 Sovereign risk premium

The macroeconomic effects of a fiscal stimulus depend not only on monetary policy but also on the response of financial markets. As our review of the literature shows (Section 2), if investors are worried about the solvency of the government, they will demand a higher premium in response to a fiscal expansion. Moreover, the sovereign risk premium will be quickly transmitted to the borrowing cost of domestic households and firms, crowding out their spending decisions (this is the sovereign-risk channel of fiscal policy; see Corsetti et al. 2012a). Accordingly, this sovereign-risk channel may reduce the fiscal multiplier in times of financial turbulence. This conjecture is supported by some recent empirical evidence. Laubach (2012) studies the dependence of the sovereign spread on the current level of fiscal indicators (such as the surplus-to-GDP or the debt-to-GDP ratios) for a panel of EA countries and finds that the elasticity is small or nil in non-crisis periods but increases rapidly and dramatically at times of financial stress.

This section reports the model results for an increase in public consumption of 1 percent of pre-stimulus GDP for 1, 2 and 5 years and permanently. Consistent with equation (5), we assume that the fiscal expansion entails an immediate 75-basis-point rise in the sovereign premium, hence in the interest rate on Italian government bonds. The effects of the stimulus depend crucially on the dynamics of the sovereign risk premium. We assume that after the initial rise the spread declines linearly, returning to baseline level by the time the stimulus is withdrawn.[40] In line with the empirical evidence for Italy (see Albertazzi et al. 2012, Neri 2013 and Zoli 2013), the increase in sovereign risk is fully passed through in one quarter to the borrowing rate for the Italian private sector. Monetary policy follows the standard Taylor rule and public debt is stabilized by lump-sum taxes after the end of the fiscal stimulus. The output multipliers are reported in Table 12: 0.78, 0.61, 0.27 and 0.18 in the first year when, respectively, the stimulus is for 1, 2, and 5 years and permanent; in the second year, they fall to -0.12, 0.57, 0.07 and 0.03 respectively. The values are lower than in the scenarios where the sovereign channel is lacking (Table 6), because of the larger crowding-out effect on private-sector spending due to higher interest rates. Moreover, the longer the stimulus, the slower the decrease in the spread, the greater the reduction in the multiplier. In the case of the 5-year stimulus, private consumption decreases by 1.19 percent in the first year and 1.28 percent in the second, private investment by 1.51 and 2.35 percent. Absent the sovereign risk channel (Table 6), private consumption would fall by 0.15 percent in the first year and 0.32 percent in the second, while private investment would increase.

Figure 3 sums up the results given here and in the previous section. The government-consumption multiplier depends heavily on the monetary policy response and on the change of the sovereign risk premium; in particular, it can be greater than 1 only if the monetary policy rate is held constant for an extended period. Moreover, monetary policy should remain accommodative for the duration of the fiscal stimulus (compare the bars for accommodative monetary policy and partial overlap). Otherwise, multipliers are less – possibly much less – than 1, if the sovereign risk premium increases.

[40] In the case of a permanent stimulus, we assume this takes 5 years.

4.4 Fiscal consolidation and sovereign risk

The foregoing results suggest that in times of financial stress fiscal consolidation may reduce borrowing costs for households and firms. If the consolidation is credible, financial markets, anticipating that the public finances will become fully sustainable, might demand a lower sovereign risk premium. With quick and complete pass-through of the premium to the private sector borrowing rate, the decrease in the borrowing cost for households and firms should at least partially offset the contractionary effects of the consolidation.

This section analyzes the output effects of fiscal consolidation when the sovereign risk channel is operative. The policy tightening may be induced by an abrupt increase in the sovereign spread as a result of financial market turbulence, as it was in Italy in late 2011. Our results on fiscal consolidation should be compared, ideally, to a benchmark scenario in which there is no fiscal plan.

Table 13 reports the results of permanently reducing the debt-GDP ratio by 1 percentage point. As in Italy's fiscal package in the second half of 2011, public spending is reduced permanently by 0.25 percentage points while taxation (on labour income, capital income and consumption) is increased by 0.75 percentage points.[41] The sovereign spread responds as follows: on impact it narrows by 75 basis points (the reduction observed in Italy following the announcement of the consolidation in the autumn of 2011) and then gradually returns to its baseline value after 1, 2, 3 or 5 years. We simulate both a standard monetary policy response and a constant rate for five years. The sharpest reduction in output is 0.69 percent in the first year and 0.79 in the second. This occurs when the monetary policy rate is held constant and there is no sovereign risk channel. The smallest reduction in output is 0.04 percent in the first year and 0.16 in the second, which occurs when the decrease in the risk premium is durable (5 years). In this case, households benefit from a lower real interest rate, partially offsetting the increase in distortionary taxation.[42] As a limiting case, the effect on output can even be positive in the first year if the spread comes back to the baseline value in three or five years. For a permanent spread reduction, the effects would be larger still. Our assumptions are deliberately conservative, because they preclude large – and probably counterfactual – macroeconomic effects associated with perfect anticipation of permanent changes in spreads. In this respect, the estimate of the sovereign risk effect should

[41] See Ministero dell'Economia e delle Finanze (2012).

[42] Note that public spending decreases, helping to crowd in household consumption and investment spending.

be taken as a lower bound.

Simulation results suggest that under conditions of financial stress, when the sovereign risk channel is active the negative impact of fiscal consolidation can be quite modest, certainly less than under normal conditions.

4.5 Sensitivity analysis

This section reports the sensitivity analysis for the public consumption multipliers (see Table 6). We now assume that the share of liquidity-constrained households is 30 percent of the Italian population and, alternatively, that the increase in public consumption is implemented simultaneously in Italy and the REA, under standard or accommodative monetary policy. Finally, we report the multipliers when the spread increases by 37 basis points, in line with the estimates provided by Borgy et al. (2011).

Liquidity constrained households

Table 14 shows the results when liquidity constraints affect 30 percent of Italian households instead of none.

Following Campbell and Mankiw (1989) and Galí et al. (2004, 2007), we assume that in each period liquidity-constrained households consume their entire after-tax disposable income. That is, the budget constraint of the generic liquidity-constrained household j is:

$$(1+\tau_t^c)P_tC_t\,(j) = (1-\tau_t^\ell)W_t\,(j)\,L_t\,(j)$$

We assume liquidity-constrained households' wages and hours of labour are the same as those of unconstrained households, as are the tax rates on labour income and consumption.

The multipliers are now larger, owing to the income effect associated with the liquidity-constrained households, who increase consumption immediately as they do not save but spend their entire available wage income. The latter increases because firms expand employment, to serve increased aggregate demand. The differences with respect to the benchmark scenarios are not particularly great. In any event, the multipliers remain below 1.

Simultaneous fiscal stimulus in the EA

We assess the extent to which Italian fiscal multipliers change when the stimulus is implemented simultaneously in Italy and the REA. We assume an increase in public consumption by 1 percent of pre-shock GDP for two years. The monetary policy is conducted according to the Taylor rule or is accommodative (policy rate held at its baseline level during the fiscal stimulus).

The results are reported in Table 14. Under standard monetary policy, the multipliers are slightly smaller for EA-wide stimulus than for unilateral Italian stimulus. As in the case of unilateral Italian stimulus, the multiplier is less than 1. Italian net exports (not reported) now diminish less, because the Italian exchange rate vis-à-vis the REA appreciates less. The monetary policy rate now rises more, given the increase in EA-wide aggregate demand. Accordingly, the real interest rate falls more modestly when the fiscal stimulus is coordinated, crowding out relatively more Italian household and business demand.

The Italian multipliers are greater than 1 when the monetary policy is accommodative and the fiscal stimulus lasts for two years at least. The constant interest rate stimulates REA aggregate demand by lowering the real interest rate. Italian gross exports decrease less, thanks to greater aggregate REA demand. The Italian GDP multiplier is 1.31 percent in the first year. For unilateral Italian stimulus and accommodative monetary policy lasting two years, it is 0.86 percent (Table 9). This suggests that the accommodative monetary policy is more effective in driving the multiplier above 1 when the fiscal stimulus comes simultaneously at EA level.

