Optimal Monetary Policy and Interest Income Taxation

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Resumo:
Esse artigo estuda política monetária ótima discricionária quando o modelo Novo-Keynesiano incorpora tributação da renda dos juros de títulos públicos. No modelo, a elasticidade da inflação e do hiato do produto em relação aos choques de oferta e demanda são funções crescentes da alíquota de tributação. Adiconalmente, simulações numéricas mostram que altos níveis de tributação aumentam as volatilidades do hiato e da inflação, como também a função de perda do Banco Central.

Palavras-Chave: política monetária, tributação de rendimento de juros e discricionariedade

Abstract:
This paper studies optimal discretionary monetary policy when the basic new Keynesian model is extended to incorporate interest income taxation. The elasticities of inflation and the output gap to supply and demand shocks are increasing functions of the tax rate. Moreover, numerical simulations show that high levels of taxation increase inflation volatility, the output gap volatility and the unconditional expectation of the central bank's loss function.

Keywords: monetary policy, interest income taxation, discretion

Área da ANPEC: Área 3-Macroeconomia, Economia Monetária e Finanças
JEL: E43, E52, E58

1 Introduction

Despite the growing literature on the optimal design of monetary policy, the effects of taxation on central bank strategies have received relatively little attention. In some recent papers, fiscal and monetary policy are designed jointly in the context of the Ramsey problem; Schmitt-Grohé and Uribe (2004a, 2004b) are examples of this approach. In some cases, however, the central bank has to set monetary policy taking the tax system as given. In this situation, changes in tax rates have an impact on aggregate dynamics and, consequently, on how monetary policy should be conducted.

This paper studies how the tax system can influence the monetary policy design process. In an extension of the basic new Keynesian model studied in Røisland (2003), I derive the optimal monetary policy in the absence of commitment. Røisland (2003) analyzes equilibrium determinacy in a model in which nominal interest income from government bonds and profits are taxed at a constant rate. This form of taxation alters the household's budget constraint and makes the after-tax interest rate a crucial variable for the understanding of aggregate demand.

In this paper, I show that the elasticities of inflation and the output gap to supply and demand shocks are increasing functions of the tax rate. In addition, numerical simulations show that high tax rates reduce economic welfare and increase the volatilities of inflation and the output gap.

2 The Model

The model presented in Røisland (2003) changes the basic new Keynesian framework by assuming that nominal interest income on government bonds and profits are taxed at a constant rate τ, where $0 < \tau < 1$.

Households with a time-separable utility and a discount factor β, where $0 < \beta < 1$, maximize their expected lifetime utility given a sequence of budget constraints. The period utility is given by:

$$U(C_t, N_t) = \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-\chi}\left(\frac{M_t}{P_t}\right)^{1-\chi} - \mu\frac{N_t^{1+\varphi}}{1+\varphi},$$

where C_t, $\frac{M_t}{P_t}$ and N_t are consumption, real money balances and employment, respectively.

At each date, the budget constraint is:

$$B_{t+1} - B_t + M_{t+1} - M_t = W_t N_t + I_t(1-\tau)B_t + (1-\tau)\Pi_t - P_t C_t - P_t T_t$$

where B_t is the household's nominal government bond holdings, M_t is nominal money balances, W_t is the nominal wage, I_t is the nominal interest rate, Π_t is nominal profits received from firms, and T_t is a real lump-sum tax. The government satisfies its intertemporal budget constraint, not explicitly considered, by adjusting T_t.

Aggregate demand is derived from the representative household's Euler equation. After imposing market clearing conditions, the log-linear form of the Euler equation is:

$$x_t = E_t(x_{t+1}) - \frac{1}{\sigma}[(1-\tau)i_t - E_t(\pi_{t+1})] + g_t \tag{1}$$

Firms in a monopolistic competitive environment produce differentiated goods with a linear technology using only labor. The Calvo mechanism describes price decisions, where θ is the fraction of firms not adjusting their price in a given period. In the neighborhood of a zero-inflation steady state, the new Keynesian Phillips curve characterizes inflation dynamics according to the following expression:

$$\pi_t = \beta E_t(\pi_{t+1}) + kx_t + u_t \tag{2}$$

where $k = \frac{(1-\beta\theta)(1-\theta)}{\theta}$.

