The comeback of inflation as an optimal public finance tool

Giovanni Di Bartolomeo, Nicola Acocella and Patrizio Tirelli

Department of Communication Working Paper Series.

The Department of Communication Working Paper Series is devoted to disseminate works-in-progress reflecting the broad range of research activities of our department members or scholars contributing to them. It is aimed at multi-disciplinary topics of humanities, science and social science and is directed towards an audience that includes practitioners, policymakers, scholars, and students. The series aspires to contribute to the body of substantive and methodological knowledge concerning the above issues. Since much of the research is ongoing, the authors welcome comments from readers; we thus welcome feedback from readers and encourage them to convey comments and criticisms directly to the authors.

The comeback of inflation as an optimal public finance tool[*]

Giovanni Di Bartolomeo
giovanni.dibartolomeo@uniroma1.it
Sapienza University of Rome

Nicola Acocella
Sapienza University of Rome

Patrizio Tirelli
University of Milan Bicocca

April, 2013

Abstract

We challenge the widely held belief that New-Keynesian models cannot predict optimal positive inflation rates. In fact these are justified by the Phelps argument that monetary financing can alleviate the burden of distortionary taxation. We obtain this result because, in contrast with previous contributions, our model accounts for public transfers as a component of fiscal outlays. We also contradict the view that the Ramsey policy should minimize inflation volatility and induce near-random walk dynamics of public debt in the long-run. In our model it should instead stabilize debt-to-GDP ratios in order to mitigate steady-state distortions. Our results thus provide theoretical support to policy-oriented analyses which call for a reversal of debt accumulated in the aftermath of the 2008 financial crisis.

Jel codes: E52, E58, J51, E24.
Keywords: trend inflation, monetary and fiscal policy, Ramsey plan.

1 Introduction

Optimal monetary policy analyses (Khan *et al.*, 2003; Schmitt-Grohé and Uribe, SGU henceforth, 2004a) identify two-key frictions driving the optimal level of long-run (or trend) inflation. The first one is the adjustment cost of goods prices, which invariably drives the optimal inflation rate to zero. The second one are monetary transaction costs that arise unless the central bank implements the

Friedman rule, i.e. a negative steady-state inflation rate as long as the steady-state real interest rate is positive. In their survey of the literature, SGU (2011) argue that the optimality of zero inflation is robust to other frictions, such as nominal wage adjustment costs, downward wage rigidity, hedonic prices, the existence of an untaxed informal sector, the zero bound on the nominal interest rate. This latter result is broadly confirmed by Coibion *et al.* (2012), who find that the optimal inflation rate is low, typically less than two percent, even when the economy is hit by costly but infrequent episodes at the zero-lower bound. A consensus therefore seems to exist that monetary transactions costs are relatively small at zero inflation, and that implementing low and stable inflation is the proper policy.

This theoretical result is in sharp contrast with empirical evidence. For instance, both in the US and in the Euro area, average inflation rates over the 1970-1999 period have been close to 5%. Even the widespread central bank practice of adopting inflation targets between 2% and 4% is apparently at odds with theories of the optimal inflation rate (SGU, 2011).

Furthermore, following the build up of large stocks of debt in the aftermath of the 2007-2008 financial crisis, some economists have argued that the public debt surge should be reversed and that a temporary increase in inflation might be necessary to achieve this goal. For instance Rogoff (2010) suggests that "two or three years of slightly elevated inflation strikes me as the best of many very bad options." Blanchard *et al.* (2010) point at the potential role of the inflation tax as one among several distortionary taxes which are available to policymakers. Aizenman and Marion (2009) predict that a 6% inflation rate would reduce the debt/GDP ratio by 20 percent within 4 years. These contributions are in line with the well known Phelps (1973) argument that to alleviate the burden of distortionary taxation it might be optimal for governments to resort to monetary financing, driving a wedge between the private and the social cost of money.

The Phelps argument has been widely investigated in the framework of general equilibrium models, and never found sufficient to warrant the optimality of a significantly positive inflation rate. The first result obtained in this literature is that, in a world of flexible prices, distortionary taxation does not warrant deviations from the Friedman rule unless factor incomes are suboptimally taxed (see SGU 2011 and references cited therein). The underlying intuition is that since all resources are eventually used for consumption, then the inflation tax, which affects consumption transaction costs, is desirable only to the extent that other taxes have a suboptimal effect on consumption. The second important result is that when the goods market characterization is modified to account for (suboptimally taxed) monopolistic distortions and nominal rigidities, numerical simulations suggest that the optimal inflation rate lies between the Friedman rule and zero even accounting for the Phelps' effect (SGU 2004a). This conclusion carries over to the optimality of near-zero volatility of inflation and near random walk behavior in government debt and tax rates in response to shocks, implying that the recent increase of public debt in developed economies should be regarded as a tax smoothing device in response to the financial crisis.

Our paper reconsiders the importance of the Phelps' effect and obtains results that challenge previous theoretical results. We show that a non-negligible inflation rate might indeed be optimal and that inflation (and tax rates) volatility should be exploited in order to stabilize debt/GDP ratios in the long run.

The starting point in our analysis is that the optimal zero inflation result ob-

tained in dynamic stochastic general equilibrium (DSGE) models with nominal rigidities depends on the incentives of raising revenues from inflation or the labor income tax, but such incentives depend on both size and composition of public expenditure. In the literature, standard calibrations of public expenditures focus on public consumption-to-GDP ratios, typically set at 20% (SGU, 2004a; Aruoba and Schorfeide, 2011). This follows a long-standing tradition in business cycle models, where only public consumption decisions have real effects. In our framework this choice is not correct, because the focus here is on distortionary financing of public expenditures in steady state, where also other components of public expenditure matter. As a matter of fact, public consumption accounts for a limited component of the overall public expenditures in OECD countries (Table 1).

