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The Optimal Policy Mix to Achieve Public Debt Consolidation*

Roberta Cardani[†] Patrizio Tirelli[‡]

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Abstract

In this paper we adopt a Ramsey-optimal approach to the identification of debt reduction strategies, that is, we identify the optimal policy mix for income taxes, public expenditures and inflation designed to achieve an exogenous debt reduction path. The optimal policy envisages persistent reductions in public consumption and increases in taxes and inflation. A persistent fall in consumption and investment cannot be avoided, and households that cannot exploit financial markets to smooth their consumption bear the brunt of adjustment costs.

JEL codes: E32, E62, E63

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1 Introduction

Following the large increases in public-debt-to-GDP ratios observed in the aftermath of the 2007-financial crisis, fiscal consolidation, i.e. a reduction in the debt-to-GDP ratio, has come to the forefront of political debate and macroeconomic analyses (Blanchard et al., OECD 2012). The issue is particularly relevant for the Eurozone, where institutional arrangements such as the Maastricht Treaty and the Stability and Growth Pact (SGP) should oblige member states to pursue a 60% debt-to-GDP ratio. In fact the ‘corrective arm’ of the SGP should be activated whenever public debt exceeds 60% of GDP and the excess debt is not reduced by 5% per year on average over three years (European Commission).

Empirical research emphasizes the importance of achieving fiscal consolidation through public expenditures reductions (Nickel, Rother and Zimmermann, 2010; Alesina, Favero and Giavazzi, 2015), but it is no longer supporting the view that fiscal consolidations may be expansionary provided that they are based on public expenditure reductions (Perotti, 2011). It is now widely acknowledged that fiscal consolidation causes output losses in the short run, and there is a growing concern with the distributional consequences of fiscal consolidations (OECD, 2013). One less investigated

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issue is whether inflation targets should be temporarily raised to facilitate public debt reduction (Rogoff, 2010; Aizenman and Marion, 2011).

A growing body of theoretical literature has analyzed the issue of debt reductions in the context of DSGE models where fiscal policy makers implement simple feedback rules for tax and expenditure variables, whereas the Central Bank implements a standard Taylor rule. Coenen, Mohr and Straub (2008) model the fiscal consolidation as a permanent reduction in the target for the debt-to-output ratio that enters into the feedback rules, showing that public debt reductions involve tradeoffs between short-run losses and long-run benefits. Note that short run adverse effects are mainly borne by households whose ability to smooth consumption is impaired by their limited participation to asset markets. Ferrara and Tirelli (2014) adopt a similar approach to investigate which policy mix, including targeted public transfers and an accommodative monetary policy, could be adopted to avoid the adverse redistributive effects of fiscal consolidations. Philippopoulos et al. (2015) neglect distributive issues and focus on the optimization of feedback rules, i.e. on the choice of feedback parameters that maximize the representative household's expected discounted lifetime utility for given exogenous debt and inflation targets.

In this paper we adopt a Ramsey-optimal approach to the identification of debt reduction strategies, that is, we identify the optimal policy mix for income taxes, public expenditures and inflation designed to achieve an exogenous debt reduction path as envisaged, for instance, in the Stability and Growth Pact. There is a number of questions the paper is meant to address. The first one concern the optimal combination of public expenditure reductions and tax increases. In this regard, to avoid trivial results and in contrast with authors such as Forni et al. (2010), we assume that public consumption is not a mere dissipation of resources but generates utility to households, as in Stahler and Thomas (2012) and Ferrara and Tirelli (2014). The second one relates to the desirability of adjusting the inflation target during the debt consolidation period. To this end our model incorporates a monetary transactions technology that follows Schmitt-Grohé and Uribe (2011, SGU henceforth). As a result, in our model we can identify the optimal inflation rate both in the pre-consolidation steady state and during the transition to the low public debt steady state. To better understand the importance of exploiting inflation to facilitate consolidation, we shall also consider an alternative strategy of debt consolidation, where the Central bank sticks to an inflation targeting policy and the responsibility for debt consolidation rests in the hands of the fiscal policymaker. The relevance of this issue for the EMU situation is self-apparent given the institutional arrangements that prohibit monetary financing (Article 123 of the Treaty on the Functioning of the European Union). Finally, the third question we address concerns redistributive effects of alternative policies. To capture these effects our model accounts for Limited Asset Market Participation (LAMP henceforth), that is, a fraction of households do not own interest bearing assets and can only exploit their money holdings to smooth consumption during the transition, as in Coenen, Mohr and Straub (2008).

Our results in a nutshell. We find that consolidations entail a persistent tax (public expenditure) increase (reduction). We also find that inflation follows a hump-shaped pattern, raising up to 2 percentage points above the pre-consolidation level. The consolidation is associated to a sharp reduction in investment and to a milder but persistent reduction in aggregate consumption. Output remains below the pre-consolidation level throughout the transition to the new debt-to-GDP ratios, and the consumption gains associated to the consolidation begin to materialize only after consolidation is achieved. We also identify important redistributive effects. Wealthy capital owners exploit the reduction in investment expenditures to stabilize their consumption. In addition, they reduce their labor supply in response to the increase in labor taxation. When monetary policy is not

involved in the consolidation exercise and the central bank sticks to her inflation targeting strategy the fiscal contraction is inevitably stronger and the output loss much larger. Constrained households bear the brunt of this alternative policy strategy, suffering a deeper reduction in consumption.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 describes the competitive equilibrium and defines the Ramsey optimal policy. In section 4 we obtain the steady state results. Section 5 describes the optimal Ramsey dynamics and section 6 concludes.

