Fiscal Consolidation and Rule of Thumb Consumers: Gain *With or Without* Pain?

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Abstract

In this paper we simulate an expenditure-based fiscal consolidation experiment within a NK-DSGE model augmented for Limited Asset Market Participation. Both real and welfare effects of the policy are stressed.

We find that temporary tax reductions or temporary transfer increases strongly stabilize the consumption of liquidity constrained agents, recovering the *gain without pain* result got in the standard DSGE models. The result is even strengthened when the monetary authority targets both inflation and output gap. Moreover, we find that fiscal consolidation is welfare improving for both Ricardian and Non-Ricardian agents, while the larger welfare gain accrues to the rule of thumbers.

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Keywords: Fiscal Consolidation, DSGE modelling, Rule of Thumb Consumers, Fiscal Policy, Monetary Policy

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1 Introduction

In the last years a number of euro area countries has experienced a large increase in levels of public debt. Then, the issue of fiscal consolidation, i.e. a permanent reduction in the debt-to-GDP ratio, has gained considerable attention in the macroeconomic literature.

Empirical contributions emphasize the importance of achieving fiscal consolidation through public expenditures reductions. Nickel, Rother and Zimmermann (2010) find that major debt reductions in the EU-15 during the period 1985-2009 were mainly caused by strategies based on reduction of government consumption. Revenue-based consolidation efforts were less successful. The same conclusion is reached in Alesina, Favero and Giavazzi (2012), who argue that spending-based adjustments are associated with mild and short-lived output losses, while tax-based adjustments are associated with deep and prolonged recessions.

Within the theoretical framework of DSGE models characterized by complete financial markets and optimizing households, expenditure based fiscal consolidations are a win-win strategy. As a matter of fact, long-run debt reductions are associated with lower steady state distortionary taxation. Moreover, the short run output losses - determined by the combination of lower public demand and nominal rigidities - are more than compensated by the boom of private consumption. This later effect obtains because, despite the output drop, a *positive wealth effect* is in place, deriving from the expectation of permanently lower taxes. From this viewpoint, the NK-DSGE model gives similar predictions to those of RBC models (see, for example, Linnemann and Schabert (2003)). Therefore, reducing public expenditure increases the household wealth by decreasing the present value of households tax liabilities. Therefore expenditure-based consolidations produce a *gain without pain*.

However, the assumption of homogeneous and forward-looking households is at best only partly consistent with actual consumer behavior. The predicted effect of fiscal consolidations may look rather grim if one takes into account the hypotesis of Limited Asset Market Participation (LAMP henceforth)[1], where it is assumed that a fraction of households (Rule of Thumb, RT henceforth) do not participate in financial markets and consume their current labor income. For these households a slump must be associated with a fall in consumption, because they neither hold any wealth neither can borrow. It follows a *gain with pain*, as the consolidation process occurs with a decline of consumption. In this regard, Anderson, Inoue and Rossi (2012) argue that unexpected fiscal shocks have substantially different effects on consumption under LAMP hypothesis relative to the case of homogeneous and optimizing agents.

This work simulates an expenditure-based fiscal consolidation within a NK-DSGE model augmented for LAMP. The goal of the paper is twofold. First, we

[1] The Limited Asset Market Partecipation assumption refers to a long tradition in the literature set out by Campbell and Mankiw (1989). See also Galì *et al.* (2004, 2007), Coenen and Straub (2005), Bilbiie (2008), Colciago *et al.* (2008) , Forni *et al.* (2009), Motta and Tirelli (2012)

want to investigate the contribution of tax and public transfers policies that under LAMP may stabilize the consumption of liquidity constrained households, also considering the potential role of monetary policy. Second, we carry out a welfare analysis which takes into account distributional issues due to the different situation of the two households' groups.

Our contribution is akin to Coenen, Mohr and Straub (2008), who consider alternative strategies of fiscal consolidation using the ECB's New Area-Wide Model. There are some important differences between their work and ours. First, their definition of LAMP is such that a fraction of households do not participate in stocks and bonds markets but are allowed to hold money. Thereofore, to the extent that their initial holdings of money balances are sufficiently large, these households may partly smooth consumption in response to a fiscal consolidation. Second, they do not explore the potential complementarity between public consumption reductions and tax (and monetary) expansionary policies which is the focus of this paper.

In a nutshell, our results are summarized as follows. First, we show that, during a fiscal consolidation temporary tax reductions or temporary transfers increases allow to both reduce public debt and boost consumption. This is due to the impact of the automatic stabilizers on the disposable income of RT consumers. Second, we find that an interest rate rule which reacts not only to inflation but also to the output gap is an effective complement to fiscal policy as a stabilization tool. In fact, the output gap target induces the Central Bank to implement a stronger interest rate reaction which triggers a surge in the consumption of Ricardian households. This has in turn beneficial effects on labor incomes and on RT households' consumption.

Finally, when measuring the welfare effects of the fiscal consolidation experiment, we find that fiscal consolidation is welfare improving for both household types, while the larger welfare gain accrues to RT consumers. This happens because the debt reduction redistributes lowers debt-service payments to Ricardian households. Moreover, the RT's welfare gain further increases with an active fiscal policy implementing automatic stabilizers and even more grows when monetary policy targets the output gap.

The rest of the paper is organized as follows. Section 2 describes the main features of the model and the experiment implementation. Section 3 shows the short and long run results. Welfare effects of the consolidation process are discussed in section 4. Finally, section 5 concludes.

2 The Fiscal Consolidation Exercise

In this section we firstly provide a brief overview of the standard medium-scale NK-DSGE model with particular focus on the nominal and real rigidities. Then we discuss the implementation of the consolidation experiment underlining the fiscal and monetary policy actions during the consolidation process. Finally, we describe the calibration of the model.

2.1 A Sketch of the Model[2]

Our model is an extended version of the NK-DSGE model developed by Smets and Wouters (2003, henceforth SW (2003), Schmitt-Grohé and Uribe (2005), henceforth SGU (2005) and Christiano, Eichenbaum and Evans (2005), henceforth CEE (2005). It embodies both real and nominal frictions. Real frictions include: monopolistic competition in good and labour markets, internal habits in consumption, variable capital utilization, adjustment costs in investment decisions and distortionary taxation on labor and capital income. As for nominal frictions, prices and wages are sticky à la Calvo (1983), with an indexation clause. In particular, price and wage contracts are indexed to a geometric average of past inflation and trend inflation[3].

Our model accounts for LAMP, i.e. the economy is populated by two different household types: optimizing (Ricardian) households, who hold assets, and Rule-of-Thumb (RT henceforth) households, who just consume their current income and do not own any wealth.

To implement a welfare analysis of alternative policies based on expenditure reductions we assume that government spending enters households' utility functions. In particular, preferences are defined over private individual consumption c_t^i, individual labor supply h_t^i and government consumption G_t^i, where $i = o, rt$ refers to optimizing and RT consumers, respectively.

$$U_t^i = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln\left(c_t^i - bc_{t-1}^i\right) - \frac{\phi_1}{(1+\phi)} \left(h_t^i\right)^{(1+\phi)} + \xi \ln G_t^i \right\}$$

Moreover, b is the degree of internal habit formation in consumption, ϕ represents the inverse of Frish elasticity and ξ denotes the weight of public spending in the utility function.