Table 1 – Government expenditures and revenues (1998-2008)*

	(1)	(2)	(3)		(1)	(2)	(3)
Australia	18,00	16,97	36,26	Japan	17,07	21,28	31,81
Austria	19,10	32,29	49,71	Netherlands	23,57	22,19	45,34
Belgium	22,13	27,82	49,39	New Zealand	17,97	20,89	42,01
Canada	19,49	21,56	42,08	Norway	20,76	23,54	56,63
Czech Republic	21,24	22,81	40,12	Poland	17,95	25,34	39,20
Denmark	25,84	27,88	55,96	Portugal	19,57	25,48	41,59
Finland	21,75	27,74	53,12	Slovak Republic	20,24	21,35	36,55
France	23,39	29,21	49,90	Spain	17,75	21,52	38,67
Germany	18,96	27,58	44,61	Sweden	26,67	29,03	57,21
Greece	16,52	28,32	40,19	Switzerland	11,4	23,48	34,40
Hungary	21,98	27,42	43,20	United Kingdom	19,83	22,28	40,38
Ireland	15,11	19,40	44,16	United States	15,26	20,51	33,47
Italy	19,10	28,94	45,25	Euro area	20,17	27,11	45,39

(1) public consumption; (2) other public expenditures; (3) total revenues
* avearge ratios to GDP – Source OECD

Even if a proportion of total expenditures goes into production subsidies, it is apparent that distortionary taxation substantially exceeds public consumption, in order to finance redistributive policies. For instance in the US, according to the National Accounts (NIPA) data, in the 1998-2008 period government transfer payments and government purchases respectively were close to 12% and 15% of GDP. Oh and Reis (2011) document that between 2008 and 2009 three quarters of the US huge fiscal stimulus in response to the financial crisis were due to increases in transfers.

We show that just allowing for a plausible parameterization of public transfers to households in the SGU (2004a) model reverses their conclusion about the optimal inflation rate, which now monotonically increases from 2% to 12% as the transfers-to-GDP ratio goes from 10% to 20%. We also find that an identical increase in the public-consumption-to-GDP ratio would have a negligible impact on the optimal inflation rate. So, what is special about public transfers? The answer to this question is that permanent changes in public consumption and

transfers differently affect in steady state the planner's ability to raise revenues through inflation. In fact, for any given level of the tax and inflation rates, an increase in public consumption causes a fall in private consumption and in real money balances, eroding the inflation tax base. By contrast, a coeteris paribus increase in public transfers has no effect on public consumption and real money balances. As a result incentives to choose inflation and the tax rate depend on the ability of raising revenues through the two instruments and on the distortions imposed on the economy. Taking into account that both policy tools are associated to Laffer curves, this explains why the optimal financing mix gradually shifts towards stronger reliance on inflation when transfers become relatively large.

We also investigate the optimal fiscal and monetary policy responses to shocks. The issue is admittedly not new, but we are able to provide new contributions to the literature. When prices are flexible and governments issue non-contingent nominal debt (Chari *et al.*, 1991), it is optimal to use inflation as a lump-sum tax on nominal wealth, and the highly volatile inflation rate allows to smooth taxes over the business cycle. This result is intuitive in so far as taxes are distortionary whereas inflation volatility is costless. SGU (2004a) show that when price adjustment is costly optimal inflation volatility is in fact minimal and long-run debt adjustment allows to obtain tax-smoothing over the business cycle. In our paper the SGU result is reversed even when the amount of public transfers is relatively small (12% of GDP). In this case tax and inflation volatility are exploited to limit debt adjustment in the long run.

The interpretation of this result is simple. As discussed above, public transfers increase the tax burden in steady state. In this case, the accumulation of debt in the face of an adverse shock – which would work as a tax smoothing device in SGU (2004a) – is less desirable, because it would further increase long-run distortions. To avoid such distortions, the policymaker is induced to front-load fiscal adjustment, and to inflate away part of the real value of outstanding nominal debt. Consumption smoothing is therefore reduced relative to SGU (2004a)

To the best of our knowledge this is the first study of the optimal interaction between inflation and tax policies when transfers account for the relatively large proportion of public expenditures that is documented in the data. A number of recent papers have analyzed the macroeconomic implications of public transfer schemes, but their focus is different from ours. Alonso-Ortiz and Rogerson (2010) investigate the labour supply response and the welfare implications of an optimal public transfer scheme in the context of a model with idiosyncratic productivity shocks, incomplete financial markets and flexible prices. Oh and Reis (2011) analyze the role of transfers for consumption stabilization in the context of heterogeneous agents, incomplete markets and sticky prices – when taxes are lump-sum, no public debt accumulation is allowed and the central bank is constrained to implement a zero-inflation policy. Angelopoulos *et al.* (2007) maintain the representative agent hypothesis and incorporate an uncoordinated redistributive struggle for transfers into an otherwise standard DSGE model. Zubairy (2010) investigates the consequences of temporary public transfer shocks in an estimated representative agent DSGE model.

The remainder of the paper is organized as follows. The next section describes the model. Section 3 introduces the Ramsey policy and illustrates our main results. Section 4 discusses optimal monetary and fiscal stabilization poli-

cies. Section 5 concludes.

2 The model

We consider a simple infinite-horizon production economy populated by a continuum of households and firms whose total measures are normalized to one. Monopolistic competition and nominal rigidities characterize product markets. The labor market is competitive. A demand for money is motivated by assuming that money facilitates transactions. The government finances an exogenous stream of expenditures by levying distortionary labor income taxes and by printing money. Optimal policy is set according to a Ramsey plan. Right from the outset, it should be noted that the focus here is on the identification of the optimal financing mix for exogenous levels of public expenditures, including both consumption and transfers.

2.1 Households

The representative household (i) maximizes the following utility function

$$U = E_{t=0} \sum_{t=0}^{\infty} \beta^t u\left(c_{t,i}, l_{t,i}\right); \quad u\left(c_{t,i}, l_{t,i}\right) = \ln c_{t,i} + \eta \ln\left(1 - l_{t,i}\right) \tag{1}$$

where $\beta \in (0,1)$ is the intertemporal discount rate, $c_{t,i} = \left(\int_0^1 c_{t,i}(j)^\rho dj\right)^{\frac{1}{\rho}}$ is a consumption bundle, $l_{t,i}$ denotes the individual labor supply. The consumption price index is $P_t = \left(\int_0^1 p_t(i)^{\frac{\rho}{\rho-1}} di\right)^{\frac{\rho-1}{\rho}}$.