Spread increase

Table 15 reports the public consumption multipliers when the spread increases immediately by 37 basis points, in line with estimates provided by Borgy et al. (2011). The multipliers are in general slightly lower than benchmark (see Table 6), but they are now larger than in the case of a 75-basis-point increase in the spread (Table 12). The smaller increase in the spread implies less crowding-out of household and business spending, which therefore does not contract as much. Overall, the multipliers do not differ greatly in the different scenarios, in particular for stimuli of plausible duration. Only for protracted stimulus (five years or permanent) do the multipliers increase substantially.

Finally, we exploit the calibration implicitly suggested by Borgy et al. (2011) to simulate the 2011 Italian fiscal consolidation again. The spread decreases on impact by 37 basis points, then returns to its baseline value after 1, 2, 3 or 5 years. Table 16 shows the results. The effects are larger than in the benchmark case (Table 13). The spread decreases less, giving households and firms less incentive to increase consumption and investment. Even if the monetary policy rate is held constant for five years, the implied multiplier continues to be less than 1.[43]

5 Conclusion

This paper estimates the size of fiscal multipliers in Italy under various assumptions concerning the reaction of the central bank and the sovereign risk premium. There are four main conclusions. First, short-run fiscal multipliers are typically less than 1, and tax multipliers are lower than public consumption multipliers. Second, public consumption multipliers are substantially greater than 1 when the monetary policy rate is kept constant for an exceptionally extended period (five years in our simulations). Third, under conditions similar to those currently prevailing in the euro area, in countries with a high public debt ratio the stimulus causes a worsening of the public finances and consequently a rapid increase in the sovereign risk premium, which in turn substantially reduces the multiplier and diminishes the effectiveness of fiscal policy. Fourth, the short-run contractionary effects of fiscal consolidation can be mitigated by a lowering of the sovereign risk premium. Overall, our results suggest that the magnitude of fiscal multipliers differs between normal times and periods of financial distress, insofar as initial public finance conditions and the stance of monetary policy can be decisive to the financing conditions of to the private sector.

[43]We have also experimented by calibrating the spread on the basis of Corsetti et al. (2012a). According to our elaborations, the spread would increase by 20 basis points in response to a 1-percentage-point expected increase in the public debt-GDP ratio. The results, available upon request, are intermediate between zero-spread case and the case considered in the sensitivity analysis.

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Table 1. Parametrization of Italy, the rest of the Euro Area and the rest of the world

Parameter	IT	REA	RW
Discount rate β	0.993	0.993	0.993
Intertemporal elasticity of substitution $1/\sigma$	1.0	1.0	1.0
Inverse of Frisch elasticity of labor supply τ	2.0	2.0	2.0
Habit h	0.6	0.6	0.6
Depreciation rate of (private and public) capital δ	0.025	0.025	0.025
Tradable Intermediate Goods			
Substitution between factors of production $\xi_T, \xi_T^*, \xi_T^{**}$	0.93	0.93	0.93
Bias towards capital $\alpha_T, \alpha_T^*, \alpha_T^{**}$	0.56	0.46	0.46
Non-tradable Intermediate Goods			
Substitution between factors of production $\xi_N, \xi_N^*, \xi_N^{**}$	0.93	0.93	0.93
Bias towards capital $\alpha_N, \alpha_N^*, \alpha_N^{**}$	0.53	0.43	0.43
Final consumption goods			
Substitution between domestic and imported goods $\phi_A, \phi_A^*, \phi_A^{**}$	1.50	1.50	1.50
Bias towards domestic tradable goods a_H, a_F^*, a_G^*	0.68	0.59	0.90
Substitution between domestic tradables and non-tradables $\rho_A, \rho_A^*, \rho_A^{**}$	0.50	0.50	0.50
Bias towards tradable goods a_T, a_T^*, a_T^{**}	0.68	0.50	0.50
Final investment goods			
Substitution between domestic and imported goods $\phi_E, \phi_E^*, \phi_E^{**}$	1.50	1.50	1.50
Bias towards domestic tradable goods υ_H, υ_F^*	0.50	0.49	0.90
Substitution between domestic tradables and non-tradables ρ_E, ρ_E^*	0.50	0.50	0.50
Bias towards tradable goods υ_T, υ_T^*	0.78	0.70	0.70

Note: IT=Italy; REA=rest of the euro area; RW=rest of the world.

Table 2. Gross Markups

	Markups and Elasticities of Substitution		
	Tradables	Non-tradables	Wages
IT	1.08 ($\theta_T = 13.32$)	1.30 ($\theta_N = 4.44$)	1.60 ($\psi = 2.65$)
REA	1.11 ($\theta_T^* = 10.15$)	1.24 ($\theta_N^* = 5.19$)	1.33 ($\psi^* = 4$)
RW	1.11 ($\theta_T^{**} = 10.15$)	1.24 ($\theta_N^{**} = 5.19$)	1.33 ($\psi^{**} = 4$)

Note: IT=Italy; REA=rest of the euro area; RW=rest of the world; source: OECD (2012).

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Table 3. Real and Nominal Adjustment Costs

Parameter	IT	REA	RW
Real Adjustment Costs			
Investment ϕ_I, ϕ_I^*, ϕ_I^{**}	6.00	6.00	6.00
Households' financial net position ϕ_{b1}, ϕ_{b2}	0.00055, 0.00055	-	0.00055, 0.00055
Nominal Adjustment Costs			
Wages κ_W, κ_W^*, κ_W^{**}	200	200	200
Italian produced tradables κ_H, k_H^* k_H^{**}	300	300	50
REA produced tradables κ_H, k_H^* k_H^{**}	300	300	50
RW produced tradables κ_H, k_H^* k_H^{**}	50	50	300
Non-tradables κ_N, κ_N^*, κ_N^{**}	500	500	500

Note: IT=Italy; REA=rest of the euro area; RW=rest of the world.

Table 4. Fiscal and Monetary Policy Rules

Parameter	IT	REA	EA	RW
Fiscal policy rule				
$\phi_1, \phi_1^*, \phi_1^{**}$	±0.05	±1.01	-	±1.01
$\phi_2, \phi_2^*, \phi_2^{**}$	±1.01	±1.01	-	±1.01
Common monetary policy rule	-	-		
Lagged interest rate at t-1 ρ_R, ρ_R^{**}	-	-	0.87	0.87
Inflation ρ_Π, ρ_Π^{**}	-	-	1.70	1.70
GDP growth $\rho_{GDP}, \rho_{GDP}^{**}$	-	-	0.10	0.10

Note: IT=Italy; REA=rest of the euro area; EA=euro area; RW=rest of the world.

Table 5. Main macroeconomic variables (ratio to GDP) and tax rates

	IT	REA	RW
Macroeconomic variables			
Private consumption	61.0	57.1	64.0
Private Investment	18.0	16.0	20.0
Imports	29.0	24.3	4.3
Net Foreign Asset Position	0.0	0.0	0.0
GDP (share of world GDP)	0.03	0.17	0.80
Public expenditures			
Public purchases	20.0	20.0	20.0
Interests	4.0	2.0	2.0
Public investment	2.0	3.0	3.0
Debt (ratio to annual GDP)	119	79	79
Tax Rates			
on wage	42.6	34.6	34.6
on rental rate of capital	34.9	25.9	25.9
on price of consumption	16.8	20.3	20.3

Note: IT=Italy; REA=rest of the euro area; RW=rest of the world. Sources: European Commission (2012b); tax rates (in percent) are from Eurostat (2012).