2 The model

We consider a standard DSGE model characterized by monopolistic competition and nominal rigidities in the goods and labor markets. Following [Schmitt-Grohé and Uribe \(2004a\)](#), monetary transaction costs are introduced in order to motivate a demand for money:

$$s_{t,i} = Av_{t,i} + \frac{B}{v_{t,i}} - 2\sqrt{AB} \quad (1)$$

where $v_{t,i} = \frac{c_{t,i}}{m_{t,i}}$ defines money velocity, $c_{t,i}$ is household's i real consumption, $m_{t,i} = \frac{M_{t,i}}{P_{t,i}}$ denotes real money balances. Note that

$$s'(v_{t,i}) > 0 \text{ for } v_{t,i} > v^*; v^* > 0 \quad (2)$$

$v^* > 0$ defines a satiation level for money velocity because at $v_{t,i} = v^*$ the transaction cost is nil. Note that $\frac{c_{t,i}}{m_{t,i}} = v^*$ is associated to a zero nominal interest rate.

The government finances an exogenous stream of expenditures by levying distortionary income taxes and by printing money. Optimal policy is set according to a Ramsey plan.

Households utility function is as in [Schmitt-Grohé and Uribe \(2004a\)](#)

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t^i, l_t^i, g_t); u(c_t^i, l_t^i, g_t) = \ln c_t^i + \eta \ln(1 - l_t^i) + \xi \ln g_t \quad (3)$$

where β is the subjective discount rate and l_t^i denotes supply of a differentiated labor type. A fraction $\theta \in [0, 1]$ of households only participates in the money market and does not hold any other asset (henceforth constrained or non-Ricardian agents, c). The remaining $1 - \theta$ fraction of households have full access to financial markets and own firms (henceforth unconstrained or Ricardian agents, u).

2.1 Labor Packers

Firms use a labor bundle, l_t^d , as a production factor. Such bundle is produced by labor packers who buy the differentiated labor services from households. Under perfect competition, labor packers solve the following problem:

$$\max w_t l_t^d - \int_0^1 w_i^i l_t^i di$$

s.t.

$$l_t^d = \left[\int_0^1 (l_t^i)^{\rho_w} di \right]^{\frac{1}{\rho_w}} \quad (4)$$

Demand function for labor type i is

$$l_t^i = l_t^d \left(\frac{w_t^i}{w_t} \right)^{\frac{1}{\rho_w - 1}} \quad (5)$$

and the wage index is¹

$$w_t = \left[\int_0^1 (w_t^i)^{\frac{\rho_w}{\rho_w - 1}} di \right]^{\frac{\rho_w - 1}{\rho_w}} = \left[(1 - \theta) (w_t^u)^{\frac{\rho_w}{\rho_w - 1}} + \theta (w_t^c)^{\frac{\rho_w}{\rho_w - 1}} \right]^{\frac{\rho_w - 1}{\rho_w}} \quad (6)$$

Similarly, equation (4) can be rewritten as

$$l_t^d = [(1 - \theta) (l_t^u)^{\rho_w} + \theta (l_t^c)^{\rho_w}]^{\frac{1}{\rho_w}} \quad (7)$$

2.2 Households

Ricardian households are subject to the following period budget constraint

$$\begin{aligned} c_t^u (1 + s_t) + k_t^u + \frac{M_t^u}{P_t} + \frac{B_t^u}{P_t} &= (1 - \tau_t) (w_t^u l_t^u + r_t^k k_{t-1}) + [1 - \delta (1 - \tau_t)] k_{t-1}^u + \\ &+ \frac{M_{t-1}^u}{P_t} + \frac{\Pi_t^u}{P_t} + \frac{R_{t-1} B_{t-1}^u}{P_t} - \frac{\xi_w}{2} l_t^u \left(\frac{w_t^u \pi_t}{w_{t-1}^u} - 1 \right)^2 \end{aligned} \quad (8)$$

where τ_t is the income tax rate; Π_t are nominal firms profits; R_t is the gross nominal interest rate, B_t^u is a one-period nominally riskless bond that pays one unit of currency. M_t^u defines nominal money holdings, $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross inflation rate. k_t^u denotes the capital stock, r_t^k is the rental rate of capital and δ is the depreciation rate.² Parameter ξ_w identifies Rotemberg nominal wage adjustment costs, defined in terms of real output.