2.2 Fiscal sector

The period government budget constraint is described as follows:

$$G_t + TR_t + \frac{B_t}{\pi_t} = \tau_t^k \sigma_t K_t + \tau_t^h w_t h_t + \frac{B_{t+1}}{R_t}$$

Public expenditures include government consumption G_t, transfers to households TR_t, and interest payments on outstanding debt B_t/π_t[4]. Revenues are obtained levying taxes on labor and capital, τ^h and τ^k respectively, and by issuing new debt. In particular, σ_t denotes the pre-tax return on capital and $w_t h_t$ is the pre-tax labor income.

We model fiscal consolidation as a permanent reduction of the debt-to-output ratio via a temporary decline of the expenditure ratio. Before the consolidation,

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[2] The full model is laid out in Appendix A.

[3] SW (2003) argue that partial indexation scheme makes the model more robust for policy and welfare analysis with respect to a constant price setting behavior.

[4] Public debt is assumed to be nominal, consistent with the debt generally issued around the world.

the steady state debt-to-GDP ratio b_y^* is set at 70%, consistently with the euro area average public debt ratio in the last ten years[5].

As in Coenen, Mohr and Straub (2008) the fiscal consolidation produces a fall in the debt-to-output ratio that, starting from the initial level of 70%, gradually achieves the target $b_y^{**} = 60\%$, in line with Maastricht Treaty prescriptions. In the long run, reducing the amount of outstanding public debt implies lower interest rate payments on government debt. In this experiment we assume that savings on interest payments are used to reduce taxes. Therefore in the steady state associated to $b_y^{**} = 60\%$ tax distortions are unambiguously reduced and $y^{**} > y^*$. Since we are not interested in policy-induced changes in capital-labor tax rate ratios, we posit that $\left(\tau^{k**}/\tau^{h**}\right) = \left(\tau^{k*}/\tau^{h*}\right)$.

The key tool used to achieve the debt reduction is an unanticipated temporary reduction in public consumption. We assume that the fiscal authority follows the rule:

$$\left(\frac{g_{y,t}}{g_y}\right) = \left(\frac{b_{y,t}}{b_y^{**}}\right)^{-\phi_g} \tag{1}$$

where $g_y = (G^*/y^*) = (G^{**}/y^{**})$ is the constant public consumption-to-GDP target ratio, $g_{y,t} \equiv (G_t/y^{**})$ and $b_{y,t} \equiv (B_t/y^{**})$ respectively define time t levels of public consumption and debt in terms of post-consolidation steady-state output.

To model the behavior of taxes during the transition phase, we assume that relative tax rates are constant, i.e. $\left(\tau_t^k/\tau_t^h\right) = \left(\tau^{k**}/\tau^{h**}\right)$. This implies the same adjustment pattern during the transition. Then for the sake of brevity, from now on we only refer to labor tax rate. In particular, we consider two alternative rules. In the first case, we assume that taxes follow a highly inertial path towards the new steady state:

$$\tau_t^h = (1 - \phi^\tau)\,\tau_{t-1}^h + \phi^\tau \tau^{h**} \tag{2}$$

In the early stages of the consolidation experiment this allows to identify the permanent income effect of a future tax reduction, that only affects consumption choices of Ricardian households.

With the second rule we model taxes as automatic stabilizers in the spirit of Colciago *et al.* (2008)[6].

$$\left(\frac{\tau_t^h}{\tau^{h**}}\right) = \left(\frac{y_t}{y^{**}}\right)^{\delta_0} \tag{3}$$

This allows to assess the contribution of short-run tax adjustments to output stabilization, where taxes immediately impact on RT consumers' disposable income. Due to LAMP, temporary redistributive policies may have powerful stabilisation effects on RT consumption and no effect on ricardian households. To investigate this issue we also assume that transfers benefiting RT consumers

[5] Source: Eurostat.

[6] See also Van den Noord (2000), Westaway (2003) and Andres and Domenech (2006).

evolve according to the following rule:

$$\left(\frac{tr_{y,t}}{tr_y}\right) = \left(\frac{y_t}{y^{**}}\right)^{-\delta_1} \tag{4}$$

where $tr_y = (TR^*/y^*) = (TR^{**}/y^{**})$ is the constant public transfer-to-GDP target ratio and $tr_{y,t} \equiv (TR_t/y^{**})$ defines time t levels of public transfers in terms of post-consolidation steady-state output. Fiscal transfers operating according to (4) temporarily increase thanks to lower interest rate payments.

Moreover, we assume that also steady state transfers are assigned only to constrained households. This guarantees that levels of consumption are not too dissimilar across the two household groups (see Coenen *et al.*, 2008).

2.3 Monetary policy

We assume that the monetary authority sets its policy instrument R_t according to a standard Taylor rule:

$$\left(\frac{R_t}{R}\right) = \left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{y_t}{y^{**}}\right)^{\phi_y} \tag{5}$$

where π_t, π, R and y_t/y^{**} respectively denote the inflation rate, the inflation target, the interest rate target and the output gap defined with reference to the post-consolidation steady state.

2.4 Calibration

The baseline calibration of structural parameters[7] follows SW (2003) who estimate a DSGE model for the euro area.

As for fiscal sector, the parameter governing the debt stabilization ϕ_g in the government spending rule is set equal to 1, in line with the debt reduction experiment carried out by Coenen *et al.* (2008). As in Colciago *et al.* (2008), fiscal responses to output - δ_0 in (3) and δ_1 in (4) - are calibrated at 0.5. This value is also consistent with the empirical evidence in Van den Noord (2000) and adopted in studies on fiscal stabilization (e.g. Westaway, 2003). Moreover, to guarantee the inertial behavior of taxes according to (2) we set $\phi^\tau = 0.01$. Furthemore, we draw from the estimates reported in Mendoza, Razin and Tesar (1994) to assign the value to the average effective capital-labor tax rate ratio[8], i.e. $\left(\frac{\tau^{k**}}{\tau^{h**}}\right) = 0.92$[9]. Finally, the public spending and transfer steady state ratios are both fixed at 0.18, consistently with the national accounts data for euro area countries.

[7] Appendix B summerizes in Table B1 parameters values and their description

[8] In particular, while the labor tax rate is calibrated such that the fiscal authority's budget is balanced at the debt-to-GDP target, the capital tax rate is anchored to the capital-labor tax rate ratio.

[9] Results hold for different values of capital-labor tax rate ratios found in the literature, (Coenen *et al.*, 2008; SGU, 2005)

As for monetary policy, the parameter governing inflation stabilization ϕ_π is calibrated at 1.5, in line with a conservative parametrisation in the literature and the parameter governing output stabilization ϕ_y is set at 0.5, according to the classical Taylor rule specification.

The fraction of population following the rule of thumb in the euro area is estimated by the empirical evidence[10] in a range between 0.25 and 0.40. Following Campbell and Mankiw (1989), we fix the fraction of liquidity constrained consumers at 0.50. As a matter of fact, this higher value makes robuster our results; since the restoring of the *gain without pain* effect might be affected by a lower share of non Ricardian households.

3 Results

3.1 The Long-Run Effects of Fiscal Consolidation

In Table 1 we report the steady state adjustment of some key variables in consequence of the fiscal consolidation.

Table 1 - Steady state percentage variations after consolidation

$\Delta\tau^{h**} = -0.70$	$\Delta\left(\frac{k^{**}}{h^{**}}\right) = 0.42$
$\Delta\tau^{k**} = -0.70$	$\Delta h^{**} = 0.31$
$\Delta y^{**} = \Delta G^{**} = 0.43$	$\Delta w^{**} = 0.13$
$\Delta c_{pc}^{o**} = -0.02$	$\Delta c_{pc}^{rt**} = 0.82$

where k^{**}/h^{**} is the capital labor ratio, w denotes the real wage, c_{pc}^{o**} and c_{pc}^{rt**} respectively define the per-capita consumption levels of the two household types.