The variables x_t, i_t and π_t are the output gap, the nominal interest rate and inflation, respectively. Inflation and the nominal interest rate are expressed in log-deviations from their steady states, which are normalized to zero.

Demand shocks g_t and supply shocks u_t are added to the model. These disturbances follow autoregressive structures:

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g \tag{3}$$

$$u_t = \rho_u u_{t-1} + \varepsilon_t^u \tag{4}$$

where $0 < \rho_g < 1$ and $0 < \rho_u < 1$ are the autoregressive coefficients. Both ε_t^g and ε_t^u are white noise, with variances σ_g^2 and σ_u^2, respectively.

3 Optimal Monetary Policy under Discretion

The policy problem is to choose time paths for π_t, x_t and i_t that minimize the central bank's loss function, which translates the behavior of macroeconomic aggregates into a welfare measure to evaluate different policy choices. Clarida et al. (1999) and Giannoni & Woodford (2003a, 2003b) discuss more extensively the design of optimal monetary policies in new Keynesian models.

I assume that the policymaker seeks to minimize the objective function

$$L = E\left\{(1-\beta)\frac{1}{2}\sum_{t=0}^{\infty}\beta^t\left[\pi_t^2+\lambda_x x_t^2+\lambda_i i_t^2\right]\right\} \tag{5}$$

subject to the constraints imposed by the structural equations (1) to (4).

Expression (5) can be interpreted as a second-order approximation to the lifetime utility function of a representative household; Woodford (2003) discusses this interpretation in detail. The presence of the interest rate variability is related to costs of transactions and to the fact that the nominal interest rate has a lower bound at zero. The relative weights placed on the stabilization of the output gap and the nominal interest rate are λ_x and λ_i, respectively. These weights are strictly positive.

I assume that a commitment technology is absent. In practice, monetary authorities do not make any kind of binding commitments concerning the course of future policy actions. In this context, the central bank chooses its policy by reoptimizing in every period. This type of policy is known as a discretionary policy. Since central banks cannot manipulate private agents' beliefs, private expectations are taken as given, and the optimal policy is obtained by solving the following sequence of static optimization problems:

$$\underset{\pi_t,x_t,i_t}{Min}\frac{1}{2}[\pi_t^2+\lambda_x x_t^2+\lambda_i i_t^2]+F_t$$

subject to

$$x_t = -\frac{1}{\sigma}(1-\tau)i_t + f_t \tag{6}$$

and

$$\pi_t = kx_t + h_t \tag{7}$$

where $f_t = E_t(x_{t+1}) + \frac{1}{\sigma}E_t(\pi_{t+1}) + g_t$ and $h_t = \beta E_t(\pi_{t+1}) + u_t$

The first order conditions are:

$$\pi_t + \varphi_{1t} = 0$$

$$\lambda_x x_t + \varphi_{1t} - k\varphi_{2t} = 0$$

$$\lambda_i i_t + \frac{1}{\sigma}(1-\tau)\varphi_{1t} = 0$$

where φ_{1t} and φ_{2t} are Lagrange multipliers associated with restrictions (6) and (7), respectively.

After solving for the Lagrange multipliers, the nominal interest rate is:

$$i_t = \frac{(1-\tau)}{\lambda_i \sigma}\left(\lambda_x x_t + k\pi_t\right) \tag{8}$$

To find an analytical solution, according to the method of undetermined coefficients, I posit the following decision rules for inflation and the output gap:

$$\pi_t = a_1\ g_t + a_2 u_t \tag{9}$$

$$x_t = a_3 g_t + a_4 u_t \tag{10}$$

Using equations (1) to (4), (8), (9) and (10), I solve for the unknown coefficients a_1, a_2, a_3 and a_4 as a function of the structural parameters. The results are:

$$a_1 = \frac{k}{(1-\beta\rho_g)(1-\rho_g) - \frac{\rho_g k}{\sigma} + [\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_g)]z}$$

$$a_2 = \frac{(1-\rho_u) + \frac{\lambda_x}{\lambda_i}z}{(1-\beta\rho_u)(1-\rho_u) - \frac{\rho_u k}{\sigma} + [\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_u)]z}$$

$$a_3 = \frac{(1-\beta\rho_g)}{(1-\beta\rho_g)(1-\rho_g) - \frac{\rho_g k}{\sigma} + [\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_g)]z}$$

$$a_4 = \frac{\frac{\rho_u}{\sigma} - \frac{k}{\lambda_i}z}{(1-\beta\rho_u)(1-\rho_u) - \frac{\rho_u k}{\sigma} + [\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_u)]z}$$

where $z = \left(\frac{1-\tau}{\sigma}\right)^2$.