The representative constrained household is subject to the flow budget constraint

$$c_t^c \left[1 + s \left(\frac{P_t c_t^c}{M_t^c} \right) \right] + \frac{M_t^c}{P_t} = (1 - \tau_t) w_t l_t^c + \frac{M_{t-1}^c}{P_t} - \frac{\xi_w}{2} l_t^c \left(\frac{w_t^c \pi_t}{w_{t-1}^c} - 1 \right)^2 \quad (9)$$

Solving the optimization problem for each group one obtains that the following first-order conditions are identical for all households:

$$\lambda_t^i = \frac{u_c(c_t^i, l_t^i)}{1 + s(v_{t,i}) + v_{t,i} s'(v_{t,i})} \quad (10)$$

$$1 - E_t \left[\frac{\beta}{\pi_{t+1}} \frac{\lambda_{t+1}^i}{\lambda_t^i} \right] = s'(v_t^i) (v_t^i)^2 \quad (11)$$

$$\begin{aligned} &\frac{\left(w_t^i \rho_w + \frac{u_l(c_t^i, l_t^i)}{(1 - \tau_t) \lambda_t^i} \right) \left(\frac{w_t^i}{w_t} \right)^{\frac{1}{\rho_w - 1}}}{1 - \rho_w} + \xi_w \frac{w_t^i \pi_t}{w_{t-1}^i} \left(\frac{w_t^i \pi_t}{w_{t-1}^i} - 1 \right) = \\ &\beta E_t \left\{ \frac{l_{t+1}^i \lambda_{t+1}^i}{l_t^i \lambda_t^i} \xi_w \left[\frac{w_{t+1}^i \pi_{t+1}}{w_t^i} \left(\frac{w_{t+1}^i \pi_{t+1}}{w_t^i} - 1 \right) \right] \right\} \end{aligned} \quad (12)$$

¹Wage setting decisions are identical for households belonging to the same group.

²We assume that the government grants depreciation tax allowances.

As shown in [Schmitt-Grohé and Uribe \(2004a\)](#), in (10) the transaction costs introduce a wedge between the marginal utility of consumption, $u_c(c_t^u, l_t^u)$, and the marginal utility of wealth, λ_t^u , that vanishes only if $\frac{c_t^u}{m_t^u} = v_t^u = v^*$. Equation (12) represents the standard wage setting equation. Finally, equation (11) describes an implicit money demand function.

Asset market participation allows to characterize two additional first-order conditions:

$$\lambda_t^i = \beta E_t \left(\frac{\lambda_{t+1}^i R_t}{\pi_{t+1}} \right) \quad (13)$$

$$\lambda_t^i = \beta E_t \left\{ \lambda_{t+1}^i \left[(1 - \tau_{t+1}) (r_{t+1}^k - \delta) + 1 \right] \right\} \quad (14)$$

that respectively define the Euler equations with respect to bonds and to physical capital. One important point is that, unlike cashless models, here consumption dynamics cannot be taken as the sole determinant of consumption dynamics. In fact these are also determined by expected dynamics in monetary transaction costs.

Note that taking into account (13), from (11) one would obtain the familiar relationship between money velocity and the nominal interest rate that in our model only characterizes money demand for unconstrained households.

$$1 - \frac{1}{R_t} = s'(v_t^u) (v_t^u)^2 \quad (15)$$

Condition (15) allows to clarify a fundamental distinction between unconstrained and constrained households. In fact the inverse of the nominal interest rate defines the opportunity cost of holding money for unconstrained households, whose consumption decisions are driven by the expected real interest rate in (13). By contrast, constrained households cannot base their consumption decisions on returns from interest bearing assets. As a result, for these households the opportunity cost of holding money is $\frac{\beta}{\pi_{t+1}} \frac{\lambda_{t+1}^c}{\lambda_t^c}$. Thus money demand is affected by expected inflation.³

Further, the money demand equation (11) can also be interpreted as an Euler equation driving consumption decisions for constrained households:

$$1 - E_t \left[\frac{\beta}{\pi_{t+1}} \frac{\lambda_{t+1}^c}{\lambda_t^c} \right] = s'(v_t^c) (v_t^c)^2 \quad (16)$$

$$c_t^c = \left\{ \frac{\pi_{t+1} \left[1 - s'(v_t^c) (v_t^c)^2 \right] \left[1 + s(v_{t+1,i}^c) + v_{t+1}^c s'(v_{t+1}^c) \right]}{\beta \left[1 + s(v_t^c) + v_{t,i}^c s'(v_t^c) \right]} \right\} c_{t+1}^c$$

We discussing transition dynamics during the consolidation exercise we will show that inflation may have an important effect in stabilizing their consumption.

By contrast the Euler equation (13) for unconstrained households reads as follows

$$c_t^u = \left\{ \frac{\pi_{t+1} \left[1 + s(v_{t+1}^u) + v_{t+1}^u s'(v_{t+1}^u) \right]}{\beta R_t \left[1 + s(v_t^u) + v_{t,i}^u s'(v_t^u) \right]} \right\} c_{t+1}^u$$

³Note that money-to consumption ratios for the two groups are identical in steady state, when $\frac{\lambda_{t+1}^u}{\lambda_t^u} = \frac{\lambda_{t+1}^c}{\lambda_t^c} = 1$ and $R = \frac{\pi}{\beta}$.

2.3 Firms

Perfectly competitive final good firms buy differentiated goods $z \in (0, 1)$ from intermediate firms and assemble them into a final good bundle, $y_t^d = \left[\int_0^1 y_t(z)^\rho dz \right]^{\frac{1}{\rho}}$, which can be used both for consumption and for investment. The optimality condition reads as follows:

$$y_t(z) = y_t^d \left[\frac{P_t(z)}{P_t} \right]^{\frac{1}{\rho-1}} \quad (17)$$

where $P_t = \left[\int_0^1 P_t(z)^{\frac{\rho}{\rho-1}} dz \right]^{\frac{\rho-1}{\rho}}$ is the price index.