Table 6. Public consumption multipliers

	1 year-stimulus		2 year-stimulus		5 year-stimulus		permanent stimulus		
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	LR
Italian variables									
GDP	0.86	-0.10	0.80	0.67	0.78	0.56	0.69	0.52	0.59
Consumption	-0.04	-0.06	-0.08	-0.17	-0.15	-0.32	-0.51	-0.80	-0.79
Investment	-0.05	-0.13	-0.03	-0.25	0.34	0.31	0.57	1.03	0.54
Exports	-0.42	-0.18	-0.56	-0.73	-0.62	-0.98	-0.48	-0.69	-0.30
Imports	0.05	0.00	0.09	0.06	0.22	0.30	0.01	0.11	-0.16
Terms of Tr. REA (+=deterior.)	-0.13	-0.11	-0.21	-0.35	-0.27	-0.54	-0.20	-0.38	-0.20
Terms of Tr. RW (+=deterior.)	-0.35	-0.12	-0.44	-0.55	-0.47	-0.69	-0.36	-0.49	-0.20
Real Exc. Rate REA (+=depr.)	-0.05	-0.05	-0.09	-0.16	-0.13	-0.27	-0.09	-0.20	-0.15
Real Exc. Rate RW (+=depr.)	-0.06	-0.05	-0.10	-0.16	-0.15	-0.29	-0.12	-0.21	-0.15
Inflation(annualized)	0.08	-0.03	0.15	0.02	0.20	0.11	0.14	0.07	0.00
Real.Int.Rate (annualized)	-0.03	0.04	-0.12	0.04	-0.18	-0.07	-0.12	-0.05	0.00
Nominal Int. Rate (annualized)	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00
Labor	1.34	-0.18	1.22	0.99	1.17	0.74	1.02	0.66	0.46
Pub.Def.(%gdp)	0.72	-0.10	0.75	0.84	0.76	0.90	0.84	0.98	0.00
Prim.Pub.Def.(%gdp)	0.73	-0.13	0.76	0.82	0.78	0.89	0.85	0.97	0.00
REA GDP	0.00	0.00	0.00	0.00	-0.01	-0.02	-0.02	-0.01	0.00
RW GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: LR=long run, REA=rest of the euro area; RW=rest of the world. All variables as % dev. from initial steady state, inflation, interest rate, public deficit/GDP and primary public deficit/GDP as % point dev. from initial steady state.

Table 7. Public consumption multipliers. Labor tax-based financing

	1 year-stimulus		2 year-stimulus		5 year-stimulus		permanent stimulus		
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	LR
Italian variables									
GDP	0.83	-0.14	0.74	0.54	0.66	0.27	0.49	0.14	-0.33
Consumption	-0.05	-0.09	-0.11	-0.24	-0.22	-0.50	-0.85	-1.33	-1.76
Investment	-0.07	-0.18	-0.09	-0.41	0.23	-0.07	0.45	0.67	-0.13
Exports	-0.47	-0.26	-0.68	-0.97	-0.83	-1.46	-0.58	-0.97	-1.31
Imports	0.05	0.00	0.09	0.06	0.22	0.28	-0.19	-0.19	-0.42
Terms of Tr. REA (+=deterior.)	-0.16	-0.15	-0.27	-0.48	-0.37	-0.82	-0.26	-0.56	-0.89
Terms of Tr. RW (+=deterior.)	-0.39	-0.18	-0.54	-0.73	-0.62	-1.03	-0.43	-0.68	-0.88
Real Exc. Rate REA (+=depr.)	-0.07	-0.07	-0.12	-0.22	-0.18	-0.43	-0.13	-0.32	-0.65
Real Exc. Rate RW (+=depr.)	-0.07	-0.07	-0.13	-0.23	-0.22	-0.46	-0.16	-0.33	-0.65
Inflation(annualized)	0.10	-0.03	0.20	0.04	0.29	0.20	0.20	0.13	0.00
Real.Int.Rate (annualized)	-0.05	0.04	-0.17	0.03	-0.29	-0.15	-0.20	-0.12	0.00
Nominal Int. Rate (annualized)	0.01	0.00	0.01	0.02	0.01	0.01	0.00	0.00	0.00
Labor	1.29	-0.26	1.11	0.76	0.97	0.23	0.68	0.01	-0.68
Pub.Def.(%gdp)	-0.31	-0.11	-0.29	-0.22	-0.27	-0.13	-0.12	0.03	0.00
Prim.Pub.Def.(%gdp)	-0.29	-0.11	-0.26	-0.20	-0.24	-0.10	-0.10	0.05	0.00
GDP REA	0.00	0.00	-0.01	-0.01	-0.02	-0.03	-0.02	-0.02	-0.01
GDP RW	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00

Note: LR=long run, REA=rest of the euro area; RW=rest of the world. All variables as % dev. from initial steady state, inflation, interest rate, public deficit/GDP and primary public deficit/GDP as % point dev. from initial steady state.

Table 8. Tax multipliers. Italian GDP and inflation

	labor tax			capital tax			consumption tax		
	1st year	2nd year	LR	1st year	2nd year	LR	1st year	2nd year	LR
1 year-stimulus	0.02	0.04	0.00	0.02	0.02	0.00	0.34	0.07	0.00
2 year-stimulus	0.06	0.13	0.00	0.08	0.11	0.00	0.30	0.37	0.00
5 year-stimulus	0.11	0.29	0.00	0.23	0.47	0.00	0.28	0.30	0.00
permanent stimulus	0.19	0.37	0.89	0.17	0.53	2.51	0.08	0.15	0.37
Inflation									
1 year-stimulus	-0.02	0.00	0.00	0.00	0.00	0.00	0.06	-0.01	0.00
2 year-stimulus	-0.04	-0.02	0.00	0.00	-0.01	0.00	0.09	0.03	0.00
5 year-stimulus	-0.09	-0.08	0.00	0.04	-0.03	0.00	0.11	0.07	0.00
permanent stimulus	-0.06	-0.07	0.00	0.00	-0.05	0.00	-0.02	-0.03	0.00

Note: LR=long run. GDP as % dev. from initial steady state, inflation as annualized % point dev. from initial steady state.

Table 9. Public consumption multipliers. Constant monetary policy rate

	1 year-stimulus		2 year-stimulus		5 year-stimulus		permanent stimulus		
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	LR
Italian variables									
GDP	0.88	-0.09	0.86	0.73	1.37	1.13	0.79	0.62	0.59
Consumption	-0.02	-0.05	-0.01	-0.11	0.50	0.22	-0.40	-0.71	-0.79
Investment	-0.02	-0.09	0.09	-0.09	1.43	1.80	0.77	1.29	0.54
Exports	-0.40	-0.17	-0.50	-0.70	-0.17	-0.71	-0.40	-0.64	-0.30
Imports	0.06	0.01	0.15	0.13	0.77	0.92	0.11	0.22	-0.16
Terms of Tr. REA (+=deterior.)	-0.13	-0.11	-0.22	-0.35	-0.29	-0.55	-0.20	-0.38	-0.20
Terms of Tr. RW (+=deterior.)	-0.36	-0.12	-0.47	-0.55	-0.75	-0.69	-0.41	-0.49	-0.20
Real Exc. Rate REA (+=depr.)	-0.05	-0.05	-0.09	-0.16	-0.13	-0.27	-0.09	-0.20	-0.15
Real Exc. Rate RW (+=depr.)	-0.03	-0.04	0.00	-0.11	0.75	0.16	0.04	-0.13	-0.15
Inflation(annualized)	0.10	-0.03	0.21	0.05	0.81	0.44	0.25	0.12	0.00
Real.Int.Rate (annualized)	-0.06	0.03	-0.19	0.00	-0.78	-0.35	-0.23	-0.09	0.00
Nominal Int. Rate (annualized)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labor	1.37	-0.16	1.34	1.09	2.21	1.62	1.21	0.82	0.46
Pub.Def.(%gdp)	0.69	-0.12	0.70	0.78	0.42	0.54	0.77	0.92	0.00
Prim.Pub.Def.(%gdp)	0.72	-0.13	0.73	0.79	0.48	0.60	0.80	0.92	0.00
REA GDP	0.02	0.01	0.07	0.06	0.58	0.53	0.09	0.08	0.00
RW GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: LR=long run, REA=rest of the euro area; RW=rest of the world. All variables as % dev. from initial steady state, inflation, interest rate, public deficit/GDP and primary public deficit/GDP as % point dev. from initial steady state.