The flow budget constraint in period t is given by

$$c_{t,i}\left(1 + s_{t,i}\right) + \frac{M_{t,i}}{P_t} + \frac{B_{t,i}}{P_t} = \left(1 - \tau_t\right) w_{t,i} l_{t,i} + \frac{M_{t-1,i}}{P_t} + \theta_t + \frac{T_t}{P_t} + \frac{R_{t-1} B_{t-1,i}}{P_t} \tag{2}$$

where $w_{t,i}$ is the real wage; τ_t is the labor income tax rate; T_t denotes fiscal transfers; θ_t are firms profits; R_t is the gross nominal interest rate, $B_{t,i}$ is a nominally riskless bond that pays one unit of currency in period $t+1$. $M_{t,i}$ defines nominal money holdings to be used in period $t+1$ in order to facilitate consumption purchases.

Consumption purchases are subject to a transaction cost[1]

$$s(v_{t,i}), \quad s'(v_{t,i}) > 0 \tag{3}$$

where $v_{t,i} = \frac{P_{t,i} c_{t,i}}{M_{t,i}}$ is the household's consumption-based money velocity. The features of $s(v_{t,i})$ are such that a satiation level of money velocity ($v^* > 0$) exists where the transaction cost vanishes and, simultaneously, a finite demand for money is associated to a zero nominal interest rate. Following SGU (2004a)

---

[1] See Sims (1994), SGU (2004a, 2011), Guerron-Quintana (2009), Altig *et al.* (2011).

the transaction cost is parameterized as[2]

$$s(v_{t,i}) = Av_{t,i} + \frac{B}{v_{t,i}} - 2\sqrt{AB} \tag{4}$$

The first-order conditions of the household's maximization problem are:[3]

$$c_t(j) = c_t \left(\frac{p_t(j)}{P_t} \right)^{\frac{1}{\rho-1}} \tag{5}$$

$$\lambda_t = \frac{u_c(c_t, l_t)}{1 + s(v_t) + v_t s'(v_t)} \tag{6}$$

$$\lambda_t = \beta E_t \left(\frac{\lambda_{t+1} R_t}{\pi_{t+1}} \right) \tag{7}$$

$$w_t = -\Omega_t \frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} \tag{8}$$

$$\frac{R_t - 1}{R_t} = s'(v_t) v_t^2 \tag{9}$$

Equation (5) is the demand for the good j. As in SGU (2004a) condition (6) states that the transaction cost introduces a wedge between the marginal utility of consumption and the marginal utility of wealth that vanishes only if $v = v^*$. Equation (7) is a standard Euler condition where $\pi_{t+1} = P_{t+1}/P_t$ denotes the gross inflation rate. Equation (8) defines the individual labor supply condition and $\Omega_t = \frac{1+s(v_t)+v_t s'(v_t)}{1-\tau_t}$ denotes the policy wedge, which depends on both tax and inflation decisions. Finally, equation (9) implicitly defines the money demand function, such that

$$\frac{M_t}{P_t} = \left(\frac{R_t - 1}{R_t A} + \frac{B}{A} \right)^{-\frac{1}{2}} c_t \tag{10}$$

2.2 Firms' pricing decisions

Each firm (j) produces a differentiated good using the production function:[4]

$$y_t(j) = z_t l_{t,j}, \tag{11}$$

where z_t denotes a productivity shock.[5]

---

[2] Our results are robust to the alternative specification for the transaction cost used by Brock (1989) and Kimbrough (2006), which implies a Cagan (1956) money demand function. A proof is available upon request. The model is also compatible with Baumol (1952) demand for money (see SGU, 2004a).

[3] When solving its optimization problem, the household takes as given goods and bond prices. As usual, we also assume that the household is subject to a solvency constraint that prevents him from engaging in Ponzi schemes.

[4] We abstract from capital accumulation and assume constant returns to scale of employed labor. The consequences of these two assumptions are discussed in SGU (2006) and SGU (2011) respectively. Our results are not affected by the introduction of diminishing returns to scale for labor (simulation results available upon request).

[5] We assume that $\ln z_t$ follows an $AR(1)$ process.

We assume a sticky price specification based on Rotemberg (1982) quadratic cost of nominal price adjustment:

$$\frac{\xi_p}{2} y_t \left(\pi_t - 1\right)^2 \tag{12}$$

where $\xi_p > 0$ is a measure of price stickiness. In line with Ascari *et al.* (2011), we assume that the re-optimization cost is proportional to output.[6]

In a symmetrical equilibrium the price adjustment rule satisfies:

$$\frac{z_t \left(\rho - mc_t\right)}{1 - \rho} + \xi_p \pi_t \left(\pi_t - 1\right) = E_t \beta \frac{y_{t+1} \lambda_{t+1}}{y_t \lambda_t} \xi_p \left[\pi_{t+1} \left(\pi_{t+1} - 1\right)\right] \tag{13}$$

where

$$mc_t = \frac{1}{z_t} w_t$$

From (5) it would be straightforward to show that $\frac{1}{\rho} = \mu^p$ defines the price markup that obtains under flexible prices.

2.3 Government budget and aggregate resource constraints

The government supplies an exogenous, stochastic and unproductive amount of public good G_t and implements exogenous transfers T_t. Government financing is obtained through a labor-income tax, money creation and issuance of one-period, nominally risk free bonds. The government's flow budget constraint is then given by[7]

$$R_{t-1} \frac{B_{t-1}}{P_t} + G_t + T_t = \tau_t w_t l_t + \frac{M_t - M_{t-1}}{P_t} + \frac{B_t}{P_t} \tag{14}$$

The aggregate resource constraint closes the model:

$$y_t = c_t \left(1 + s_t\right) + G_t + \frac{\xi_p}{2} y_t \left(\pi_t - 1\right)^2 \tag{15}$$

3 Ramsey policy

The Ramsey policy is a set of plans $\{C_t, l_t, \lambda_t, mc_t, \pi_t, v_t, R_t, \tau_t\}_{t=0}^{+\infty}$ that maximizes the expected value of (1) subject to the competitive equilibrium conditions (i.e., (6), (7), (8), (10), (13), (14), (15)) and the exogenous stochastic process driving the fiscal and technology shocks. Solution requires numerical simulations.[8] The time unit is meant to be a year; we set the subjective discount rate β to 0.96 to be consistent with a steady-state real rate of return of 4 percent per year; following SGU, transaction cost parameters A and B are set at 0.011 and 0.075, the debt-to-GDP ratio (B/Y) is set at 0.44 percent, in the goods market monopolistic competition implies a gross markup of 1.2, and the annualized Rotemberg price adjustment cost is 4.375 (this implies that firms change

---

[6] Our results are independent of this assumption A proof is available upon request.