The representative intermediate firm produces a differentiated good under a standard Cobb-Douglas technology:

$$y_t(z) = a_t l_t(z)^\alpha k_{t-1}(z)^{1-\alpha} \quad (18)$$

where a_t is stochastic total factor productivity. Pricing decisions for intermediate goods are subject to a quadratic costs of nominal price adjustment (Rotemberg (1982)):

$$\frac{\xi_p}{2} y_t^d \left[\frac{P_t(z)}{P_{t-1}(z)} - 1 \right]^2 \quad (19)$$

As a result the standard Phillips curve obtains:

$$\frac{(\rho - mc_t)}{1 - \rho} + \xi_p \pi_t (\pi_t - 1) = \beta E_t \left\{ \frac{y_{t+1} \lambda_{t+1}^u}{y_t \lambda_t^u} \xi_p [\pi_{t+1} (\pi_{t+1} - 1)] \right\} \quad (20)$$

where mc_t are the real marginal costs.

Cost minimization implies the following factor demands:

$$w_t = a_t \alpha mc_t \left(\frac{l_t}{k_{t-1}} \right)^{\alpha-1} \quad (21)$$

$$r_t^k = a_t (1 - \alpha) mc_t \left(\frac{l_t}{k_{t-1}} \right)^\alpha \quad (22)$$

Firm profits are

$$\frac{\Pi_t}{P_t} = a_t l_t^\alpha k_{t-1}^{1-\alpha} - w_t l_t^d - r_t^k k_{t-1} - \frac{\xi_p}{2} a_t l_t^\alpha k_{t-1}^{1-\alpha} (\pi_t - 1)^2 \quad (23)$$

2.4 Aggregation

Equations (24)-(29) define aggregate consumption, aggregate hours, aggregate real money balances, bonds, profits, aggregate capital and total output:

$$c_t = (1 - \theta) c_t^u + \theta c_t^c \quad (24)$$

$$m_t = (1 - \theta) m_t^u + \theta m_t^c \quad (25)$$

$$B_t^u = \frac{B_t}{1 - \theta} \quad (26)$$

$$\Pi_t^u = \frac{\Pi_t}{1 - \theta} \quad (27)$$

$$k_t^u = \frac{k_t}{1 - \theta} \quad (28)$$

$$y_t^d = (1 - \theta) c_t^u \left(1 + s \left(\frac{c_t^u}{m_t^u} \right) \right) + \theta c_t^c \left(1 + s \left(\frac{c_t^c}{m_t^c} \right) \right) + k_t - (1 - \delta) k_{t-1} + \quad (29)$$

$$g_t + \frac{\xi_p}{2} y_t (\pi_t - 1)^2 + (1 - \theta) \frac{\xi_w}{2} l_t^u \left(\frac{w_t^u \pi_t}{w_{t-1}^u} - 1 \right)^2 + \theta \frac{\xi_w}{2} l_t^c \left(\frac{w_t^c \pi_t}{w_{t-1}^c} - 1 \right)^2$$

2.5 Government

Government expenditures are equal to g_t , and are financed by an income tax, by money creation and by issuance of one-period, nominally risk free bonds. The government flow budget constraint is then given by

$$R_{t-1} \frac{B_{t-1}}{P_t} + g_t + t_t = \tau_t (w_t l_t^d + r_t^k k_{t-1}) - \tau_t \delta k_{t-1} + \frac{M_t - M_{t-1}}{P_t} + \frac{B_t}{P_t} \quad (30)$$

The debt consolidation experiment is defined as a sequence of public consumption, tax and inflation rates that allow to achieve in each period a reduction in the debt-to-GDP ratio, $\frac{B_t}{P_t y_t}$, such that a 20% reduction is obtained over a 10-year horizon. This implies that dynamics for real debt, b_t , is defined as follows

$$\frac{b_t}{y_t} = \frac{b_{t-1}}{y_{t-1}} - \rho^b; 0 < t \leq T \quad (31)$$

where b_0 is set equal to 80% of pre-consolidation steady state GDP and b_T is the post-consolidation amount of debt, equal to 60% of post-consolidation GDP. We set T equal to 10 years, and set ρ^b equal to 0.02, such that the government achieves an equal reduction in the debt to GDP ratio each year during the consolidation period.

3 Equilibrium and Ramsey policy

3.1 Competitive Equilibrium

Definition 1 *A competitive equilibrium is a set of plans*

$$\left\{ c_t^u, c_t^c, c_t, l_t^u, l_t^c, l_t, \lambda_t^u, \lambda_t^c, m c_t, \pi_t, w_t, w_t^u, w_t^c, m_t^u, m_t^c, m_t, y_t, b_t, R_t, k_t, r_t^k, \tau_t, g_t \right\}_{t=0}^{\infty},$$

that, given initial values $\{m_{-1}^u, m_{-1}^c, m_{-1}, b_{-1}, k_{-1}\}$ satisfies equations (5), (10), (13), (12), (14), (11), (9), (12), (16), (7), (18), (20), (21), (22), (30), (24), (25), (29), and the debt-consolidation rule (31).⁴

⁴The competitive equilibrium must also satisfy the no-Ponzi game condition and the non-negativity constraint $R_t \geq 1$.

3.2 Ramsey Optimal Policy

Definition 2 *A Ramsey optimal policy is a competitive equilibrium that attains the maximum of the following additive social welfare function*

$$W = E_0 \sum_{t=0}^{\infty} \beta^t [(1 - X^R) u(c_t^u, l_t^u, g_t^u) + X^R u(c_t^c, l_t^c, g_t^i)] \quad (32)$$

where X^R is the weight given to constrained households utility.