Table 10. Public consumption multipliers. Partial monetary policy accommodation

	1 year-stimulus		2 year-stimulus		5 year-stimulus		permanent stimulus		
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	LR
Italian variables									
GDP	0.87	-0.09	0.81	0.68	0.88	0.65	0.71	0.55	0.59
Consumption	-0.03	-0.06	-0.06	-0.16	-0.04	-0.23	-0.48	-0.78	-0.79
Investment	-0.04	-0.11	0.00	-0.22	0.52	0.55	0.62	1.09	0.54
Exports	-0.41	-0.17	-0.54	-0.73	-0.55	-0.93	-0.46	-0.68	-0.30
Imports	0.06	0.00	0.11	0.07	0.31	0.40	0.04	0.14	-0.16
Terms of Tr. REA (+=deterior.)	-0.13	-0.11	-0.21	-0.35	-0.27	-0.54	-0.20	-0.38	-0.20
Terms of Tr. RW (+=deterior.)	-0.35	-0.12	-0.45	-0.55	-0.52	-0.69	-0.38	-0.49	-0.20
Real Exc. Rate REA (+=depr.)	-0.05	-0.05	-0.09	-0.16	-0.13	-0.27	-0.09	-0.20	-0.15
Real Exc. Rate RW (+=depr.)	-0.04	-0.05	-0.07	-0.15	0.00	-0.22	-0.08	-0.19	-0.15
Inflation(annualized)	0.09	-0.03	0.16	0.03	0.30	0.16	0.16	0.08	0.00
Real.Int.Rate (annualized)	-0.05	0.03	-0.15	0.03	-0.29	-0.13	-0.15	-0.06	0.00
Nominal Int. Rate (annualized)	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Labor	1.36	-0.17	1.25	1.01	1.35	0.89	1.07	0.70	0.46
Pub.Def.(%gdp)	0.70	-0.11	0.72	0.82	0.69	0.83	0.82	0.96	0.00
Prim.Pub.Def.(%gdp)	0.72	-0.13	0.75	0.81	0.73	0.84	0.84	0.96	0.00
REA GDP	0.01	0.01	0.01	0.01	0.09	0.07	0.01	0.01	0.00
RW GDP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: LR=long run, REA=rest of the euro area; RW=rest of the world. All variables as % dev. from initial steady state, inflation, interest rate, public deficit/GDP and primary public deficit/GDP as % point dev. from initial steady state.

Table 11. Tax multipliers. Constant monetary policy rate. Italian GDP and inflation

	labor tax			capital tax			consumption tax		
	1st year	2nd year	LR	1st year	2nd year	LR	1st year	2nd year	LR
1 year-stimulus	0.02	0.04	0.00	0.02	0.02	0.00	0.35	0.08	0.00
2 year-stimulus	0.05	0.12	0.00	0.09	0.12	0.00	0.36	0.42	0.00
5 year-stimulus	0.00	0.17	0.00	0.45	0.68	0.00	0.80	0.80	0.00
permanent stimulus	0.39	0.56	0.89	1.44	1.75	2.51	0.16	0.23	0.37
Inflation									
1 year-stimulus	-0.02	0.00	0.00	0.00	0.00	0.00	0.07	-0.01	0.00
2 year-stimulus	-0.05	-0.03	0.00	0.02	-0.01	0.00	0.14	0.05	0.00
5 year-stimulus	-0.22	-0.15	0.00	0.25	0.08	0.00	0.64	0.36	0.00
permanent stimulus	0.14	0.04	0.00	1.32	0.65	0.00	0.06	0.02	0.00

Note: LR=long run. GDP as % dev. from initial steady state, inflation as annualized % point dev. from initial steady state.

Table 12. Public consumption multipliers. Spread increase

	1 year-stimulus		2 year-stimulus		5 year-stimulus		permanent stimulus		
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	LR
Italian variables									
GDP	0.78	-0.12	0.61	0.57	0.27	0.07	0.18	0.03	0.59
Consumption	-0.22	-0.10	-0.48	-0.36	-1.19	-1.28	-1.55	-1.75	-0.73
Investment	-0.20	-0.21	-0.51	-0.67	-1.51	-2.35	-1.28	-1.64	0.56
Exports	-0.37	-0.15	-0.42	-0.62	-0.15	-0.33	-0.01	-0.04	-0.37
Imports	-0.12	-0.06	-0.35	-0.23	-1.17	-1.37	-1.37	-1.56	-0.08
Terms of Tr. REA (+=deterior.)	-0.12	-0.10	-0.17	-0.30	-0.09	-0.25	-0.02	-0.09	-0.25
Terms of Tr. RW (+=deterior.)	-0.31	-0.10	-0.33	-0.47	-0.10	-0.21	0.01	-0.01	-0.25
Real Exc. Rate REA (+=depr.)	-0.05	-0.05	-0.07	-0.14	-0.05	-0.15	-0.02	-0.07	-0.18
Real Exc. Rate RW (+=depr.)	-0.05	-0.05	-0.08	-0.14	-0.06	-0.15	-0.03	-0.07	-0.18
Inflation(annualized)	0.07	-0.03	0.12	0.03	0.07	0.09	0.00	0.05	0.00
Real.Int.Rate (annualized)	-0.03	0.03	-0.10	0.02	-0.07	-0.12	-0.01	-0.09	0.00
Nominal Int. Rate (annualized)	0.01	0.00	0.01	0.01	0.00	-0.01	-0.01	-0.02	0.00
Labor	1.21	-0.19	0.91	0.88	0.36	0.13	0.21	0.05	0.44
Pub.Def.(%gdp)	1.27	-0.03	1.46	1.30	1.73	1.91	1.81	1.99	0.00
Prim.Pub.Def.(%gdp)	0.78	-0.14	0.87	0.86	1.08	1.15	1.16	1.23	0.00
GDP REA	0.00	0.00	-0.01	-0.01	-0.03	-0.03	-0.03	-0.03	0.00
GDP RW	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00

Note: LR=long run, REA=rest of the euro area; RW=rest of the world. All variables as % dev. from initial steady state, inflation, interest rate, public deficit/GDP and primary public deficit/GDP as % point dev. from initial steady state.

Table 13. Fiscal consolidation and spread reduction. Italian GDP

	standard monetary policy		5 year constant mon. pol. rate	
	1st year	2nd year	1st year	2nd year
No spread	-0.29	-0.40	-0.69	-0.79
Spread: -75 bp on impact, 0 bp after 1 year	-0.21	-0.38	-0.62	-0.78
Spread: -75 bp on impact, 0 bp after 2 years	-0.10	-0.30	-0.51	-0.70
Spread: -75 bp on impact, 0 bp after 3 years	0.02	-0.17	-0.38	-0.56
Spread: -75 bp on impact, 0 bp after 5 years	0.22	0.10	-0.04	-0.16

Note: GDP as % dev. from initial steady state.

Table 14. Sensitivity on public consumption multipliers. Italian GDP and inflation

	benchmark			ROT households			fiscal coord.			fiscal coord.+constant m.p.		
	1st year	2nd year	LR	1st year	2nd year	LR	1st year	2nd year	LR	1st year	2nd year	LR
GDP												
1 year-stimulus	0.86	-0.10	0.00	0.98	-0.13	0.00	0.85	-0.10	0.00	0.99	0.00	0.00
2 year-stimulus	0.80	0.67	0.00	0.90	0.75	0.00	0.75	0.63	0.00	1.31	1.13	0.00
5 year-stimulus	0.78	0.56	0.00	0.88	0.61	0.00	0.60	0.35	0.00	6.96	6.14	0.00
permanent stimulus	0.69	0.52	0.59	0.76	0.56	0.68	0.53	0.37	0.56	1.56	1.34	0.56
Inflation												
1 year-stimulus	0.08	-0.03	0.00	0.09	-0.04	0.00	0.12	-0.02	0.00	0.22	0.01	0.00
2 year-stimulus	0.15	0.02	0.00	0.17	0.02	0.00	0.20	0.07	0.00	0.71	0.30	0.00
5 year-stimulus	0.20	0.11	0.00	0.22	0.12	0.00	0.17	0.17	0.00	6.76	3.57	0.00
permanent stimulus	0.14	0.07	0.00	0.14	0.06	0.00	0.04	0.03	0.00	1.09	0.58	0.00

Note: LR=long run; GDP as % dev. from initial steady state, inflation as annualized % point dev. from initial steady state.