[7] As in SGU (2004a), $\ln g_t$, $g_t = G_t/Y_t$, is assumed to evolve exogenously following an independent $AR(1)$ process. We assume instead that the level of the real transfer is non stochastic.

[8] These are obtained implementing SGU (2004b) second order appoximation routines.

their price on average every 9 months, see SGU, 2004a: 210). The preference parameter η is set so that in the flexible-price steady state households allocate 20 percent of their time to work.[9]

In Figure 1 we describe the optimal inflation response in steady state to the transfer increase and to a corresponding variation in public consumption beyond the values assumed in SGU (2004a) calibrations. Simulations show that steady state inflation rapidly increases when T/Y grows beyond the 8% threshold. For instance, the optimal inflation rate is close to 3% when T/Y is 10%, and exceeds 13% when the transfer ratio is 20%. Simulations also show that in the case where public expenditure is confined to public consumption, optimal inflation would exceed 5% only for $G/Y > 35\%$.
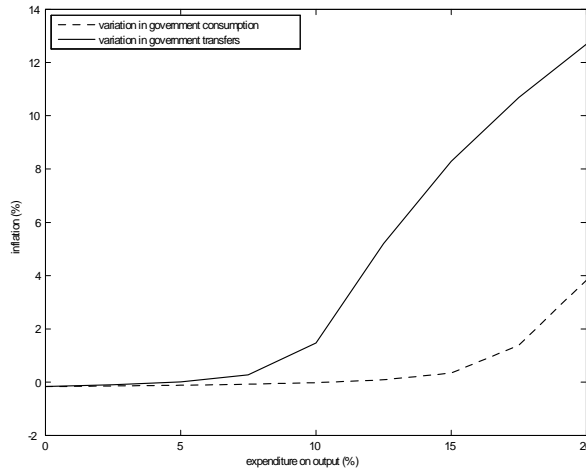

Figure 1 – Public expenditure and optimal inflation: Variation in public expenditure in addition to the 20% benchmark value for government consumption.

The same pattern obtains when we replicate the same exercise assuming flexible prices but the absence of price adjustment costs induces the policymaker to choose higher inflation rates.[10]

To understand these results it is necessary to analyze how, for given levels of π and τ, permanent changes in public expenditures differently affect in steady state the planner's ability to raise revenues either through the labor-income tax, $\tau\left(\frac{W}{P}l\right)$, or through inflation

$$(\pi - 1)\left(\frac{M}{P}\right) = (\pi - 1)\left(\frac{R-1}{RA} + \frac{B}{A}\right)^{-\frac{1}{2}} c \qquad (16)$$

_____

[9] This is computed in the flexible price equilibrium, when the public consumption-to-GDP (G/Y) ratio is 0.20 and public transfers are nil $(T/Y = 0)$. For the sake of comparision, we calibrate our model as SGU (2004a).

[10] Results available upon request.

where $R = \frac{\pi}{\beta}$. From (7), (8), (15), it is straightforward to show that

$$c = \frac{\left(1 - \frac{\xi_p}{2}(\pi - 1)^2\right) - G}{(1 + s) + \Omega \frac{\eta}{w}\left(1 - \frac{\xi_p}{2}(\pi - 1)^2\right)} > 0 \tag{17}$$

and

$$l = 1 - \frac{\Omega \eta}{w}c \tag{18}$$

where $w = \rho + \xi_p \pi (\pi - 1)(1 - \beta)(1 - \rho)$. Thus an increase in public consumption is associated to a fall in private consumption and to an increase in the labor supply. The reduction in private consumption is associated to a fall in real money holdings, that is, to a reduction in the inflation tax base. By contrast, revenues from the labor income tax increase due to the labor supply expansion. In fact the elasticities of inflation and labor tax revenues with respect to G, η_π^G and η_τ^G,

$$\eta_\pi^G = -\frac{G}{\left(1 - \frac{\xi_p}{2}(\pi - 1)^2\right) - G} \tag{19}$$

$$\eta_\tau^G = \left[(1 + s) + \frac{\eta \Omega}{w}\left(1 - \frac{\xi_p}{2}(\pi - 1)^2\right)\right]^{-1} \frac{\Omega \eta G}{wl} \tag{20}$$

respectively fall and increase in G. Thus it not surprising that an increase in public consumption is not associated to an increase in inflation.

The above result carries over to a different specification of the utility function, such as the Greenwood-Hercowitz-Huffman (1988) (GHH, henceforth) preferences

$$_{GHH}u(C_{t,i}, l_{t,i}) = \frac{\left(C_{t,i} - \eta l_{t,i}^{1+\phi}\right)^{1-\sigma}}{1 - \sigma} \tag{21}$$

In this case the marginal rate of substitution $-\frac{u_l(c_t,l_t)}{u_c(c_t,l_t)} = \eta l_{t,i}^\phi$ is independent of consumption, i.e. there is no wealth effect on the labour supply, and labor market equilibrium condition in steady state is $\eta l_{t,i}^\phi = w$. It follows that $_{GHH}\eta_\tau^G = 0$, because $\partial l_t/\partial G_t = 0$. For the same reason, however, under (21) the increase in public consumption is associated to a larger fall in consumption and real money holdings than under (1). As a result we obtain that $_{GHH}\eta_\pi^G = -\frac{G}{l\left(1 - \frac{\xi_p}{2}(\pi-1)^2\right) - G} < \eta_\pi^G$. Simulations confirm that under GHH preferences an increase in public consumption is met by an expansion in the labor tax whereas inflation remains very close to zero.[11]

The different inflation response to an increase in public transfers is now more easily understood. In fact in this case $\eta_\pi^T = \eta_\tau^T = 0$. As a result incentives to choose inflation and the labor income tax depend on the ability of raising revenues and on the distortions imposed on the economy. Note that both policy tools are associated to Laffer curves. In addition inflation has a distortionary effect on monetary transactions and imposes a price adjustment cost on firms.