The Ramsey program is non-stationary because in the first period an incentive exists for the planner to generate inflation or tax "surprises". Following the literature we assume the planner does not engage in such policies (Schmitt-Grohé and Uribe, 2004a).⁵

4 Ramsey Steady State

The time unit is a year⁶ and we set the subjective discount rate β to 0.96 to be consistent with a steady-state real rate of return of 4% per year. As Erosa and Ventura (2002), we set α to 64% and δ to 8%. Parameters concerning monopolistic competition in the goods and labor market, nominal rigidities, the transaction technology and the share of public consumption over GDP in steady state are set following Schmitt-Grohé and Uribe (2004a). ρ and ρ_w are such that in the goods and labor markets monopolistic competition implies a gross markups of 1.2 under flexible prices and nominal wages. The annualized Rotemberg price and wage adjustment costs (ξ_p and ξ_w) are 4.375. Monetary transaction cost parameters A and B are set at 0.011 and 0.075 respectively, and steady state public consumption is 19% of GDP. The fraction of constrained households, θ , is set at 0.5.

⁵Since the analytical derivation of the first order conditions of the Ramsey plan is cumbersome, we compute them using symbolic Matlab routines. The steady state of the Ramsey program is obtained using the OLS approach suggested in Schmitt-Grohé and Uribe (2011). Dynamics of the Ramsey plan around the steady state are computed using Dynare.

⁶In setting the time unit to be a year, we follow the literature. See, e.g., Schmitt-Grohé and Uribe (2004a). Tax rate adjustments require a political process that may take time. As a consequence, it may be difficult to change them at quarterly frequency. We feel one year is a much more realistic time length. No fundamental result of the paper depends on this assumption.

Table 1 reports parameter values:

| Parameters | | Description |
|------------|------------|---|
| β | 0.96 | Discount Factor |
| α | $0.64 - 1$ | Capital Share |
| δ | 0.08 | Depreciation Rate |
| A | 0.011 | Trans. Cost Parameter |
| B | 0.075 | Trans. Cost Parameter |
| ρ | 1/1.2 | Inverse Price Mark-up |
| ρ_w | 1/1.2 | Inverse Wage Mark-up |
| ξ_p | 4.375 | Rotemberg Par. on Prices |
| ξ_w | 4.375 | Rotemberg Par. on Wages |
| θ | 0.5 | Share of constrained households |
| g | 0.19y | Pre-consolidation Public Consumption over GDP |
| b_0 | 0.8y | Pre-consolidation Public Debt/GDP |
| b_T | 0.6y | Post-consolidation Public Debt/GDP |

Table 1: Calibration

Table 2 summarizes our results about steady state outcomes. In particular, we report the pre- and post-consolidation steady state values for the policy variables and for individual consumption and leisure levels.

| | Baseline Model | | Inflation Targeting Model | |
|-----------------------------|----------------|------------|---------------------------|------------|
| | Pre-Cons | Post-Cons. | Pre-Cons | Post-Cons. |
| Tax rate | 33.09% | 32.10% | 33.85% | 32.03% |
| Gross Inflation rate | 1.70 | 1.42 | 1.7 | 1.7 |
| Unconstrained Consumption | 0.2848 | 0.2877 | 0.2813 | 0.2878 |
| Constrained Consumption | 0.1104 | 0.1127 | 0.1087 | 0.1128 |
| Aggregate Consumption | 0.1976 | 0.2002 | 0.1950 | 0.2003 |
| Constrained labour Effort | 0.2051 | 0.2050 | 0.2 | 0.2051 |
| Unconstrained labour Effort | 0.2013 | 0.2064 | 0.2051 | 0.3203 |
| Aggregate labour Effort | 0.2032 | 0.2057 | 0.2026 | 0.2059 |

Table 2: Pre and Post consolidation outcomes

The pre-consolidation inflation rate is 1.7%. Menna and Tirelli (2013) show that LAMP causes an increase in the optimal inflation rate relative to the representative agent (RA) model. This happens because the planner exploits the inflation tax to lower the income tax rate, thus redistributing income from unconstrained to constrained households. We obtain an identical result here: under the RA model pre-consolidation inflation is 0.41%. After consolidation the income tax is reduced by one percentage point and the optimal inflation rate falls to 1.45%. This happens because after the consolidation lower revenues are sufficient to balance the budget and because the consolidation *per se* redistributes incomes towards constrained households and the incentive to exploit inflation as a redistributive tool is therefore reduced.

5 Tax and inflation during the transition. Optimal dynamics vs pure inflation targeting

Figure 1 shows transition dynamics under LAMP and under the representative agent assumption. Consider this latter case first. The Ramsey planner immediately raises taxes by up to 5 percentage points and, to a more limited extent, lowers public expenditures. This tax-expenditure mix is obviously driven by the importance of public goods in households preferences. In addition, the planner chooses a persistent fall in the real interest rate, allowing a substantial increase in inflation, that after 3 years reaches a peak of 2% above the initial steady state. The mix of contractionary fiscal policies, low real interest rates and high inflation is very persistent. After 10 years the tax rate is still above the initial steady state and public spending-to-GDP remains below it. The surge in inflation is slightly less persistent. The tax increase causes a reduction in disposable income but, in spite of the real interest rate fall, the amount of consumption smoothing is limited. In fact consumption falls by more than investment. This is the consequence of the adverse effect of inflation-induced monetary transaction costs, that operate as a sort of consumption tax. Overall the consolidation causes a large and persistent fall in output. Output rises above the pre-consolidation level only after 12 years.