The following proposition summarizes how changes in the tax rate impact the above coefficients.

Proposition 1 *The elasticities of inflation and the output gap to supply and demand shocks are increasing functions of the tax rate* τ*.*

Proof. The elasticities are the coefficients a_1, a_2, a_3 and a_4. I take the derivative of each coefficient with respect to τ. After some algebraic manipulations,

$$\frac{da_1}{d\tau} = \frac{\left[\frac{2k(1-\tau)}{\sigma^2}\right]\left[\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_g)\right]}{\left\{(1-\beta\rho_g)(1-\rho_g) - \frac{\rho_g k}{\sigma} + \left[\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_g)\right] z\right\}^2}$$

$$\frac{da_2}{d\tau} = \frac{\left[\frac{2(1-\tau)}{\sigma^2}\right]\left[\frac{\lambda_x}{\lambda_i}\frac{\rho_u k}{\sigma} + (1-\rho_u)\frac{k^2}{\lambda_i}\right]}{\left\{(1-\beta\rho_u)(1-\rho_u) - \frac{\rho_u k}{\sigma} + [\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_u)]z\right\}^2}$$

$$\frac{da_3}{d\tau} = \frac{\left[\frac{2(1-\tau)(1-\beta\rho_g)}{\sigma^2}\right]\left[\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_g)\right]}{\left\{(1-\beta\rho_g)(1-\rho_g) - \frac{\rho_g k}{\sigma} + \left[\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_g)\right] z\right\}^2}$$

$$\frac{da_4}{d\tau} = \frac{\left[\frac{2(1-\tau)(1-\beta\rho_u)}{\sigma^2}\right]\left[\frac{\lambda_x}{\lambda_i}\frac{\rho_u}{\sigma} + (1-\rho_u)\frac{k}{\lambda_i}\right]}{\left\{(1-\beta\rho_u)(1-\rho_u) - \frac{\rho_u k}{\sigma} + [\frac{k^2}{\lambda_i} + \frac{\lambda_x}{\lambda_i}(1-\beta\rho_u)]z\right\}^2}$$

Since all structural parameters are strictly positive, $0 < \tau < 1$, $0 < \beta < 1$, $0 < \rho_g < 1$ and $0 < \rho_u < 1$, the conclusion is that all the derivatives are strictly positive. ■

The variances of inflation and the output gap are:

$$\sigma_\pi^2 = (a_1)^2\sigma_g^2 + (a_2)^2\sigma_u^2$$

$$\sigma_x^2 = (a_3)^2\sigma_g^2 + (a_4)^2\sigma_u^2$$

The derivatives with respect to τ are:

$$\frac{d\sigma_\pi^2}{d\tau} = 2\left[a_1\sigma_g^2\frac{da_1}{d\tau} + a_2\sigma_u^2\frac{da_2}{d\tau}\right]$$

$$\frac{d\sigma_x^2}{d\tau} = 2\left[a_3\sigma_g^2\frac{da_3}{d\tau} + a_4\sigma_u^2\frac{da_4}{d\tau}\right]$$

The behavior of inflation and the output gap volatilities as a function of τ depends upon the signs of the coefficients a_1, a_2, a_3 and a_4. If all coefficients are positive, then the variances of inflation and the output gap increase with τ. The next proposition shows that some restrictions on the autoregressive coefficients lead to positive elasticities. These restrictions are:

$$\rho_g \leq \frac{1}{2}\left[\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right) - \sqrt{\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right)^2 - \frac{4}{\beta}}\right] \tag{11}$$

$$\rho_u \leq \frac{1}{2}\left[\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right) - \sqrt{\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right)^2 - \frac{4}{\beta}}\right] \tag{12}$$

$$\rho_u > \frac{k\sigma}{\lambda_i}z \tag{13}$$

Proposition 2 *If conditions (11), (12) and (13) are satisfied, then the variances of inflation and the output gap are increasing functions of* τ.