The fiscal consolidation causes a reduction in debt service payments of about 9% of GDP. These resources are used to lower labor and capital income taxes. This causes in turn an output expansion, due to an increase in both capital and labor supply. RT consumption unambiguously increases. Just like RT consumers, Ricardian households benefit from the labor tax reduction. In addition they entirely appropriate the capital income tax reduction. However, the consolidation exercise entails a reduction in debt service payments which is entirely borne by them. As a result, the steady state variation in their consumption is negative. Finally, note that the more efficient economy allows to raise public consumption at a constant value of g_y.

3.2 Transition dynamics

The next step in our analysis is a discussion of the short-run effects under different fiscal and monetary rules. We consider alternative scenarios.

[10] See, for instance, Coenen and Straub (2005), Forni *et al.* (2009).

1. No short-run fiscal stabilization and pure inflation targeting. In this case we are able to identify the role of "pure" announcements of future tax reductions. The tax rule follows (2), transfers are held constant and we set $\phi_y = 0$ in (5).

2. Short run fiscal stabilization based on (3), constant transfers and pure inflation targeting.

3. Taxes follow (2), monetary policy is a pure inflation targeter and transfers to RT consumers are activated as stabilizers according to (4).

4. The Taylor rule reacts to the output gap, i.e. $\phi_y = 0.5$. We consider the contribution of output gap targeting under the alternative tax rules described in (3) and in (4) , scenarios **4a** and **4b**, respectively.

In the following we report transition paths for the relevant variables under scenarios 1-4. Each panel shows the transition dynamics starting from the initial steady state in which the value of the debt-to-GDP ratio is equal to 70%[11].

3.3 Scenario 1. No automatic stabilizers and pure inflation targeting

Figure 1 exhibits the profile of the short-run adjustment dynamics under scenario 1. Achieving the desired fall in the debt-to-GDP ratio takes about 37 quarters. Consider first what happens when all agents are Ricardian (blue line). After the government consumption reduction of about 2.5 percentage points, the recessionary effect is unavoidable. This is in turn associated to a lower real wage. As a consequence, marginal costs fall, bringing down inflation and interest rates. Note that without RT agents the output reduction is associated with a boom in consumption, which initially overshoots its new long-run level. In line with previous contributions in thies field (see, for instance, Linnemann and Schabert, 2003), expenditure fiscal consolidations produce a *gain without pain* result because private consumption rises and the labor supply falls.

By contrast, with RT consumers (red line) the initial output fall is larger due to the fall in RT consumption. Note that in this case the fiscal consolidation causes a temporary but strong increase in consumption inequality. In fact while Ricardian households raise their consumption, RT households do just the opposite in consequence of the fall in their current income. In turn, this brings down aggregate consumption producing a *gain with pain*.

[11] All dynamic effects are reported as percentage deviations from the initial steady state, with the exception of fiscal ratios which are reported in absolute values.

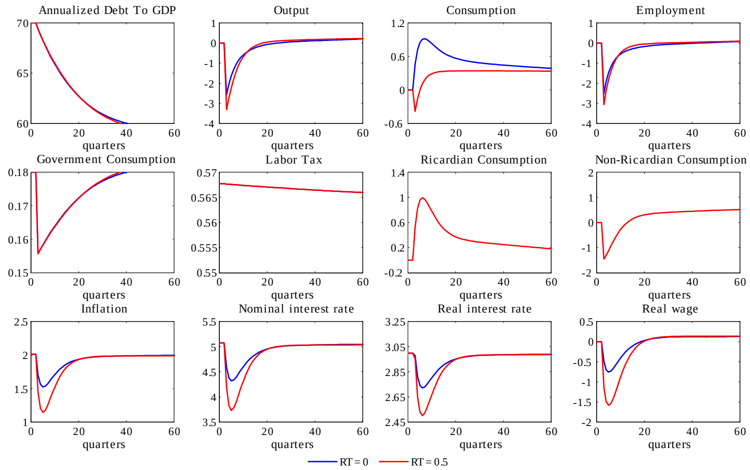

Fig.1-Short-run effects of fiscal consolidation

3.4 Scenario 2. Tax stabilizers and pure inflation targeting

Relatively to Scenario 1, Figure 2 shows that the automatic stabilizers (blue line) driven by (3) reduce consumption volatility for both Ricardian and Non-Ricardian households. In particular, labor taxes undershoot their long-run fall in response to the short-run output reduction. This boosts RT households' disposable income and consumption. The *gain without pain* result is restored.

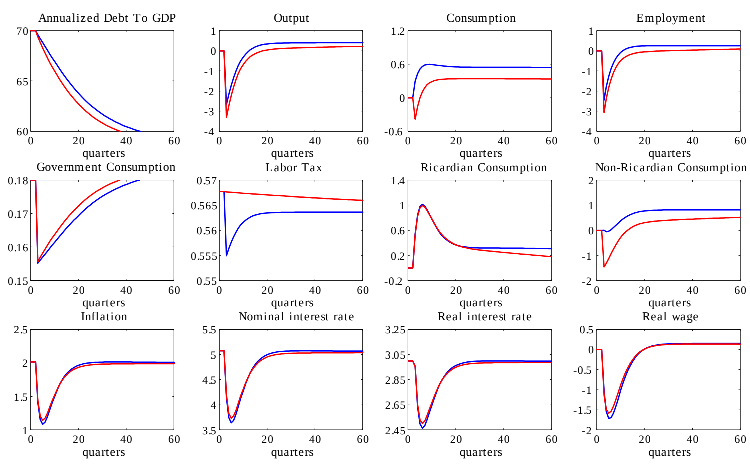

Fig.2-Tax stabilizers vs Tax "announcement"

Therefore, aggregate demand increases and the recession softens. This result is obtained at the cost of slowing down the speed of debt reduction, which is now achieved in about 44 quarters.

3.5 Scenario 3. Stabilization through redistribution

Stabilization through redistribution allows to both reduce debt and boost consumption, as well. In Figure 3, stabilization by means of transfers policy (red line - scenario 3) only operates through the demand-side effect stemming from RT consumption, whereas use of taxes as stabilizers (blue line - scenario 2) produces favourable supply side effects that raise output and labor income, thus increasing RT consumption. As a result we obtain that a pure demand-side fiscal policy is less effective in stimulating output convergence and has a weaker effect on RT consumption. The other side of the coin is that now stabilization through transfers entails a much faster speed of debt reduction which is completed in about 38 quarters and a quicker convergence of public consumption to the new steady state level.