It is interesting to compare our interpretation of the inflationary outcome generated by the need to finance transfers with the one offered by SGU (2006:

---

[11] Results available upon request.

385). In fact, they claim that when the private sector must receive an exogenous amount of (after-tax) transfers, it is optimal to exploit the inflation tax on money balances in order to impose an indirect levy on the (transfers-determined) source of household income. In our view this claim is not correct. In fact, the incentive to choose a positive inflation rate arises because taxes are distortionary and, as shown above, financing transfers by means of inflation is profoundly different from financing an equivalent amount of public consumption. Thus the Ramsey planner chooses a positive inflation rate in order to limit output distortions and consumption losses. In Figure 2 below we show the consumption responses to different transfer ratios when inflation is zero and when it is chosen optimally. Our interpretation of the reason why a sufficiently large amount of transfers calls for a positive inflation differs from the one presented in SGU (2006: 397), and is a novel contribution of the paper.
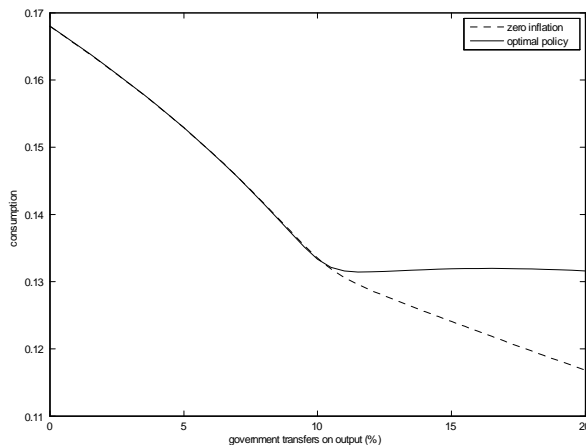

Figure 2 – Public transfers, policy wedges and consumption.

As discussed by SGU (2011), positive inflation may be a desirable instrument if some part of income is suboptimally taxed. [12] In our framework this implies that the choice of inflating the economy depends on monopolistic distortions in the goods market. In fact, when $\mu^p = 1.1$ optimal inflation remains close to zero for $T/Y \leq 15\%$ (Figure 3).

---

[12] Thus, in the narrow framework of our model the introduction of a uniform income tax would greatly reduce the incentive to inflate. However, the tax system might be incomplete or suboptimal for other reasons. For instance, one might take into account the existence of an informal sector of the economy. Further, if one introduces monopolistic competition in the labor market, with a wage markup of 1.1, optimal inflation increases by about 1% in spite of the labor income tax.
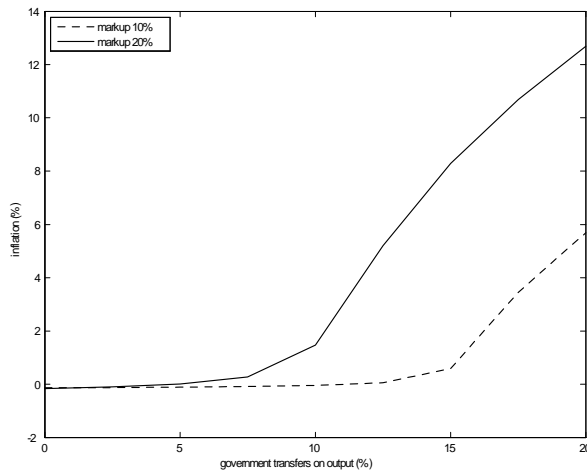
Figure 3 – The effects of different price markups.

4 Optimal monetary and fiscal stabilization policies

In this section we investigate whether our characterization of steady-state public expenditures also bears implications for the conduct of macroeconomic policies over the business cycle. SGU (2004a) show that, when public transfers are nil, costly price adjustment induces the Ramsey planner to choose a minimal amount of inflation volatility and to select a permanent public debt response to shocks in order to smooth taxes over the business cycle. Benigno and Woodford (2004), who emphasize the complementarity between fiscal and monetary policies, substantially confirm the optimality of near-zero inflation volatility for a plausible amount of nominal price stickiness.

We discuss how the optimal fiscal and monetary stabilization policies[13] change when in steady state T/Y is 0.12 instead of zero, other fiscal figures are assumed to be $G/Y = 0.17$[14] and $B/Y = 0.44$.[15] In Table 2 we show that in this latter case the volatility of both taxes and inflation dramatically increases whereas the strong persistence of taxes vanishes.[16] Thus, even if we still obtain a unit root in the dynamic process for debt accumulation, a more

---

[13]We consider a productivity and a public consumption shock. Properties of stochastic processes are described in Table 2. We compute the second-order approximation using SGU (2004b) routines (See also SGU 2004a: Section 7).

[14]SGU (2004a) calibrate $G/Y = 0.2$. This does not affect our results. Note that our assumption about G/Y is more adverse in supporting any Phelps' effect.

[15]Our calibration is consistent with US data. Averages are obtained considering the period 1990-2012, but they are rather stable (see also Klein *et al.*, 2005). Later we will explore the effects of larger real debts, in line with the increase observed in the aftermath of the financial crisis, and different assumptions about public consumption expenditure.