Proof. A set of sufficient conditions for all coefficients to be positive is: $(1-\beta\rho_g)(1-\rho_g) - \frac{\rho_g k}{\sigma} \geq 0$, $(1-\beta\rho_u)(1-\rho_u) - \frac{\rho_u k}{\sigma} \geq 0$ and $\rho_u > \frac{k\sigma}{\lambda_i}z$. The first two conditions lead to the following inequality:

$$F(\rho) = \rho^2 - \frac{\left(1+\beta+\frac{k}{\sigma}\right)}{\beta}\rho + \frac{1}{\beta} \geq 0$$

Since $F(0) = \frac{1}{\beta} > 0$ and $F(1) = -\frac{k}{\beta\sigma} < 0$, $F(\rho) \geq 0$ if and only if $0 < \rho \leq \overline{\rho}$, where $\overline{\rho}$ is the smallest root of $F(\rho)$, which is less than one. After some algebra, I find that $F(\rho)$ has two real roots since $\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right)^2 - \frac{4}{\beta} = \left(1-\frac{1}{\beta}\right)^2 + 2\left(1+\frac{1}{\beta}\right)\frac{k}{\beta\sigma} + \left(\frac{k}{\beta\sigma}\right)^2 > 0$, and the smallest root is given by $\frac{1}{2}\left[\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right) - \sqrt{\left(1+\frac{1}{\beta}+\frac{k}{\beta\sigma}\right)^2 - \frac{4}{\beta}}\right]$. ■

Proposition 2 derives only sufficient conditions such that variances are increasing functions of τ. In sum, the implications of changes in τ for macroeconomic volatility depend upon specific parameter values.

4 Numerical Results

I simulate the model using a benchmark parameterization to evaluate the impact of changes in τ on macroeconomic volatility and welfare. The parameters are calibrated following Gianonni and Woodford (2003b). I set $\beta = 0.99$, $\frac{1}{\sigma} = 0.16$, $k = 0.024$, $\lambda_x = 0.048$, $\lambda_i = 0.236$ and $\rho_u = \rho_g = 0.35$ as my baseline values. The variances of the shocks are $\sigma_g^2 = 0.35$ and $\sigma_u^2 = 0.17$.

I normalize all variances and the central bank's loss associated with the absence of taxation to 1. Therefore, Figure 1 reports relative values. The volatilities of inflation and the output gap are increasing functions of τ. The unconditional expectation of the central bank's loss function is also an increasing function of τ. Thus, increases in interest rate income taxes reduce social welfare. By contrast, the interest rate volatility decreases as a result of an increase in τ. We can see that the impact of changes in τ on welfare is minor under the baseline parameters. Additional simulations, not reported here, indicate that these results are very robust as long as the shocks are not extremely persistent.

The magnitude of the impact of changes in τ on welfare and volatilities, however, depends upon the relative importance of the output gap in the monetary policy design process. Figure 2 shows relative volatilities and losses for $\lambda_x = 0.5$. As long as the output gap becomes more important for monetary policy, increases in τ cause significant changes in welfare. High tax rates are also associated with more volatile output gaps.

5 Conclusion

This paper studies how interest income taxation affects aggregate dynamics when the central bank chooses its policy optimally under discretion. I show analytically that the elasticities of inflation and the output gap to supply and demand shocks are increasing functions of the tax rate. In addition, numerical simulations show that high tax rates reduce economic welfare and increase the volatilities of inflation and the output gap. Therefore, changes in interest income taxes have important implications for the design of monetary policy strategies.

References

Clarida, R., J. Gali and M. Gertler., 1999, The Science of Monetary Policy: A New Keynesian Perspective, Journal of Economic Literature 37, 1661-1706.

Giannoni, M. and M. Woodford, 2003a, Optimal Interest-Rules I: General Theory, NBER Working Paper Number 9419

Giannoni, M. and M. Woodford, 2003b, Optimal Interest-Rules II: Applictions, NBER Working Paper Number 9419

Røisland, Ø., 2003, Capital income taxation, equilibrium determinacy and the Taylor principle, Economics Letters 81, 147-153.