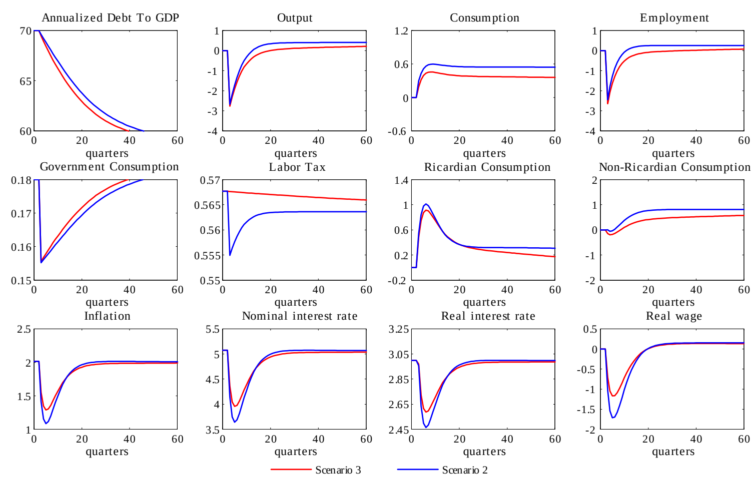

Fig.3-Transfer stabilizers vs Tax stabilizers

3.6 Scenario 4. Monetary policy reacts to the output gap

Figure 4a and 4b compare the effects of a countercyclical monetary policy complementing fiscal policy under rules (3) and (4), respectively. In both cases, relatively to Scenarios 2 and 3, output gap targeting allows to achieve better inflation stabilization and faster convergence of the debt ratio to the new target b_y^{**}. In addition, the strong reaction of Ricardian consumption to the interest rate stimulus notably reduces the slump, therefore allowing faster growth in RT consumption.

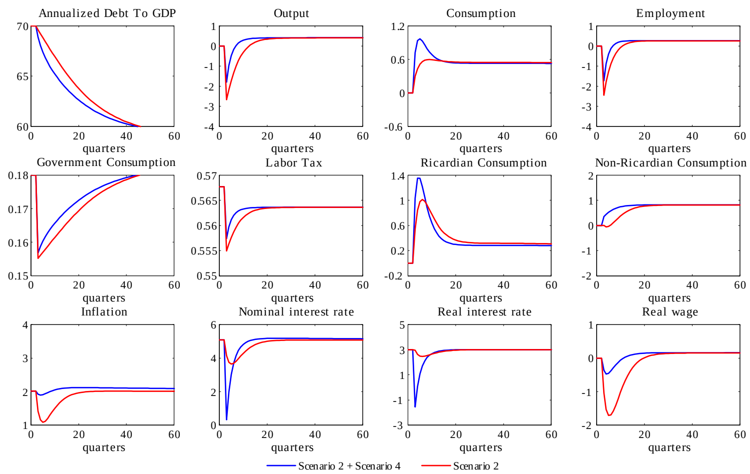

Fig.4a-Countercyclical monetary policy and Scenario 2

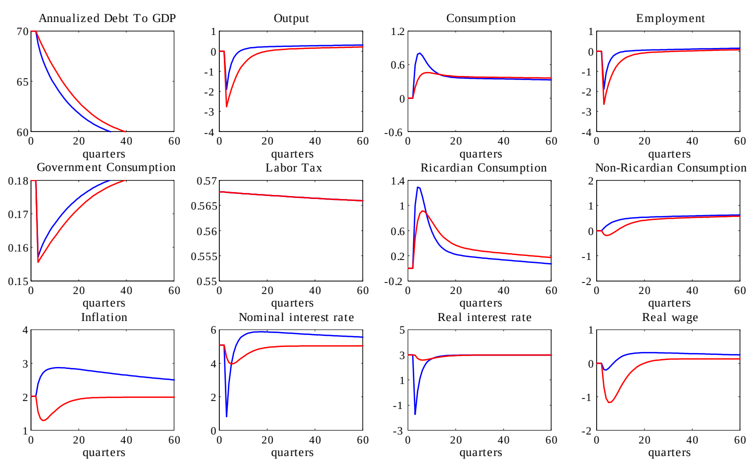

Fig.4b-Countercyclical monetary policy and Scenario 3

Summing up, the transmission channels are the following. Fiscal policy *directly* stabilizes RT consumption and *indirectly* contributes to reduce the output fluctuations. Monetary policy *directly* dampens the output losses determined by the consolidation phase and *indirectly* spures RT consumers' labor income. The effects are even strengthened with a joint action of fiscal and monetary policies.

4 The Welfare Perspective

The literature on fiscal consolidation generally focuses on the short and long run effects on the key macroeconomic variables. In this section we are interested in examining the welfare effects of fiscal consolidations.

4.1 The Welfare Based Ratio

In order to measure the welfare effects of the fiscal consolidation experiment we follow Ascari and Ropele (2012) using the consumption equivalent measure to compute the welfare-based ratio[12].

Welfare effects are reported in Table 2. In the post-consolidation steady state (first row), RT consumers unambiguously benefit from the fiscal consolidation. Indeed, they gain about an extra 8% of consumption each period. To a much lesser extent, welfare increases for Ricardian consumers. Given that in the new steady state these households consume less and work more, this result is entirely determined by the beneficial effects of increased public consumption G_t, as documented in Table 1.

Let's now consider the distributional effects during the transition, according to the different policy scenarios.

RT households unambiguously suffer, irrespective of the policy scenario that is being implemented. Their preferred policy scenario is 4a, which entails an output gap targeting using both interest rate and tax rules. In this case, RT consumers pay the minimum cost in terms of consumption, that is, they give up about 1.26% of consumption each period. In spite of the favorable income redistribution obtained under transfer policies, scenarios 3 and 4b are not particularly helpful for RT households. The reason lies in the quicker consolidation process. RT households pay the maximum cost under scenario 1, in which the pure "announcement" of tax reduction is not sufficient to spur RT consumption.

Ricardian households gain during the consolidation process, except under scenario 3 and 4b. This is due not only to the asymmetric distribution of transfers in the model but also, as for RT households, to the faster debt reduction. Moreover, while their preferred scenario is 2, the lowest benefit occurs under scenario 1. This is due to two opposite effects working on the Ricardians welfare. In fact, it decreases because public expenditure enters the utility function, but it increases because of the positive wealth effect. Despite under both scenarios 1 and 2 the latter effect is prevailing, under scenario 1 public consumption G_t falls much more with respect to scenario 2.

[12] Appendix C shows the derivation of the consumption equivalent measure and of the welfare-based ratio.

Table 2-Welfare Effects

Scenarios	Welf. measure	Ricardian h.	Non-Ricardian h.
	$WR^J_{long\_run}$	-0.0250	-8.36
1	$WR^J_{short\_run}$	-0.2950	4.42
2	$WR^J_{short\_run}$	-1.5750	1.73
3	$WR^J_{short\_run}$	0.2050	3.93
4a	$WR^J_{short\_run}$	-1.5250	1.26
4b	$WR^J_{short\_run}$	0.1650	2.58

All the values are expressed in percentage terms

5 Concluding Remarks

This paper investigates the real and welfare effects of a permanent reduction in the debt-to-output ratio via a temporary reduction in the public spending ratio.

Results can be summarized as follows. We find that, following a temporary reduction in public expenditure to implement fiscal consolidation, temporary tax reductions or temporary transfer increases strongly stabilize the consumption of liquidity constrained agents, recovering the *gain without pain* result got in the standard DSGE models. The result is even strengthened when the monetary authority targets both inflation and output gap.

Finally, in measuring the welfare effects of the fiscal consolidation experiment, we find that fiscal consolidation is welfare improving for both ricardian and non ricardian households, but the larger welfare gain accrues to RT consumers. Moreover, the RT's welfare gain becomes larger with an active fiscal policy implementing automatic stabilizers and further grows when monetary policy targets the output gap.

Summing up, this paper shows that under LAMP it's possible to reduce public debt without any suffering in terms of consumption thereby restraining the output losses deriving from the consolidation process. LAMP represents a crucial channel on which fiscal and monetary policy can act to improve the output performance and the economy welfare.

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6 Appendix A: The Model

In this Appendix we lay out the full model structure.