[16]To sharpen the analysis we assume the shock is not serially correlated.

realistic calibration of fiscal outlays has important implications for the dynamic pattern of fiscal and monetary stabilization policies. To grasp intuition consider the impulse response functions to a 3% (one standard deviation) increase in government purchases (Figure 4). Under both scenarios the permanent debt adjustment allows to smooth tax distortions. However, the different magnitudes of the permanent debt and tax adjustments associated to the two cases ($T/Y = 0$ and $T/Y = 0.12$) are also evident. When $T/Y = 0.12$, the long-run debt adjustment is reduced by 75%. In this case long-run tax and inflation distortions are already relatively large, and the accumulation of debt in the face of an adverse shock becomes less desirable. Instead, the planner finds it optimal to front-load tax adjustment and to inflate away part of the real value of outstanding nominal debt.[17] In addition, the increase in inflation positively impacts on seigniorage revenues. This explains the surge in inflation volatility reported in Table 2. Our model is also able to match the positive empirical correlation between average inflation and inflation variability.[18]

Table 2[19]– Dynamic properties of the Ramsey allocation (2nd or. approx.)

	mean	st. dev.	auto. corr.	corr(x,y)	corr(x,g)	corr(x,z)
$T/Y = 0$, $G/Y = 0.17$						
τ	21,48	0,898	0,810	-0,257	0,455	-0,190
π	-0,18	0,126	0,036	-0,113	0,364	-0,247
R	3,77	0,571	0,859	-0,961	-0,056	-0,976
y	0,21	0,007	0,813	1,000	0,189	0,960
h	0,21	0,002	0,820	-0,132	0,558	-0,388
c	0,18	0,007	0,814	0,958	-0,086	0,967
$T/Y = 0.12$, $G/Y = 0.17$						
τ	42,16	2,904	-0,071	-0,141	0,251	-0,362
π	1,71	0,921	-0,070	-0,080	0,270	-0,296
R	5,76	0,485	0,747	-0,796	0,144	-0,910
y	0,17	0,005	0,827	1,000	0,364	0,905
h	0,17	0,003	0,696	-0,316	0,664	-0,679
c	0,14	0,005	0,774	0,876	-0,085	0,986

---

[17] For the sake of fairness, it is worth noticing that inflation volatility still appears to be substantially limited relative to the case of flexible prices, which is the main point of SGU (2004a). Our contribution here is that a substantial complementarity exists between inflation and taxes in response to the public consumption shock.

[18] See, e.g., Friedman (1977), Ball and Cecchetti (1990), Caporale and McKiernan (1997).

[19] We consider a productivity and a public consumption shock. In the paper the $AR(1)$ processes driving the government spending and the technology shock are calibrated as in SGU (2004a), The serial correlation of $\ln g_t$ is set at 0.9 and the standard deviation of innovation to $\ln g_t$ is 0.0302; the serial correlation of $\ln z_t$ is 0.82 and the standard deviation of innovation is 0.0229.
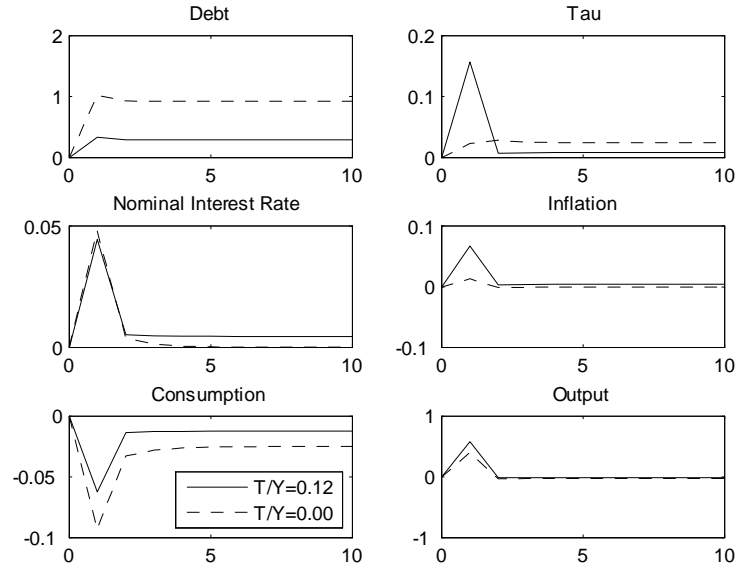
Figure 4 – Fiscal shock IRF under different levels of public transfers. Impulse response to an i.i.d. government purchases shock. Note: The size of the innovation in government purchases is one standard deviation (a 3% increase in g). The shock takes place in period 1. Public debt, consumption, and output are measured in percent deviations from their pre-shock levels. The tax rate, the nominal interest rate, and the inflation rate are measured in percentage points.

In Figure 5 we present the IRFs obtained when total government outlays in steady state are as high as in the case discussed in Figure 4 (29% of GDP), but $T/Y = 0$. This allows to disentangle the composition and level effects of steady state fiscal outlays. It is easy to see that when $T/Y = 0$ debt accumulation is much increased, the short run inflation response is close to the SGU case, and the short-run tax response is definitely milder. Bearing in mind that steady state inflation is -0.5% when $T/Y = 0$ and about 2% when $T/Y = 0.12$, one might argue that the smaller steady-state proceedings from the inflation tax when $G/Y = 0.29$ induce the Ramsey planner to choose a steady state characterized by a relatively large debt accumulation and a higher tax rate.
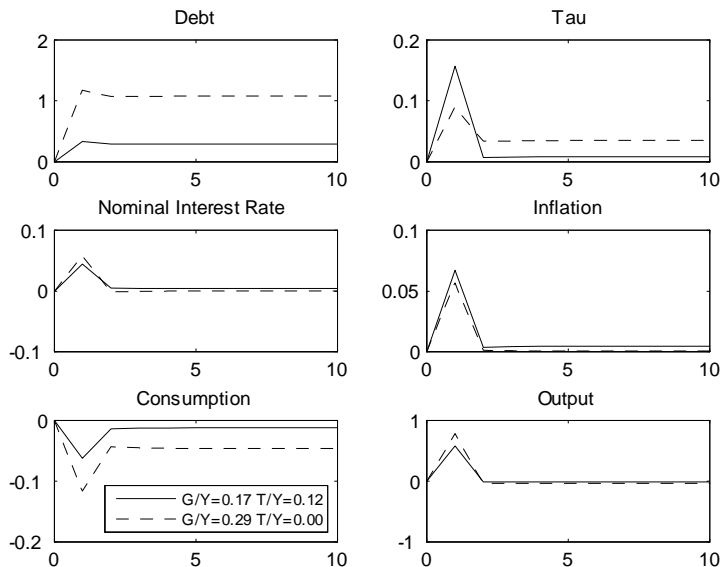
Figure 5 – Fiscal shock IRF under different public expenditure composition.