Table 15. Sensitivity. Public consumption multipliers. Spread increase

	1 year-stimulus		2 year-stimulus		5 year-stimulus		permanent stimulus		
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	LR
Italian variables									
GDP	0.82	-0.11	0.70	0.62	0.52	0.31	0.43	0.27	0.59
Consumption	-0.13	-0.08	-0.28	-0.27	-0.68	-0.81	-1.04	-1.29	-0.76
Investment	-0.13	-0.17	-0.27	-0.46	-0.59	-1.04	-0.36	-0.33	0.55
Exports	-0.39	-0.16	-0.49	-0.67	-0.38	-0.65	-0.24	-0.36	-0.33
Imports	-0.04	-0.03	-0.13	-0.09	-0.49	-0.55	-0.69	-0.73	-0.12
Terms of Tr. REA (+=deterior.)	-0.13	-0.11	-0.19	-0.33	-0.18	-0.39	-0.11	-0.23	-0.22
Terms of Tr. RW (+=deterior.)	-0.33	-0.11	-0.39	-0.51	-0.28	-0.45	-0.17	-0.25	-0.22
Real Exc. Rate REA (+=depr.)	-0.05	-0.05	-0.08	-0.15	-0.09	-0.21	-0.06	-0.13	-0.16
Real Exc. Rate RW (+=depr.)	-0.05	-0.05	-0.09	-0.15	-0.11	-0.22	-0.07	-0.14	-0.16
Inflation(annualized)	0.08	-0.03	0.13	0.03	0.13	0.10	0.07	0.06	0.00
Real.Int.Rate (annualized)	-0.03	0.03	-0.11	0.03	-0.13	-0.10	-0.07	-0.07	0.00
Nominal Int. Rate (annualized)	0.01	0.00	0.01	0.02	0.00	0.00	0.00	-0.01	0.00
Labor	1.27	-0.19	1.07	0.94	0.76	0.43	0.61	0.35	0.45
Pub.Def.(%gdp)	1.00	-0.07	1.10	1.07	1.25	1.41	1.33	1.49	0.00
Prim.Pub.Def.(%gdp)	0.75	-0.13	0.82	0.84	0.93	1.02	1.01	1.10	0.00
GDP REA	0.00	0.00	-0.01	0.00	-0.02	-0.02	-0.02	-0.02	0.00
GDP RW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

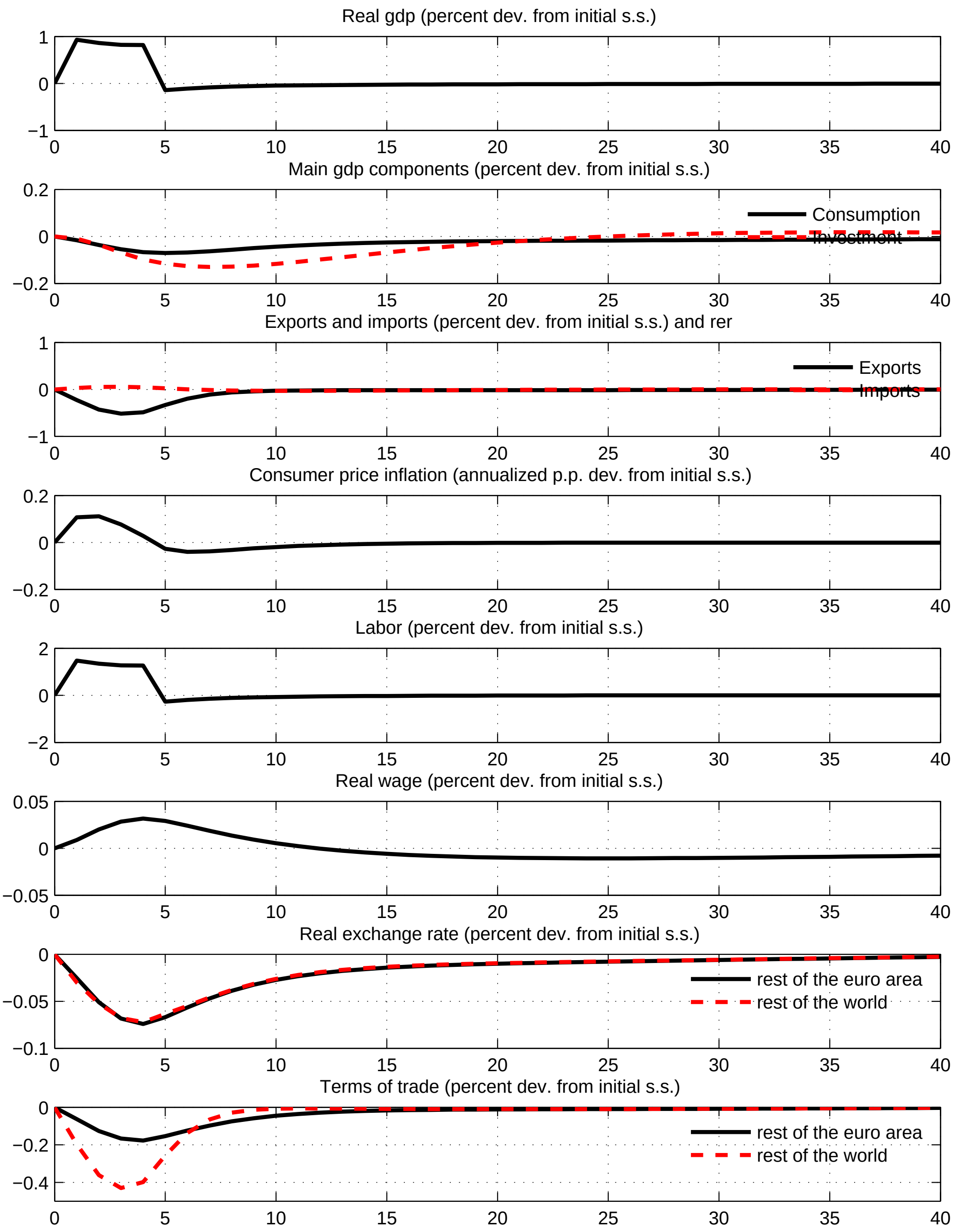
Note: LR=long run, REA=rest of the euro area; RW=rest of the world. All variables as % dev. from initial steady state, inflation, interest rate, public deficit/GDP and primary public deficit/GDP as % point dev. from initial steady state.

Table 16. Sensitivity. Fiscal consolidation and spread reduction. Italian GDP

	standard monetary policy		5 year constant mon. pol. rate	
	1st year	2nd year	1st year	2nd year
No spread	-0.29	-0.40	-0.69	-0.79
Spread: -37 bp on impact, 0 bp after 1 year	-0.25	-0.39	-0.65	-0.78
Spread: -37 bp on impact, 0 bp after 2 years	-0.19	-0.35	-0.60	-0.74
Spread: -37 bp on impact, 0 bp after 3 years	-0.14	-0.29	-0.54	-0.67
Spread: -37 bp on impact, 0 bp after 5 years	-0.03	-0.15	-0.36	-0.47