6.1 Households

There is a continuum of households indexed by i, $i \in [0,1]$. RT (rt) and Ricardian (o) agents are respectively defined over the intervals $[0,\Omega]$ and $[\Omega,1]$. All households share the same utility function. Each household has preferences defined over private consumption c, labour effort h and public consumption G_t. Hence, the period household's utility function is:

$$U_t^i = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln\left(c_t^i - bc_{t-1}^i\right) - \frac{\phi_1}{(1+\phi)} \left(h_t^i\right)^{(1+\phi)} + \xi \ln G_t \right\} \tag{A1}$$

where c_t^i denotes total individual consumption, b represents the degree of internal habit formation in consumption, h_t^i denotes individual labor supply of a differentiated labor bundle, G_t represents the government consumption. As for preference parameters, ϕ is the inverse of the intertemporal elasticity of substitution of labour, ϕ_1 accounts for the relative importance of disutility of work and utility of consumption in the total utility and ξ is the weight of public consumption.

6.2 Consumption bundles

The consumption good is assumed to be a composite good produced with a continuum of differentiated goods c_t^i via the Dixit-Stiglitz consumption basket of household i:

$$c_t^i = \left[\int_0^1 c\left(z\right)_t^{\frac{\eta-1}{\eta}} dz\right]^{\frac{\eta}{\eta-1}}$$

where $\eta > 1$ denotes the elasticity of substitution across different varieties of goods.

In particular, the household decides how to allocate its consumption expenditures among different goods. This requires that the consumption index c_t^i is maximized for any given level of expenditures $X_t = \int_0^1 P\left(z\right)_t c\left(z\right)_t dz$. Solving the intratemporal goods allocation problem, the set of demand equation is:

$$c\left(z\right)_t = \left(\frac{P\left(z\right)_t}{P_t}\right)^{-\eta} c_t$$

where

$$P_t = \left(\int_0^1 p\left(z\right)_t^{(1-\eta)} dz\right)^{\frac{1}{1-\eta}}$$

is the aggregate price consumption index.

6.3 Labour market structure

It is assumed a continuum of differentiated labour inputs indexed by j, $j \in [0,1]$. Following Schmitt-Grohé and Uribe (2005), household i supplies all labour inputs. Moreover, labor type-specific unions indexed by $j \in [0,1]$ have some monopoly power in the labour market and make wage-setting decisions. Given the wage W_t^j fixed by union j, households are assumed to supply enough labour h_t^j to satisfy demand. That is,

$$h_t^j = \left(\frac{W_t^j}{W_t}\right)^{-\eta_w} h_t^d$$

where $\eta_w > 1$ is the elasticity of substitution across different labour inputs, h_t^d is the aggregate labour demand and $W_t = \left(\int_0^1 \left(W_t^j\right)^{(1-\eta_w)} dj\right)^{\frac{1}{(1-\eta_w)}}$ is the aggregate wage index. As in Galì (2007), it's assumed that the fraction of Ricardian and non-Ricardian households is uniformly distributed across unions and the aggregate demand for each labor type is uniformly distributed across households. Therefore optimizers and rule of thumbers work for the same amount of work. Therefore the labour supply, which is common across households, must satisfy the resource constraint $h_t^s = \int_0^1 h_t^j dj$. Combining the latter with equation (5) we get:

$$h_t^s = h_t^d \int_0^1 \left(\frac{W_t^j}{W_t}\right)^{-\eta_w} dj$$

Therefore, the common labour income is denoted by $h_t^d \int_0^1 \left(\frac{W_t^j}{W_t}\right)^{-\eta_w} dj$.

6.4 Ricardian Households

Ricardian agents are assumed to have access to market for physical capital and to contingent nominal assets. In particular, each period asset holders can purchase any state-contingent nominal payment X_{t+1}in period $t+1$ at the cost $E_t r_{t,t+1} X_{t+1}$ where $r_{t,t+1}$ is a stochastical discount factor between periods t and $t+1$. Moreover, optimizing households must pay taxes on labor income and capital, respectively denoted as τ_t^h and τ_t^k. However, a tax allowance is in place for depreciation.

Therefore, the ricardian household's period by period budget constraint in real terms reads as:

$$E_t r_{t,t+1} x_{t+1} + c_t^o + i_t^o = \frac{x_t}{\pi_t} + \left(1-\tau_t^k\right)\left[r_t^k u_t - a\left(u_t\right)\right] K_t^o +$$

$$+\tau_t^k q_t \delta K_t^o + + \left(1-\tau_t^h\right) h_t^d \int_0^1 w_t^j \left(\frac{w_t^j}{w_t}\right)^{-\eta_w} dj + d_t^o$$

where $\frac{x_t}{\pi_t} \equiv \frac{X_t}{P_t}$ is the real payoff in period t of the nominal state contingent assets purchased at $t-1$. i_t^o denotes the real purchases investment goods at time t.

It is assumed that ricardian households own physical capital K_t^o, accumulate it and then rent it out the firms at a real interest rate r_t^k. Moreover, the optimizers can control the intensity u_t at which the capital is utilized. Hence, the cost of capital depends upon the degree of utilization $a(u_t)$ and it is defined as $a(u_t) = \gamma_1 (u_t - 1) + \frac{\gamma_2}{2}(u_t - 1)^2$. The function a satisfies $a(1) = 0$ and $a'(1), a''(1) > 0$. For a discussion about the mentioned properties, see CEE (2005). The dividends received by the asset holders from the ownership of firms is d_t^o. The gross rate of inflation is $\pi_t \equiv \frac{P_t}{P_{t-1}}$.

The capital stock evolves according to the following law of motion:

$$K_{t+1}^o = (1-\delta)K_t^o + i_t^o \left[1 - S\left(\frac{i_t^o}{i_{t-1}^o}\right)\right]$$

where δ is the deprecion rate of capital. The function S introduces the adjustment costs on investment and satisfies the following properties: $S(1) = S'(1) = 0$, $S''(1) > 0$.

Hence, the Lagrangean to the maximization problem, with Lagrange multipliers $\beta^t \lambda_t (1-\tau_{t+s}^h) w_t/\mu_t$, $\beta^t \lambda_t$ and $\beta^t q_t \lambda_t$ respectively associated to the constraints (6), (7) and (8), reads as:

$$L = E_t \sum_{s=0}^{\infty} \left\{ \begin{array}{c} U\left(c_{t+s}^o(i) - bc_{t+s-1}^o; h_{t+s}(i)\right) + \\ +\lambda_{t+s}^o \left[\begin{array}{c} \frac{x_{t+s}}{\pi_{t+s}} + (1-\tau_{t+s}^k)\left[r_{t+s}^k u_{t+s} - a(u_{t+s})\right] K_{t+s}^o + \\ +\tau_{t+s}^k q_{t+s} \delta K_{t+s}^o + \\ +(1-\tau_{t+s}^h) h_{t+s}^d \int_0^1 w_{t+s}^j \left(\frac{w_{t+s}^j}{w_{t+s}}\right)^{-\eta_w} dj + \\ +d_{t+s}^o - R_{t+s,t+s+1} x_{t+s+1} - c_{t+s}^o - i_{t+s}^o \end{array} \right] + \\ +\lambda_{t+s}^o q_{t+s} \left[(1-\delta) K_{t+s}^o + i_{t+s}^o \left[1 - S\left(\frac{i_{t+s}^o}{i_{t+s-1}^o}\right)\right] - K_{t+s+1}^o\right] + \\ +\frac{\lambda_{t+s}^o (1-\tau_{t+s}^h) w_{t+s}}{\mu_{t+s}} \left[h_{t+s}^s - h_{t+s}^d \int_0^1 \left(\frac{w_{t+s}^j}{w_{t+s}}\right)^{-\eta_w}\right] \end{array} \right\}$$