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, Optimal Fiscal and Monetary Policy under Imperfect Competition, Journal of Macroeconomics 26, 183-209.

Woodford, M., 2003, Interest and Prices: Foundations of a Theory of Monetary Policy. (Princeton University Press, Princeton).

Figure 1: Relative Volatility-low λ_x

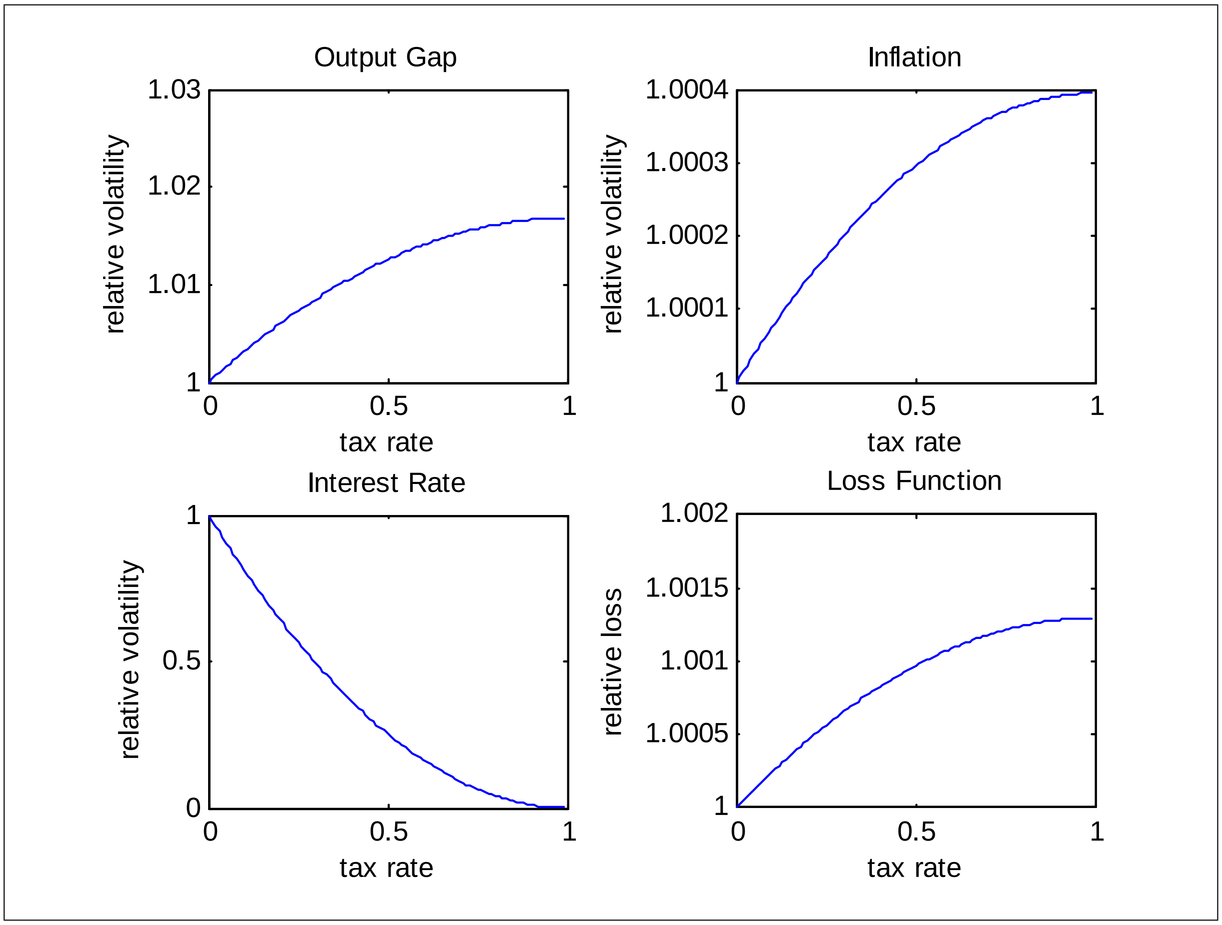

Figure 2: Relative Volatility-High λ_x