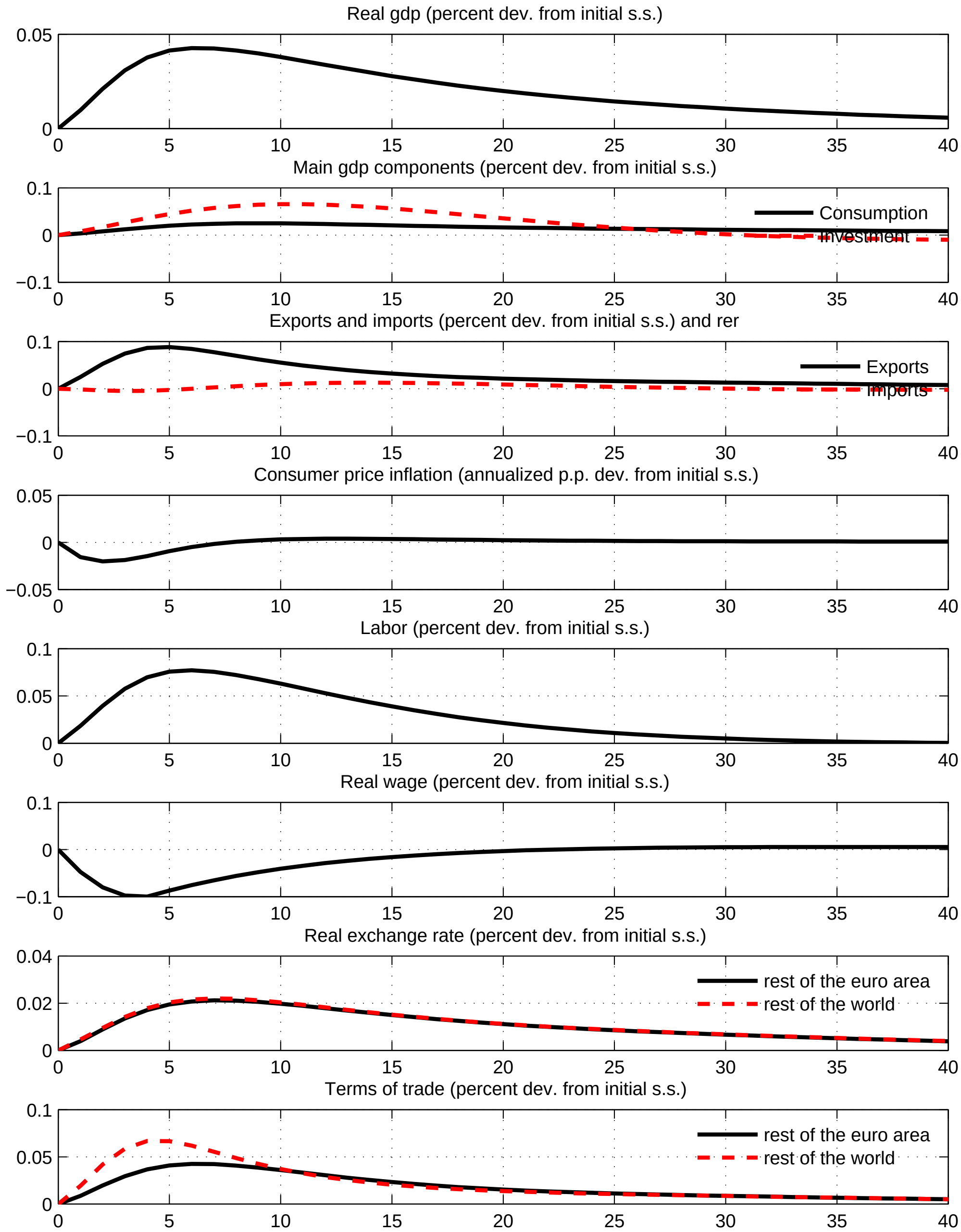
Note: GDP as % dev. from initial steady state.

Figure 1. Italian public consumption shock



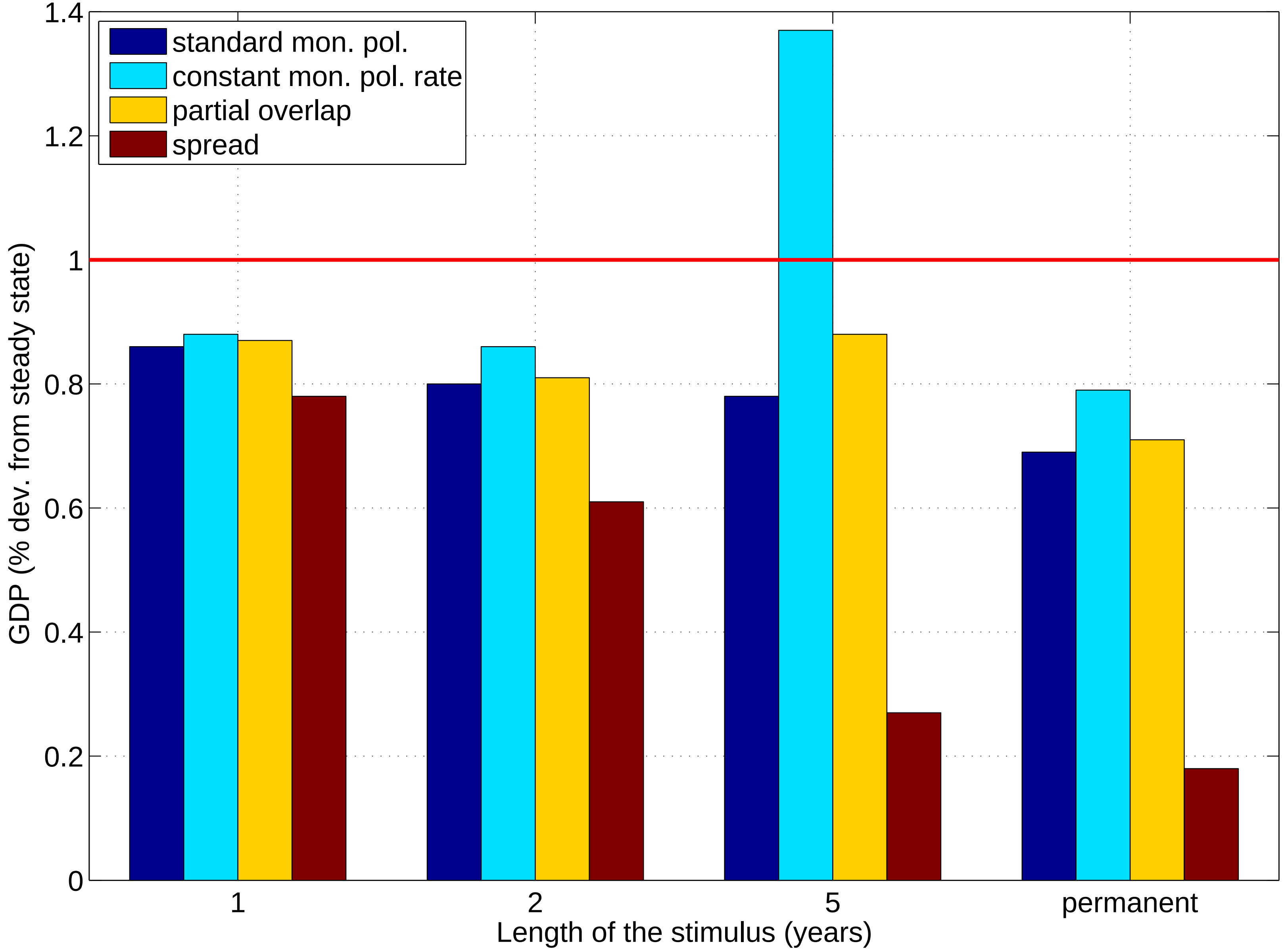
Note: 1-year increase in public consumption of 1% of (pre-shock) Italian GDP. Horizontal axis: quarters.

Figure 2. Italian labor tax shock



Note: 1-year reduction in labor taxation of 1% of (pre-shock) Italian GDP. Horizontal axis: quarters.

Figure 3. First year−GDP multiplier associated with public consumption



Appendix

In this Appendix we report a detailed description of the model, excluding the fiscal and monetary policy part and the description of the households optimization problem that are reported in the main text.[44]

There are three countries, Italy, the rest of the euro area (REA) and the rest of the world (RW). They have different sizes. Italy and the REA share the currency and the monetary authority. In each region there are households and firms. Each household consumes a final composite good made of non-tradable, domestic tradable and imported intermediate goods. Households have access to financial markets and smooth consumption by trading a risk-free one-period nominal bond, denominated in euro. They also own domestic firms and capital stock, which is rent to domestic firms in a perfectly competitive market. Households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive markets by charging a markup over their marginal rate of substitution.

On the production side, there are perfectly competitive firms that produce the final goods and monopolistic firms that produce the intermediate goods. Two final goods (private consumption and private investment) are produced combining all available intermediate goods according to constant-elasticity-of-substitution bundle. The public consumption good is a bundle of intermediate non-tradable goods.