The Ricardian household's first order conditions with respect to c_t^o, h_t^s, x_{t+1}, K_t^o, i_t^o, and u_t are respectively:

$$\frac{1}{c_t^o - bc_{t-1}^o} - \frac{b\beta}{c_{t+1}^o - bc_t^o} = \lambda_t^o \tag{A2}$$

$$\phi_1 \check{s}_t h_t^d = -\lambda_t^o \frac{(1-\tau_t^h) w_t}{\mu_t} \tag{A3}$$

$$\lambda_t^o = \beta R_{t,t+1} \frac{\lambda_{t+1}^o}{\pi_{t+1}} \tag{A4}$$

$$\lambda_t^o q_t = \left[\beta E_t \lambda_{t+1}^o \left(1-\tau_{t+1}^k\right)\left[r_{t+1}^k u_{t+1} - a\left(u_{t+1}\right)\right] + \right. \\ \left. + q_{t+1}\left(1-\delta\right) + \delta q_{t+1}\tau_{t+1}^k\right] \tag{A5}$$

$$\lambda_t^o = q_t \lambda_t^o \left[1 - S\left(\frac{i_t^o}{i_{t-1}^o}\right) - \left[S_i\left(\frac{i_t^o}{i_{t-1}^o}\right)\right] i_t^o\right] + \\ -\beta q_{t+1}\lambda_{t+1}^o S_i\left(\frac{i_{t+1}^o}{i_t^o}\right) i_{t+1}^o \tag{(A6)}$$

$$a_u\left(u_t\right) = r_t^k \tag{A7}$$

Following CEE (2005), the adjustment cost function and the capital utilization function are given by:

$$S\left(\frac{i_t}{i_{t-1}}\right) = \frac{k}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2$$

$$a\left(u_t\right) = \gamma_1\left(u_t - 1\right) + \frac{\gamma_2}{2}\left(u_t - 1\right)^2$$

6.5 Rule of thumb households

As pointed out above, Non-Ricardian agents just consume current labor income because they cannot save neither invest. Since they don't have access to capital markets, they only pay taxes on labor income and receive transfers from the government.

Therefore:

$$c_t^{rt} = w_t h_t^d (1 - \tau_t^h) + TR_t^{rt} \tag{A8}$$

The marginal utility of consumption for rule of thumbers is

$$\lambda_t^{rt} = \frac{1}{c_t^{rt} - bc_{t-1}^{rt}} - \frac{b\beta}{c_{t+1}^{rt} - bc_t^{rt}} \tag{A9}$$

6.6 Wage Setting

In this model wages are setted according to the Calvo (1983) framework. In particular each period a union faces a constant probability $(1 - \alpha_w)$ of being able to reoptimize wages. In other words, α_w denotes the degree of wage stickiness. The unions which are not able to reoptimize the wage index it to a geometric average of past inflation and steady-state inflation according to the following rule:

$$W_t^j = W_{t-1}^j\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\chi_w}\pi^{(1-\chi_w)} = W_{t-1}^j \pi_{t-1}^{\chi_w}\pi^{(1-\chi_w)}$$

where the parameter $\chi_w \in [0,1]$ is the indexation parameter.

Unions, in choosing the optimal wage w_t^*, have to take into account that they might not be able to do the same after s periods. If this is the case, taking into account that all unions resetting at time t choose the same wage, the real wage at the generic period $t+s$ will be:

$$w_{t+s} = w_t^* \prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}}$$

Hence, to derive the households' first order conditions with respect to the optimal wage, it is possible to pull out the part of the Lagrangean which is useful for this purpose. In particular, a weighted average of the two households types utility function is maximized by the optimizing union which will take into account of not being able to reoptimize in the future. Therefore the union objective is:

$$E_t \sum_{s=0}^{\infty} (\beta\alpha_w)^s \left\{ \begin{array}{c} \lambda_{t+s} \left[\left(1-\tau_{t+s}^h\right) h_{t+s}^d w_{t+s}^{\eta_w} \left(w_t^* \prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \right)^{(1-\eta_w)} \right] + \\ -\lambda_{t+s} \left[\left(1-\tau_{t+s}^h\right) h_{t+s}^d w_{t+s}^{(1+\eta_w)} \left(w_t^* \prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \right)^{(-\eta_w)} \right] \end{array} \right\}$$

where, importantly,

$$\lambda_{t+s} = \left[(1-\Omega)\,\lambda_{t+s}^{o} + \Omega\lambda_{t+s}^{rt}\right] \tag{A10}$$

is the average marginal utility between the ricardian and non ricardian's marginal utilities.

The first order condition with respect to the optimal wage is:

$$E_t \sum_{s=0}^{\infty} (\beta\alpha_w)^s h_{t+s}^d \left(\frac{w_t^*}{w_{t+s}} \right)^{(-\eta_w)} \left(\prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \right)^{(-\eta_w)} \lambda_{t+s} \times$$

$$\times \left\{ \begin{array}{c} \frac{(\eta_w-1)}{\eta_w} \left(1-\tau_{t+s}^h\right) w_t^* \left(\prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \right) + \\ +\frac{U_{n_{t+s}}}{\lambda_{t+s}} \end{array} \right\} = 0$$

The term $\frac{(\eta_w-1)}{\eta_w}$ is the markup which would prevail in absence of wage stickiness[13].

It's now convenient to write the wage setting equation in recursive form by defining:

[13] In the deterministic steady state it also denotes the wage murkup in absence of trend inflation or in case of full indexation, (this is the case in this paper).

$$
\begin{aligned}
f_{1_t} \quad \equiv \quad & \left[\frac{(\eta_w - 1)}{\eta_w} w_t^* E_t \sum_{s=0}^{\infty} (\beta \alpha_w)^s \, h_{t+s}^d \left(\frac{w_t^*}{w_{t+s}} \right)^{(-\eta_w)} \right. \\
& \left. \lambda_{t+s} \left(1 - \tau_{t+s}^h\right) \left(\prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \right)^{(1-\eta_w)} \right]
\end{aligned}
$$

and

$$
f_{2_t} \equiv -w_t^{*(-\eta_w)} E_t \sum_{s=0}^{\infty} (\beta \alpha_w)^s \, h_{t+s}^d w_{t+s}^{\eta_w} U_{n_{t+s}} \left(\prod_{k=1}^{s} \frac{\pi_{t+k-1}^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+k}} \right)^{(-\eta_w)}
$$

In recursive form:

$$
\begin{aligned}
f_{1_t} \quad = \quad & \frac{(\eta_w - 1)}{\eta_w} w_t^* h_t^d \left(1 - \tau_t^h\right) \left(\frac{w_t}{w_t^*} \right)^{(\eta_w)} \lambda_t + \\
& + \beta \alpha_w E_t \left(\frac{w_{t+1}^*}{w_t^*} \right)^{(\eta_w - 1)} \left(\frac{\pi_t^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+1}} \right)^{(1-\eta_w)} f_{1_{t+1}}
\end{aligned} \tag{A11}
$$

and

$$
f_{2_t} = -\left(\frac{w_t}{w_t^*} \right)^{(\eta_w)} h_t^d U_{n_t} + \beta \alpha_w E_t \left(\frac{w_{t+1}^*}{w_t^*} \right)^{(\eta_w)} \left(\frac{\pi_t^{\chi_w} \pi^{(1-\chi_w)}}{\pi_{t+1}} \right)^{(-\eta_w)} f_{2_{t+1}} \tag{A12}
$$