To further assess the robustness of our results we consider the impulse response functions at different steady state values of public debt when $G/Y = 0.17, T/Y = 0.12$ (Figure 6). It is easy to see that different debt-to-GDP ratios do not affect the adjustment paths of consumption and output, but the long run accumulation of debt is much limited when debt is already relatively large ($B/Y = 0.64$). This happens because the debt deflating effect of the initial increase in inflation is by far more powerful than when $B/Y = 0.44$. Finally, in Figure 7 we present the IRFs when monetary transaction costs are virtually nil. In this case front-loading adjustment is preferable, and the accumulation of public debt in the long run is greatly reduced. Relative to the benchmark case presented in Figure 4, we now observe a stronger reliance on surprise inflation as a tool to reduce debt service payment. In addition, the policy wedge Ω_t in (8) is lower for any given inflation rate, providing leeway for the stronger tax increase that we observe in Figure 8. Finally, the immediate consumption fall is now milder because inflation no longer drives a wedge between wealth and consumption.
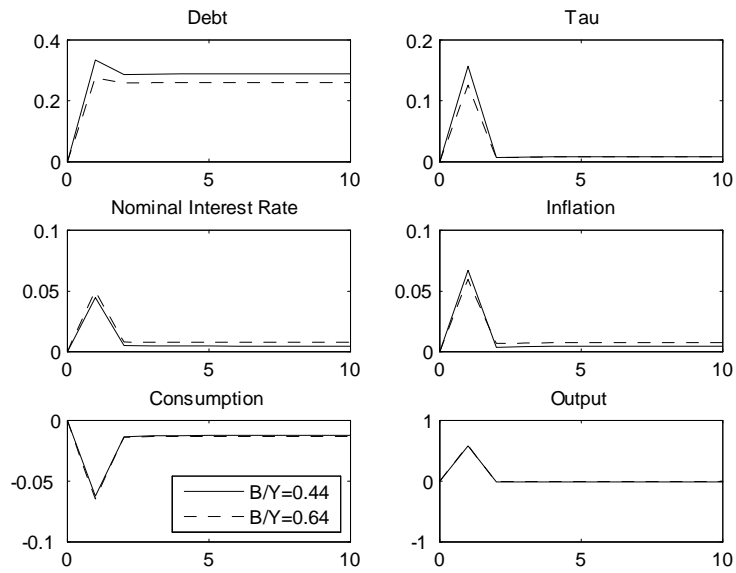
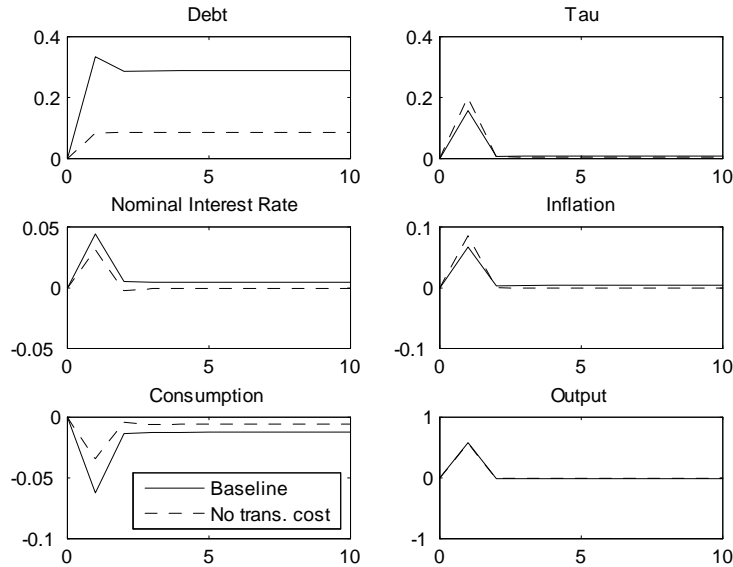Figure 6 – Fiscal shock IRF under initial levels of different real debt.

Figure 7 – Fiscal shock IRF with and without transaction costs.

5 Conclusions

Incompleteness of the tax system is a necessary condition for the existence of a public finance justification for inflation. The strong point of SGU (2004a, 2011) was to argue that irrespective of the incompleteness of the tax system, optimal inflation should be between zero and the Friedman rule. The point of this paper is to show that for the same incompleteness of the tax system a non-negligible inflation rate in steady state is indeed optimal if one adopts a realistic calibration for fiscal outlays, including transfers. Differently from SGU (2011), who argue that central bank inflation targets are too high, our contribution shows that a 2% target might indeed be too low, at least for countries where the burden of taxation is rather high, such as those of continental Europe. However, to obtain an empirically relevant assessment of the optimal inflation rate the model should be extended to account for a number of country-specific factors, such as governments' ability to optimally tax factor incomes, composition of public expenditures, monetary transaction costs, other frictions such as nominal wage stickiness and indexation, the existence of an informal sector. All this should be done bearing in mind that the tax system incompleteness probably is an inherent feature of modern economies. Similar considerations can be made concerning inflation costs. For instance, Calvo pricing, which implies price dispersion, might generate higher inflation costs than Rotemberg pricing, but one should also take into account inflation indexation and its correlation the underlying inflationary

16

regime, as shown in Fernández-Villaverde and Rubio-Ramírez (2007). All this is left for future research.

Further, our analysis of the optimal fiscal and monetary stabilization policies strengthens the Benigno and Woodford (2004) argument that the two policy tools should be seen as complements and that the monetary authority should consider the consequences of her actions for the government budget. In this regard, we show that a substantial amount of inflation volatility is indeed desirable to deflate nominal debt and to limit the accumulation of real debt in the long run. Our results thus provide theoretical support to policy-oriented analyses which call for a reversal of debt accumulated in the aftermath of the 2008 financial crisis and for a reconsideration of the role of inflation in facilitating debt reductions.

References

Aizenman, J., and N. Marion (2009), "Using inflation to erode the U.S. public debt," *NBER Working Paper* No. 15562. Forthcoming in *Journal of Macroeconomics*.

Alonso-Ortiz, J., and R. Rogerson (2010), "Taxes, transfers and employment in an incomplete markets model," *Journal of Monetary Economics*, 57: 949-958.

Altig D., L. Christiano, M. Eichenbaum, and J. Linde (2011), "Firm-specific capital, nominal rigidities and the business cycle," *Review of Economic Dynamics*, 14: 225-247.