Tradable and non-tradable intermediate goods are produced combining capital and labor in the same way. Tradable intermediate goods can be sold domestically or abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We assume that goods markets are internationally segmented and the law of one price for tradables does not hold. Hence, each firm producing a tradable good sets three prices, one for the domestic market and the other two for the export market (one for each region). Since the firm faces the same marginal costs regardless of the scale of production in each market, the different price-setting problems are independent of each other.

To capture the empirical persistence of the aggregate data and generate realistic dynamics, we include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption and production react in a gradual way. On the real side, quadratic costs and habit

[44] For a detailed description of the main features of the model see also Bayoumi (2004) and Pesenti (2008).

prolong the adjustment of the investment and consumption. On the nominal side, quadratic costs make wage and prices sticky.

In what follows we illustrate the Italian economy. The structure of each of the other two regions (REA and the RW) is similar and to save on space we do not report it.

5.1 Final consumption and investment goods

There is a continuum of symmetric Italian firms producing final non-tradable consumption under perfect competition. Each firm producing the consumption good is indexed by $x \in (0, s]$, where the parameter $0 < s < 1$ measures the size of Italy. Firms in the REA and in the RW are indexed by $x^* \in (s, S]$ and $x^{**} \in (S, 1]$, respectively (the size of the world economy is normalized to 1). The CES production technology used by the generic firm x is:

$$A_t(x) \equiv \left(\begin{array}{c} a_T^{\frac{1}{\phi_A}} \left(a_H^{\frac{1}{\rho_A}} Q_{HA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} + a_G^{\frac{1}{\rho_A}} Q_{GA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} (1 - a_H - a_G)^{\frac{1}{\rho_A}} Q_{FA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \right)^{\frac{\rho_A}{\rho_A - 1} \frac{\phi_A - 1}{\phi_A}} \\ + (1 - a_T)^{\frac{1}{\phi_A}} Q_{NA,t}(x)^{\frac{\phi_A - 1}{\phi_A}} \end{array} \right)^{\frac{\phi_A}{\phi_A - 1}}$$

where Q_{HA}, Q_{GA}, Q_{FA} and Q_{NA} are bundles of respectively intermediate tradables produced in Italy, intermediate tradables produced in the REA, intermediate tradables produced in the RW and intermediate non-tradables produced in Italy. The parameter $\rho_A > 0$ is the elasticity of substitution between tradables and $\phi_A > 0$ is the elasticity of substitution between tradable and non-tradable goods. The parameter a_H $(0 < a_H < 1)$ is the weight of the Italian tradable, the parameter a_G $(0 < a_G < 1)$ the weight of tradables imported from the REA, a_T $(0 < a_T < 1)$ the weight of tradable goods.

The production of investment good is similar. There are symmetric Italian firms under perfect competition indexed by $y \in (0, s]$. Firms in the REA and in the RW are indexed by $y^* \in (s, S]$ and $y^{**} \in (S, 1]$. Output of the generic Italian firm y is:

$$E_t(y) \equiv \left(\begin{array}{c} v_T^{\frac{1}{\phi_E}} \left(v_H^{\frac{1}{\rho_E}} Q_{HE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + v_G^{\frac{1}{\rho_E}} Q_{GE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + (1 - v_H - v_G)^{\frac{1}{\rho_E}} Q_{FE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \right)^{\frac{\rho_E}{\rho_E - 1} \frac{\phi_E - 1}{\phi_E}} \\ + (1 - v_T)^{\frac{1}{\phi_E}} Q_{NE,t}(y)^{\frac{\phi_E - 1}{\phi_E}} \end{array} \right)^{\frac{\phi_E}{\phi_E - 1}}$$

Finally, we assume that public consumption C^g is composed by intermediate non-tradable goods only.

5.2 Intermediate goods

Demand

Bundles used to produce the final consumption goods are CES indexes of differentiated intermediate goods, each produced by a single firm under conditions of monopolistic competition:

$$Q_{HA}(x) \equiv \left[\left(\frac{1}{s} \right)^{\theta_T} \int_0^s Q(h,x)^{\frac{\theta_T - 1}{\theta_T}} \, dh \right]^{\frac{\theta_T}{\theta_T - 1}} \tag{16}$$

$$Q_{GA}(x) \equiv \left[\left(\frac{1}{S-s} \right)^{\theta_T} \int_s^S Q(g,x)^{\frac{\theta_T - 1}{\theta_T}} \, dg \right]^{\frac{\theta_T}{\theta_T - 1}} \tag{17}$$

$$Q_{FA}(x) \equiv \left[\left(\frac{1}{1-S} \right)^{\theta_T} \int_S^1 Q(f,x)^{\frac{\theta_T - 1}{\theta_T}} \, df \right]^{\frac{\theta_T}{\theta_T - 1}} \tag{18}$$

$$Q_{NA}(x) \equiv \left[\left(\frac{1}{s} \right)^{\theta_N} \int_0^s Q(n,x)^{\frac{\theta_N - 1}{\theta_N}} \, dn \right]^{\frac{\theta_N}{\theta_T - 1}} \tag{19}$$

where firms in the Italian intermediate tradable and non-tradable sectors are respectively indexed by $h \in (0, s)$ and $n \in (0, s)$, firms in the REA by $g \in (s, S]$ and firms in the RW by $f \in (S, 1]$. Parameters θ_T, $\theta_N > 1$ are respectively the elasticity of substitution across brands in the tradable and non-tradable sector. The prices of the intermediate non-tradable goods are denoted $p(n)$. Each firm x takes these prices as given when minimizing production costs of the final good. The resulting demand for intermediate non-tradable input n is:

$$Q_{A,t}(n,x) = \left(\frac{1}{s} \right) \left(\frac{P_t(n)}{P_{N,t}} \right)^{-\theta_N} Q_{NA,t}(x) \tag{20}$$

where $P_{N,t}$ is the cost-minimizing price of one basket of local intermediates:

$$P_{N,t} = \left[\int_0^s P_t(n)^{1-\theta_N} \, dn \right]^{\frac{1}{1-\theta_N}} \tag{21}$$

We can derive $Q_A(h,x)$, $Q_A(f,x)$, $C_A^g(h,x)$, $C_A^g(f,x)$, P_H and P_F in a similar way. Firms y producing the final investment goods have similar demand curves. Aggregating over x and y, it can be shown that total demand for intermediate non-tradable good n is:

$$\begin{aligned} & \int_0^s Q_{A,t}(n,x)\,dx + \int_0^s Q_{E,t}(n,y)\,dy + \int_0^s C_t^g(n,x)\,dx \\ = & \left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N} \left(Q_{NA,t} + Q_{NE,t} + C_{N,t}^g\right) \end{aligned}$$

where C_N^g is public sector consumption. Italy demands for (intermediate) domestic and imported tradable goods can be derived in a similar way.

Supply

The supply of each Italian intermediate non-tradable good n is denoted by $N^S(n)$:

$$N_t^S(n) = \left((1-\alpha_N)^{\frac{1}{\xi_N}} L_{N,t}(n)^{\frac{\xi_N-1}{\xi_N}} + \alpha^{\frac{1}{\xi_N}} K_{N,t}(n)^{\frac{\xi_N-1}{\xi_N}}\right)^{\frac{\xi_N}{\xi_N-1}} \tag{22}$$

Firm n uses labor $L_{N,t}^p(n)$ and capital $K_{N,t}(n)$ with constant elasticity of input substitution $\xi_N > 0$ and capital weight $0 < \alpha_N < 1$. Firms producing intermediate goods take the prices of labor inputs and capital as given. Denoting W_t the nominal wage index and R_t^K the nominal rental price of capital, cost minimization implies:

$$L_{N,t}(n) = (1-\alpha_N)\left(\frac{W_t}{MC_{N,t}(n)}\right)^{-\xi_N} N_t^S(n) \tag{23}$$

$$K_{N,t}(n) = \alpha\left(\frac{R_t^K}{MC_{N,t}(n)}\right)^{-\xi_N} N_t^S(n)$$

where $MC_{N,t}(n)$ is the nominal marginal cost:

$$MC_{N,t}(n) = \left((1-\alpha)\,W_t^{1-\xi_N} + \alpha\left(R_t^K\right)^{1-\xi_N}\right)^{\frac{1}{1-\xi_N}} \tag{24}$$

The productions of each Italian tradable good, $T^S(h)$, is similarly characterized.