Hence, the wage setting equation reads as:

$$
f_{1_t} = f_{2_t} \tag{A13}
$$

6.7 Firms

Intermediate firms compete monopolistically by producing good z according to the following technology:

$$
y_t(z) = (K_t(z))^{\vartheta} (h_t(z))^{(1-\vartheta)}
$$

where $K_t(z)$ is the physical capital stock that firms rent by ricardian households and $h_t(z)$ is the labor input used by each firm z. In particular it is defined as:

$$
h_t(z) = \left(\int_0^1 \left(h_t^j(z) \right)^{\frac{\eta_w - 1}{\eta_w}} dj \right)^{\frac{\eta_w}{\eta_w - 1}}
$$

Firms must pay the wage bill in advance of the production. In other words they are subject to a cash in advance constraint of the form:

$$m_{zt}^{f} = \nu w_t h_{zt}$$

where m_{zt}^{f} denotes the real money balances by firm z and ν is the fraction of wage which is payed in advance. The wage is lent by ricardian households which at the end of the period receive back money at the gross nominal interest rate.

Therefore the marginal costs the firms have to face reads as:

$$mc_t = \left(\frac{r_t^k}{\vartheta}\right)^{\vartheta} w_t \left[1 + \nu\left(1 - \frac{1}{R}\right)\right] \tag{A14}$$

6.8 Price Setting

As for wages, prices are setted according to the Calvo (1983) framework. In particular each period a firm faces a constant probability $(1-\alpha)$ of being able to reoptimize prices. In other words, α denotes the degree of price stickiness. The firms which are not able to reoptimize the price index it to a geometric average of past inflation and steady-state inflation according to the following rule:

$$P_t(z) = P_{t-1}(z)\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\chi} \pi^{(1-\chi)} = P_{t-1}(z)\, \pi_{t-1}^{\chi} \pi^{(1-\chi)}$$

where the parameter $\chi \in [0,1]$ is the degree of price indexation.

The firms in choosing the optimal price P_t^* have to take into account that they might not be able to do the same after s periods. If this is the case, by taking into account that all firms resetting at time t choose the same price, at the generic period $t+s$ it will be:

$$P_{t,t+s} = P_t^* \prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{(1-\chi)}$$

The optimal price P_t^* is chosen in order to maximize the discounted value of expected future profits. Moreover, it's important to remind here that only ricardian households own firms. Hence, the firms' maximization problem is:

$$\max_{P_t^*} E_t \sum_{s=0}^{\infty} (\beta\alpha)^s \frac{P_t}{\lambda_t^o} \frac{\lambda_{t+s}^o}{P_{t+s}} \left(P_t^* \prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{(1-\chi)} - P_{t+s} mc_{t+s}\right) y_{t,t+s}(z)$$

subject to:

$$y_{t,t+s}(z) = \left(\frac{P_t^* \prod_{k=1}^{s} \pi_{t+k-1}^{\chi} \pi^{(1-\chi)}}{P_{t+s}}\right)^{(-\eta)} y_{t+s}^d$$

where y_t^d is the aggregate demand and $\frac{\lambda_{t+s}^o}{\lambda_t^o}$ denotes the stochastic discount factor of ricardian households.

The first order condition with respect to P_t^* is:

$$E_t \sum_{s=0}^{\infty} (\beta\alpha)^s \frac{\lambda^o_{t+s}}{\lambda^o_t} \left(\frac{\prod_{k=1}^{s} \pi^{\chi}_{t+k-1} \pi^{(1-\chi)}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{(-\eta)} y^d_{t+s} \left(\frac{P_t^*}{P_t} \right)^{(-\eta-1)} \left[\begin{array}{c} \left(\frac{P_t^*}{P_t} \right) \left(\frac{\prod_{k=1}^{s} \pi^{\chi}_{t+k-1} \pi^{(1-\chi)}}{\prod_{k=1}^{s} \pi_{t+k}} \right) + \\ + \frac{\eta}{(1-\eta)} mc_{t+s} \end{array} \right] = 0$$

The term $\frac{(\eta-1)}{\eta}$ is the markup which would prevail in absence of price stickiness[14].

It's useful to write the price setting equation in recursive form by defining:

$$x_{1_t} \equiv \left(\frac{P_t^*}{P_t} \right)^{(-\eta-1)} E_t \sum_{s=0}^{\infty} (\beta\alpha)^s \frac{\lambda^o_{t+s}}{\lambda^o_t} \left(\frac{\prod_{k=1}^{s} \pi^{\chi}_{t+k-1} \pi^{(1-\chi)}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{(-\eta)} y^d_{t+s} mc_{t+s}$$

and

$$x_{2_t} \equiv \left(\frac{P_t^*}{P_t} \right)^{(-\eta)} E_t \sum_{s=0}^{\infty} (\beta\alpha)^s \frac{\lambda^o_{t+s}}{\lambda^o_t} \left(\frac{\prod_{k=1}^{s} \pi^{\chi}_{t+k-1} \pi^{(1-\chi)}}{\prod_{k=1}^{s} \pi_{t+k}} \right)^{(1-\eta)} y^d_{t+s}$$

By writing recursively:

$$x_{1_t} = p_t^{*(-\eta-1)} y_t^d mc_t + E_t \left\{ (\beta\alpha) \frac{\lambda^o_{t+1}}{\lambda^o_t} \left(\frac{\pi_t^{\chi} \pi^{(1-\chi)}}{\pi_{t+1}} \right)^{(-\eta)} \left(\frac{p_t^*}{p_{t+1}^*} \right)^{(-\eta-1)} x_{1_{t+1}} \right\} \tag{A15}$$

and

$$x_{2_t} = p_t^{*(-\eta)} y_t^d + E_t \left\{ (\beta\alpha) \frac{\lambda^o_{t+1}}{\lambda^o_t} \left(\frac{\pi_t^{\chi} \pi^{(1-\chi)}}{\pi_{t+1}} \right)^{(1-\eta)} \left(\frac{p_t^*}{p_{t+1}^*} \right)^{(-\eta)} x_{2_{t+1}} \right\} \tag{A16}$$

It's possible to rewrite the price setting equation as:

$$x_{2_t} = \frac{\eta}{\eta - 1} x_{1_t} \tag{A17}$$

[14] In the deterministic steady state it also denotes the price murkup in absence of trend inflation or in case of full indexation, (this is the case in this paper).

6.9 Aggregation

The aggregate production function is:

$$y_t = (u_t K_t)^{\vartheta} h_t^{d(1-\vartheta)} \tag{A18}$$

and the aggregate absortion is:

$$y_t^d = c_t + i_t + g_t + a(u_t) K_t \tag{A19}$$

where:

$$c_t = (1 - \Omega) c_t^o + \Omega c_t^{rt} \tag{A20}$$

$$i_t = (1 - \Omega) i_t^o \tag{A21}$$

$$K_t = (1 - \Omega) K_t^o \tag{A22}$$

As for transfers, it holds:

$$TR_t = \Omega TR_t^{rt} \tag{A23}$$

given that transfers are assumed to be assigned only to RT consumers.