Comparison between the LAMP and the representative agent models shows that very small differences arise both in the use of policy tools and in the dynamics of aggregate variables. However, the two household groups react quite differently to the policy actions. Ricardian households reduce investment as much as in the RA case. This frees resources for their consumption smoothing but, relative to the RA case, such resources now benefit a much smaller number of households. As a result, wealthy Ricardian households stabilize their consumption far more than they would do in absence of constrained households. In addition, they sharply reduce their labor supply relative to the RA case. To the contrary, constrained households raise their labor supply and sharply reduce consumption. Thus, the possibility of depleting their real money holding proves a poor substitute for the physical capital holdings that Ricardian households exploit to stabilize their consumption.

These results suggest that concern for redistribution, which plays an important role in determining steady state outcomes, does not significantly affect the choice of policies during the transition. This outcome is determined by the equal weight that the two household groups have in the planner's objective function. In fact, some important policy changes during the transition are observed when we set $X^R = 0.9$ in 32 holding $\theta = 0.5$ (Figure 2). Both the real interest rate and inflation are now strikingly higher for several years. Relative to the baseline scenario, unconstrained households are induced to drastically reduce their consumption and to increase their labor supply. This outcome persists for several years. As a matter of fact the new policy mix implies transitions for consumption and labor effort that are almost identical for the two households groups.

Figure 3 shows the implications of an alternative strategy of debt reduction, entirely based on tax and public expenditure variations, whereas the Central Bank sticks to a "pure" inflation targeting strategy.⁷

The combination of fiscal contractionary stimuli is much stronger during the first three years. The output contraction is deeper and more persistent, due to the lack of monetary stimulus. To stabilize inflation the Central bank must lower real interest rates well below the baseline model case. After the first two years real interest rates begin to gradually increase. Ricardian households are therefore induced to initially raise their consumption. This outcome is gradually reversed when the

⁷To facilitate the comparison between alternative scenarios we assume that in this case the Central Bank inflation target is 1.7%, as in the pre-consolidation scenario under Ramsey-optimal consolidation policies.

real interest rate begins to rise. Higher income taxes obviously reduce returns from labor. Higher consumption raise their marginal rate of substitution between consumption and leisure. As a result they substantially reduce their labor supply. Pure inflation targeting also bears strong implications for constrained households. in fact, absent the inflation surge that characterizes the optimal policy, their consumption substantially falls relative to the baseline scenario.⁸ Given the choice of lower consumption levels during the transition, their labor supply remains relatively stable. To conclude discussion of this case, note that, relative to the optimal policy, "pure" inflation targeting causes a large and persistent additional output loss.

Finally, Figure 4 allows to analyze a situation where constrained households behave like traditional Rule-of-thumb households, i.e. they do not exploit their money holdings as a buffer to stabilize consumption as in Galì et al. (2007). Transition dynamics for inflation and the fiscal variables are marginally affected. Constrained households now can only rely on their wage-setting decisions to smooth consumption. As a result, in spite of the relative increase in their labor supply, their consumption falls more strongly.

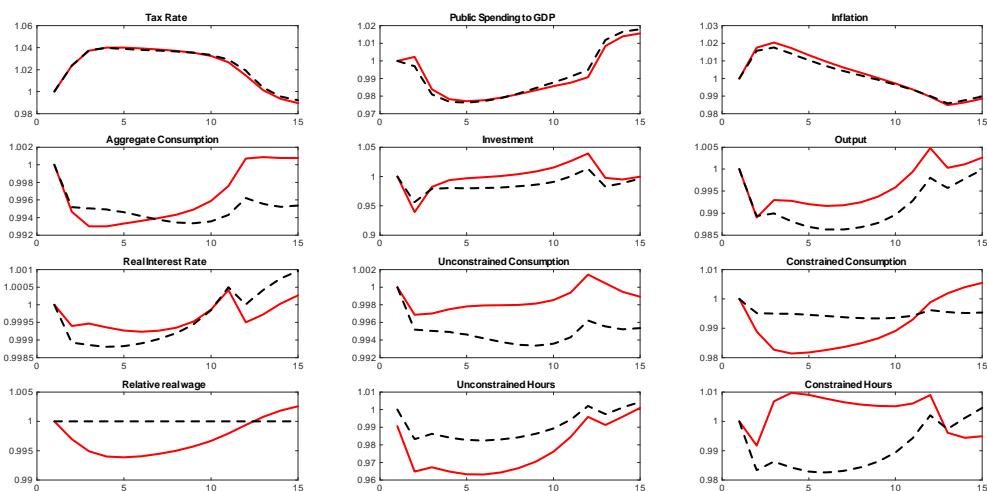


Fig. 1: Lamp baseline model (solid line) versus Representative model (dashed line)

⁸Some intertemporal dynamics do take place even in this case because of dynamics in monetary transaction costs (see eq. 16).