Price setting in the intermediate sector

Consider now profit maximization in the Italian intermediate non-tradable sector. Each firm n sets the price $p_t(n)$ by maximizing the present discounted value of profits subject to the demand constraint and the quadratic adjustment costs:

$$AC^p_{N,t}(n) \equiv \frac{\kappa^p_N}{2}\left(\frac{P_t(n)}{P_{t-1}(n)}-1\right)^2 Q_{N,t} \quad \kappa^p_N \geq 0$$

paid in unit of sectorial product $Q_{N,t}$ and where κ^p_N measures the degree of price stickiness. The resulting first-order condition, expressed in terms of domestic consumption, is:

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_t(n) - \frac{A_t(n)}{\theta_N - 1} \tag{25}$$

where $mc_t(n)$ is the real marginal cost and $A(n)$ contains terms related to the presence of price adjustment costs:

$$\begin{aligned} A_t(n) \quad &\approx \quad \kappa^p_N \frac{P_t(n)}{P_{t-1}(n)}\left(\frac{P_t(n)}{P_{t-1}(n)}-1\right) \\ &\quad -\beta\kappa^p_N \frac{P_{t+1}(n)}{P_t(n)}\left(\frac{P_{t+1}(n)}{P_t(n)}-1\right)\frac{Q_{N,t+1}}{Q_{N,t}} \end{aligned}$$

The above equations clarify the link between imperfect competition and nominal rigidities. As emphasized by Bayoumi et al. (2004), when the elasticity of substitution θ_N is very large and hence the competition in the sector is high, prices closely follow marginal costs, even though adjustment costs are large. To the contrary, it may be optimal to maintain stable prices and accommodate changes in demand through supply adjustments when the average markup over marginal costs is relatively high. If prices were flexible, optimal pricing would collapse to the standard pricing rule of constant markup over marginal costs (expressed in units of domestic consumption):

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_{N,t}(n) \tag{26}$$

Firms operating in the intermediate tradable sector solve a similar problem. We assume that there is market segmentation. Hence the firm producing the brand h chooses $p_t(h)$ in the Italian market,a price $p^*_t(h)$ in the REA and a price $p^{**}_t(h)$ in the RW to maximize the expected flow of profits (in terms of domestic consumption units):

$$E_t \sum_{\tau=t}^{\infty} \Lambda_{t,\tau} \left[\begin{array}{c} p_\tau(h) y_\tau(h) + p^*_\tau(h) y^*_\tau(h) + p^{**}_\tau(h) y^{**}_\tau(h) \\ -mc_{H,\tau}(h)\left(y_\tau(h) + y^*_\tau(h) + y^{**}_\tau(h)\right) \end{array} \right]$$

subject to quadratic price adjustment costs similar to those considered for non-tradables and standard demand constraints. The term E_t denotes the expectation operator conditional on the information set at time t, $\Lambda_{t,\tau}$ is the appropriate discount rate and $mc_{H,t}(h)$ is the real marginal cost. The first order conditions with respect to $p_t(h)$, $p_t^*(h)$ and $p_t^{**}(h)$ are:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t(h)}{\theta_T - 1} \tag{27}$$

$$p_t^*(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t^*(h)}{\theta_T - 1} \tag{28}$$

$$p_t^{**}(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t^{**}(h)}{\theta_T - 1} \tag{29}$$

where θ_T is the elasticity of substitution of intermediate tradable goods, while $A(h)$ and $A^*(h)$ involve terms related to the presence of price adjustment costs:

$$\begin{aligned}
A_t(h) &\approx \kappa_H^p \frac{P_t(h)}{P_{t-1}(h)} \left(\frac{P_t(h)}{P_{t-1}(h)} - 1 \right) \\
&\quad - \beta \kappa_H^p \frac{P_{t+1}(h)}{P_t(h)} \left(\frac{P_{t+1}(h)}{P_t(h)} - 1 \right) \frac{Q_{H,t+1}}{Q_{H,t}} \\
A_t^*(h) &\approx \theta_T - 1 + \kappa_H^p \frac{P_t^*(h)}{P_{t-1}^*(h)} \left(\frac{P_t^*(h)}{P_{t-1}^*(h)} - 1 \right) \\
&\quad - \beta \kappa_H^p \frac{P_{t+1}^*(h)}{P_t^*(h)} \left(\frac{P_{t+1}^*(h)}{P_t^*(h)} - 1 \right) \frac{Q_{H,t+1}^*}{Q_{H,t}^*} \\
A_t^{**}(h) &\approx \theta_T - 1 + \kappa_H^p \frac{P_t^{**}(h)}{P_{t-1}^{**}(h)} \left(\frac{P_t^{**}(h)}{P_{t-1}^{**}(h)} - 1 \right) \\
&\quad - \beta \kappa_H^p \frac{P_{t+1}^{**}(h)}{P_t^{**}(h)} \left(\frac{P_{t+1}^{**}(h)}{P_t^{**}(h)} - 1 \right) \frac{Q_{H,t+1}^{**}}{Q_{H,t}^{**}}
\end{aligned}$$

where κ_H^p,${\kappa_H^p}^*$,${\kappa_H^p}^{**} > 0$ respectively measure the degree of nominal rigidity in Italy, in the REA and in the RW. If nominal rigidities in the (domestic) export market are highly relevant (that is, if is relatively large), the degree of inertia of Italian goods prices in the foreign markets will be high. If prices were flexible ($\kappa_H^p = \kappa_H^{p*} = \kappa_H^{p**} = 0$) then optimal price setting would be consistent with the cross-border law of one price (prices of the same tradable goods would be equal when denominated in the same currency).

5.3 Labor Market

In the case of firms in the intermediate non-tradable sector, the labor input $L_N(n)$ is a CES combination of differentiated labor inputs supplied by domestic agents and defined over a continuum of mass equal to the country size ($j \in [0, s]$):

$$L_{N,t}(n) \equiv \left(\frac{1}{s}\right)^{\frac{1}{\psi}} \left[\int_0^s L_t(n,j)^{\frac{\psi-1}{\psi}} dj\right]^{\frac{\psi}{\psi-1}} \tag{30}$$

where $L(n,j)$ is the demand of the labor input of type j by the producer of good n and $\psi > 1$ is the elasticity of substitution among labor inputs. Cost minimization implies:

$$L_t(n,j) = \left(\frac{1}{s}\right)\left(\frac{W_t(j)}{W_t}\right)^{-\psi} L_{N,t}(j), \tag{31}$$

where $W(j)$ is the nominal wage of labor input j and the wage index W is:

$$W_t = \left[\left(\frac{1}{s}\right)\int_0^s W_t(h)^{1-\psi} dj\right]^{\frac{1}{1-\psi}}. \tag{32}$$

Similar equations hold for firms producing intermediate tradable goods. Each household is the monopolistic supplier of a labor input j and sets the nominal wage facing a downward-sloping demand, obtained by aggregating demand across Italian firms. The wage adjustment is sluggish because of quadratic costs paid in terms of the total wage bill:

$$AC_t^W = \frac{\kappa_W}{2}\left(\frac{W_t}{W_{t-1}} - 1\right)^2 W_t L_t \tag{33}$$

where the parameter $\kappa_W > 0$ measures the degree of nominal wage rigidity and L is the total amount of labor in the Italian economy.

5.4 The equilibrium

We find a symmetric equilibrium of the model. In each country there is a representative agent and four representative sectorial firms (in the intermediate tradable sector, intermediate non-tradable sector, consumption production sector and investment production sector). The equilibrium is a sequence of allocations and prices such that, given initial conditions and the sequence of exogenous shocks, each private agent and firm satisfy the correspondent first order conditions, the private and public sector budget constraints and market clearing conditions for goods, labor, capital and bond holdings.

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