Angelopoulos, K., A. Philippopoulos and V. Vassilatos (2007), "Rent-seeking competition from state coffers in a calibrated DSGE model of the euro area," *Working Papers* No 29, Department of Economics, University of Glasgow.

Ascari, G., E. Castelnuovo, and L. Rossi (2011), "Calvo vs. Rotemberg in a trend inflation world: An empirical investigation," *Journal of Economic Dynamics and Control,* 35: 1852-1867.

Aruoba, S.B. and F. Schorfheide (2011), "Sticky prices versus monetary frictions: An estimation of policy trade-offs," *American Economic Journal: Macroeconomics*, 3: 60-90.

Ball, L. and S. Cecchetti (1990), "Inflation and uncertainty at short and long horizons," *Brookings Papers on Economic Activity*, 1: 215-254.

Baumol, W.J. (1952), "The transactions demand for cash: An inventory theoretic approach," *Quarterly Journal of Economics*, 66: 545-556.

Benigno, P. and M. Woodford (2004), "Optimal monetary and fiscal policy: A linear-quadratic approach," in Gertler M. and K. Rogoff (eds.), *NBER Macroeconomic Annual 2003*, Cambridge, MIT Press: 271-364.

Blanchard, O.J., G. Dell'Ariccia and P. Mauro (2010), "Rethinking macroeconomic policy," *IMF Staff Position Note* No. 2010/03.

Brock, P.L. (1989), "Reserve requirements and the inflation tax," *Journal of Money, Credit and Banking*, 21: 106–121.

Cagan, P. (1956), "The monetary dynamics of hyperinflation" in Friedman, M. (Ed.), *Studies in the Quantity Theory of Money*, University of Chicago Press, Chicago: 25-117.

Caporale, T. and B. McKiernan (1997), "High and variable inflation: further evidence on the Friedman hypothesis," *Economics Letters*, 54: 65-68.

Chari, V., L. Christiano and P. Kehoe (1991), "Optimal fiscal and monetary policy: Some recent results," *Journal of Money, Credit, and Banking*, 23: 519-539.

Coibion, O., Y. Gorodnichenko, and J. Wieland (2012), "The optimal inflation rate in New Keynesian Models: should central banks raise their inflation targets in light of the zero lower bound?," *Review of Economic Studies*, 79: 1371-1406.

Cogley, T. and A. Sbordone (2008), "Trend inflation, indexation and inflation persistence in the New Keynesian Phillips curve," *American Economic Review*, 98: 2101-2126.

Fernández-Villaverde, J. and J. Rubio-Ramírez (2007), "How structural are structural parameters?" in Acemoglu D., K. Rogoff, and M. Woodford (eds.), *NBER, Macroeconomics Annual 2006*, Cambridge, MIT Press: 83-137.

Friedman, M. (1969), "The optimum quantity of money," in *The optimum Quantity of money and other essays*, Chicago, Aldine.

Friedman, M. (1977), "Nobel lecture: inflation and unemployment," *Journal of Political Economy*, 85: 451-472.

Greenwood, J., Z. Hercowitz and G. Huffman (1988), "Investment, capacity utilization, and the real business cycles," *American Economic Review*, 78: 402-417.

Guerron-Quintana, P.A. (2009), "Money demand heterogeneity and the great moderation," *Journal of Monetary Economics*, 56: 255-266,

Guidotti, P. and C. Végh (1993). "The optimal inflation tax when money reduces transaction costs," *Journal of Monetary Economics*, 31: 189-205.

Oh, H. and R. Reis (2011), "Targeted transfers and the fiscal response to the Great Recession," *NBER Working Papers* No. 16775.

Khan, A., R.G. King and A.L. Wolman (2003), "Optimal monetary policy," *Review of Economic Studies*, 70: 825-860.

Kimball, M. (1995), "The quantitative analytics of the basic neomonetarist model," *Journal of Money, Credit, and Banking*, 27: 1241-1277.

Kimbrough, K.P. (2006), "The quantitative analytics of the basic neomonetarist model," *Journal of Monetary Economics*, 53: 1967-1978.

Knell, M. and H. Stix (2005), "The income elasticity of money demand: A meta-analysis of empirical results," *Journal of Economic Surveys*, 19: 513-533.

Klein, P., V. Quadrini and J.V. Rios-Rull (2005), "Optimal time-consistent taxation with international mobility of capital," *The B.E. Journal of Macroeconomics*, 5.1., E.S. (1973), "Inflation in the theory of public finance," *The Swedish Journal of Economics*, 75: 67-82.

Phelps, E.S. (1973), "Inflation in the theory of public finance," *The Swedish Journal of Economics*, 75: 67-82.

Rogoff, K.S. (2010), "Why America isn't working. *Project Syndicate*," http://www.project-syndicate.org/.

Rotemberg, J.J. (1982), "Sticky prices in the United States," *Journal of Political Economy*, 90: 1187-1211.

Sbordone, A. (2002), "Prices and unit labor costs: A new test of price stickiness," *Journal of Monetary Economomics*, 49: 265-292.

Schmitt-Grohé, S. and M. Uribe (2004a), "Optimal fiscal and monetary policy under sticky prices," *Journal of Economic Theory*, 114: 198-230.

Schmitt-Grohé, S. and M. Uribe (2004b), "Solving dynamic general equilibrium models using a second-order approximation to the policy function," *Journal of Economic Dynamics and Control,* 28: 755-775

Schmitt-Grohé, S. and M. Uribe (2006), "Optimal fiscal and monetary policy in a medium-scale macroeconomic model," in Gertler M. and K. Rogoff (eds.), *NBER, Macroeconomics Annual 2005*, Cambridge, MIT Press: 383-425.

Schmitt-Grohé, S. and M. Uribe (2011), "The optimal rate of inflation," in Friedman B.M. and M. Woodford (eds.), *Handbook of Monetary Economics*, Elsevier, Amsterdam: 723-828..

Sims, C.A. (1994), "A simple model for study of the determination of the price level and the interaction of monetary and fiscal policy," *Economic Theory*, 4: 381-399.

Zubairy, S. (2010) "On fiscal multipliers: Estimates from a medium scale DSGE model," *Bank of Canada Working Paper* No. 10-30.