6.10 Market clearing

6.10.1 Goods market equlibrium

The expression warranting the equilibrium in the good market is:

$$y_t = s_t y_t^d \tag{A24}$$

where s_t denotes the resource cost due to relative price dispersion in the Calvo model. It evolves according to:

$$s_t = (1 - \alpha) p_t^{*(-\eta)} + \alpha \left(\frac{\pi_t}{\pi_{t-1}^{\chi} \pi^{(1-\chi)}} \right)^{\eta} s_{t-1} \tag{A25}$$

where p_t^*, in the light of the aggregate price index, must satisfy:

$$\alpha \pi_t^{(\eta-1)} (\pi_{t-1}^{\chi} \pi^{(1-\chi)})^{(1-\eta)} + (1 - \alpha) p_t^{*(1-\eta)} = 1$$

6.10.2 Labour market equilibrium

The equilibrium on the labour market is given by:

$$h_t^s = \widetilde{s}_t h_t^d \tag{A26}$$

where $\widetilde{s}_t$ denotes the resource cost due to relative wage dispersion in the Calvo model. It evolves according to:

$$\widetilde{s}_t = (1-\alpha_w)\left(\frac{w_t^*}{w_t}\right)^{(-\eta_w)} + \alpha_w \left(\frac{w_{t-1}}{w_t}\right)^{(-\eta_w)} \left(\frac{\pi_t}{\pi_{t-1}^{\chi_w}\pi^{(1-\chi_w)}}\right)^{\eta_w} \widetilde{s}_{t-1} \tag{A27}$$

where it must hold that:

$$w_t^* = \left(\frac{w_t^{(1-\eta_w)} - \alpha_w w_{t-1}^{(1-\eta_w)} \left(\frac{\pi_{t-1}^{\chi_w}\pi^{(1-\chi_w)}}{\pi_t}\right)^{(1-\eta_w)}}{(1-\alpha_w)}\right)^{\frac{1}{(1-\eta_w)}}$$

6.11 Fiscal Authority

Fiscal authority decides on government consumption, transfers to households, and interest payments on outstanding debt[15]. Revenues are obtained levying taxes on labor and capital, τ^h and τ^k respectively, and by issuing new debt.

The period budget constraint is:

$$G_t + TR_t + \frac{B_t}{\pi_t} = \tau_t^k \left[r_t^k u_t - a(u_t) - q_t\delta\right] K_t + \tau_t^h w_t h_t + \frac{B_{t+1}}{R_t} \tag{A28}$$

where $\left[r_t^k u_t - a(u_t) - q_t\delta\right] \equiv \sigma_t$ is the pre-tax return on capital.

6.12 Monetary Authority

Monetary authority adjusts the nominal interest rate according to the following nom-linear rule in which the policy rate responds not only to inflation but also the output gap, in line with the classical Taylor rule specification.

$$\left(\frac{R_t}{R_t^{**}}\right) = \left(\frac{\pi_t}{\pi^{**}}\right)^{\phi_\pi} \left(\frac{y_t}{y^{**}}\right)^{\phi_y} \tag{A29}$$

[15] Public debt is assumed to be nominal, consistent with the debt generally issued around the world.

7 Appendix B

Calibration of the structural parameter values follows SW (2003) calibration.

Table B1: Parameter Values

Parameter	*Value*	*Description*
Households		
β	$1.03^{(-1/4)}$	Subjective discount factor
b	0.60	Degree of habit persistence
ϕ	2	Inverse of intertemporal substitution of labor
ϕ_1	1.1196	Disutility of work
ξ	0.2736	Weight of government expenditures
η_w	6	Wage elasticity of demand for a specific labor variety
Ω	0.50	Share of Rule of Thumb consumers[16]
α_w	0.75	Calvo wage
χ_w	0.75	Wage indexation
Firms		
ϑ	0.30	Share of capital in value added
δ	0.025	Depreciation rate of capital
η	6	Price elasticity of demand for a specific good variety
α	0.9	Calvo price
χ	0.50	Price indexation
ν	0.15	Cash in advance parameter
Fiscal Sector		
by^{**}	60%	Debt-to-output ratio target (annual)
$g^* = g^{**}$	18%	Government expenditure ratio
$tr^* = tr^{**}$	18%	Transfers ratio
τ_k^*	52.23%	Capital tax rate (old target)
τ_k^{**}	51.86%	Capital tax rate (new target)
τ_h^*	56.77%	Labor tax rate (old target)
τ_h^{**}	56.37%	Labor tax rate (new target)
$\left(\frac{\tau_k^*}{\tau_h^*}\right) = \left(\frac{\tau_k^{**}}{\tau_h^{**}}\right)$	92%	Tax rate ratios
ϕ_g	1	Debt stabilization
ϕ_τ	0.01	Tax rate dynamics
δ_0	0.5	Transfer response to output
δ_1	0.5	Tax response to output
Monetary Authority		
ϕ_π	1.5	Inflation stabilization
ϕ_y	0.5	Output stabilization

[16] Campbell and Mankiw (1989), Mankiw (2000)

8 Appendix C: The Welfare-Based Ratio and the Consumption Equivalent Measure

The Welfare-Based ratio measure described here, follows Ascari and Ropele (2011).

Define V_0^J and V_{old}^J as the expected values of A1, respectively at time zero (when consolidation experiment is actually implemented) and at the initial steady state (before the consolidation experiment). $j = o, rt$ refers to optimizing and RT consumers respectively.

Determining V_{old}^J is straighforward:

$$V_{old}^J = \frac{1}{(1-\beta)}\left[\ln(1-b)\, C_{old}^J - \frac{\phi_1}{(1+\phi)}\left(hs_{old}^J\right)^{(1+\phi)} + \xi \ln G_{old}\right]$$

where C_{old}^J, hs_{old}^J and G_{old} are respectively the initial steady state values of consumption, hours and government spending. Obtaining the solution for V_0^J requires numerical simulations as it accounts for both the new steady state and for the transition phase.

Following Ascari and Ropele (2011) V_{old}^J and V_0^J allow to compute the welfare-based ratio, WR:

$$WR^j = -\left(\frac{V_0^J - V_{old}^J}{b_{y,old}^* - b_{y,new}^*}\right)$$

where the denominator $b_{y,old}^* - b_{y,new}^*$ allows to weigh the welfare change by the size of debt reduction.

Since the utility function is not cardinal, the numerator of the ratio needs to be transformed in a measure which actually can "quantify" the welfare cost (or gain) of fiscal consolidation. This is obtained computing the *consumption equivalent measure* which is defined as the constant fraction of consumption that households must give up in each period to permanently reduce debt. Following Ascari and Ropele (2011), the *consumption equivalent measure* reads as:

$$\lambda^J = 1 - \exp\left[(1-\beta)\left(V_0^J - V_{old}^J\right)\right] \tag{C1}$$

and the welfare-based ratio is:

$$WR^J = \left(\frac{\lambda^J}{b_{y,old}^* - b_{y,new}^*}\right) \tag{C2}$$

Since λ^J denotes a welfare cost, fiscal consolidation is welfare improving when the welfare-based ratio is negative.

To disentangle the welfare effects of consolidation during the transition dynamics from its the long-run welfare gains, let's define the long-run costs in terms of consumption equivalent units as:

$$\lambda_{long\_run}^J = 1 - \exp\left[(1-\beta)\left(V_{new}^J - V_{old}^J\right)\right] \tag{C3}$$

where V_{old}^J and V_{new}^J are respectively the value fuctions associated to the old and new steady-state debt ratios. Hence the long-run welfare-based ratio is:

$$WR_{long\_run}^J = \left(\frac{\lambda_{long\_run}^J}{b_{y,old}^* - b_{y,new}^*} \right) \tag{C4}$$

The short-run welfare-based ratio is then:

$$WR_{short\_run}^J = WR^J - WR_{long\_run}^J \tag{C5}$$