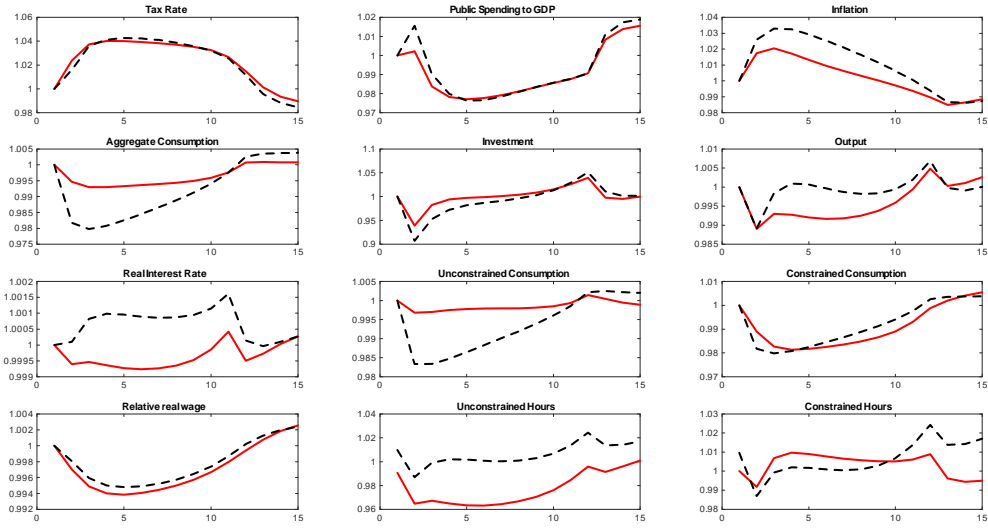


Fig. 2: Lamp baseline model (solid line) vs model with large weight for constrained agents welfare (dashed line)

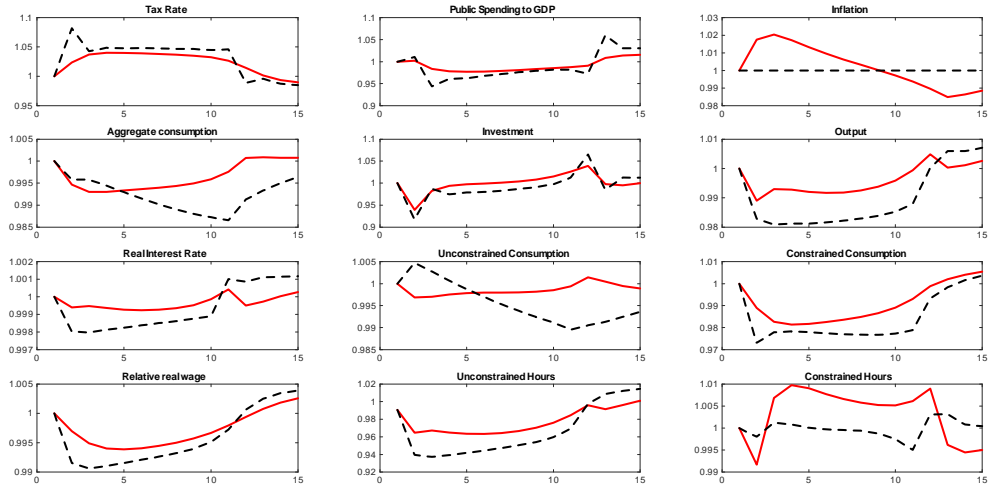


Fig. 3: Lamp Baseline model (solid line) versus Pure Inflation Targeting (dashed line)

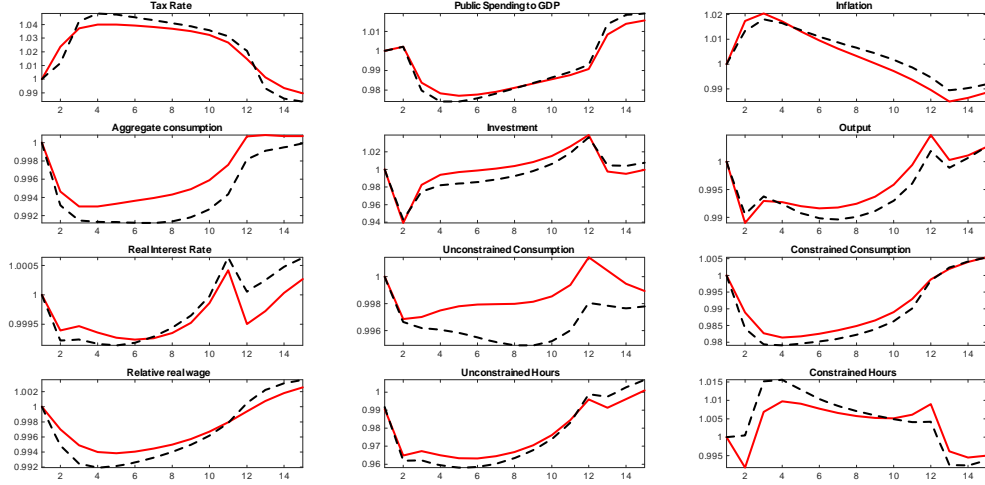


Fig. 4: Rot model (dashed line) versus Lamp Baseline model (solid line)

5.1 Optimal dynamics under a different labor market characterization

Sofar we have assumed that households supply a differentiated labor type and therefore act as wage setters. Other contributions to the LAMP literature typically postulate that households supply the whole labor bundle and wage setting decisions for each labor type j are therefore entrusted to a monopolistic trade union (Galí et al., 2004, 2007; Colciago, 2011; Motta and Tirelli, 2012). At the given wage $w_t(j)$ each household then supplies on demand the labor type j . In this case it is assumed that the two household groups are uniformly distributed across unions, and demand for each labour type is uniformly distributed across households. Households therefore work the same amount of time. Each labor union maximises a weighted average of the lifetime utility of its members subject to their budget constraints:

$$E_0 \sum_{t=0}^{\infty} \beta^t [(1 - \theta) u(c_t^u, l_t) + \theta u(c_t^c, l_t)].$$

In Figure 5 we compare transition dynamic under the two labor market characterizations. Relative to the benchmark case, "unionization" of the wage policy produce a wage rate which is too high for constrained households and too low for Ricardian households. As a result consumption of non-Ricardian household is dramatically reduced throughout the transition, whereas the opposite holds true for unconstrained households. The planner's incentive to inflate is certainly reduced. To rationalize this result bear in mind that consumption of non Ricardian households has been penalized by the union common wage policy, and higher inflation would further tax their consumption, the planner is therefore induced to choose a mix of higher taxes - that mainly fall on Ricardian labor incomes - and (to a lesser extent) greater public expenditures that support labor demand and contained households' incomes and consumption.

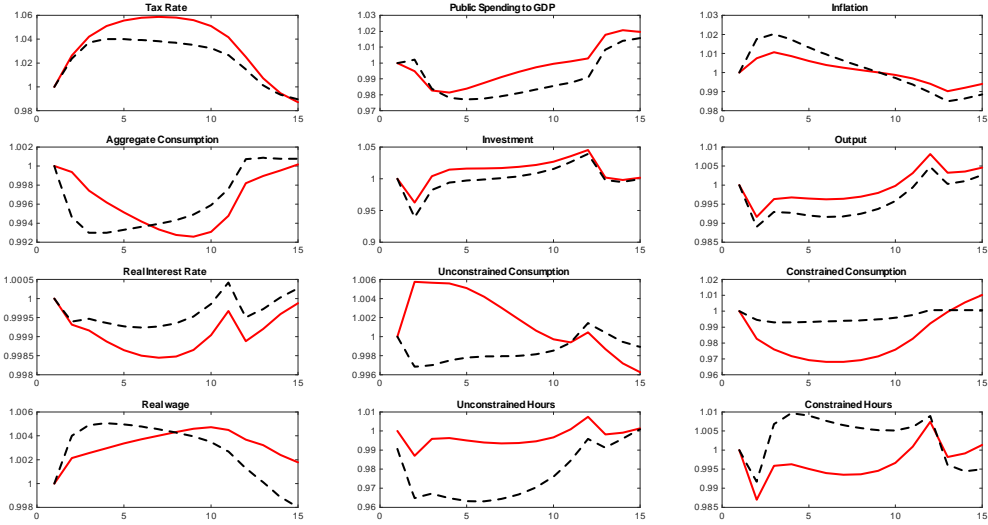


Fig. 5: Heterogeneity (dashed line) versus case homogeneity in the number of working hours (solid line)

6 Conclusions

In this paper we identify the optimal policy mix for income taxes, public expenditures and inflation designed to achieve an exogenous debt reduction path. The optimal policy envisages persistent reductions in public consumption and increases in taxes and inflation. A persistent fall in consumption and investment cannot be avoided, and households that cannot exploit financial markets to smooth their consumption bear the brunt of adjustment costs.

One key message is that an integrated package of fiscal and monetary policies may prove quite beneficial relative to a situation where the Central Bank is only concerned with inflation stability and the inflation target is defined as a ceiling, as in the Eurozone, where the ECB has repeatedly justified expansionary monetary policies on the grounds that inflation was below target. In fact the fiscal consolidation would require far more aggressive monetary policies, accepting that inflation overshoots the target for a prolonged period. As a matter of fact our results emphasize important shortcomings in the EMU system of economic governance, which utterly neglects the desirability of coordinated fiscal and monetary policy actions. In this context such coordination would entail a great deal of flexibility in the inflation target choice, based on the explicit recognition that accommodative monetary policies provide an essential contribution to limit the undesirable effects of fiscal consolidations.

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The Optimal Policy Mix to Achieve Public Debt Consolidation by Patrizio Tirelli and Roberta Cardani
Reply to the referee report

In the paper Ricardian and non-Ricardian households are allowed to supply different amounts of work in response to the consolidation plan, so Ricardians reduce worked hours and non-Ricardians do the opposite. This is in sharp contrast with previous contributions where it is assumed that in unionized labor markets all households supply the same amount of work at the given wage, set by the trade union (Gali 2007, Colciago 2011, Motta and Tirelli 2012). The innovation in the paper is certainly welcome, but it would be also interesting to learn what would happen under more standard assumption about the unionized labor market.

Our reply. We discuss the issue in a specific section of the paper

The implications of the work for the EU architecture are important, especially in term of fiscal and monetary coordination, they can be the object of a specific policy (less technical) paper.

Our reply. The issue is also discussed in less technical terms in other deliverables, i.e. executive briefs and in the green book.

As minor point, the authors should read the paper very carefully as there is an unusually large amount of typos!

Our reply. We did it.