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Interest income taxation, optimal monetary policy, and macroeconomic volatility

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ABSTRACT: This paper studies optimal discretionary monetary policy in an extension of the basic new Keynesian model that incorporates interest income taxation, focusing on the effect of changes in the interest income tax rate on macroeconomic volatility. 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.

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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. Some recent papers consider the joint design of fiscal and monetary policies 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 how monetary policy should be conducted, and, consequently, on aggregate dynamics.

Røisland (2003) analyzes the implications of nominal interest income taxation for equilibrium determinacy in a simple new Keynesian model. However, this paper does not address the implications of this form of taxation for optimal monetary policy design and macroeconomic fluctuations.

To study the effect of changes in the interest income tax rate on macroeconomic volatility, I derive the optimal monetary policy under discretion in the model described by Røisland (2003).

Numerical simulations show that high tax rates reduce economic welfare and increase the volatilities of inflation and the output gap. Interest income taxation alters the household's budget constraint and makes the after-tax interest rate a crucial variable for the dynamics of aggregate demand. In the basic new Keynesian model, the only transmission mechanism of monetary policy is the aggregate demand channel.

The introduction of interest income taxation makes aggregate demand less sensitive to movements in the interest rate, weakening the demand channel. Therefore, monetary policy responses to offset specific shocks are less effective, leading to a less stable macroeconomic environment and reducing welfare.

The paper is organized in five additional sections. The second section presents the model. In section three, I discuss the monetary policy design problem. In section four, I present the main findings. The fifth section concludes.

2. THE MODEL

This section describes the final log-linear approximations of the equations characterizing the equilibrium conditions related to the model in Røisland (2003). The appendix shows a more extensive discussion of 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<τ<1. It is possible to represent the model in terms of two equations. These equations are: the aggregate demand and the new Keynesian Phillips curve. The aggregate demand is derived from the representative household's Euler equation. After imposing equilibrium conditions, the log-linear form of the Euler equation is:

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

where the positive parameter σ represents the inverse of the intertemporal elasticity of substitution.

The new Keynesian Phillips curve characterizes inflation dynamics according to:

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

The positive parameter k can be interpreted as a measure of the speed of price adjustment, and β denotes the discount factor of the representative household, where 0<β<1.

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.

2.1 Optimal Monetary Policy under Discretion

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

The policymaker seeks to minimize the objective function:

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

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 relative weights, strictly positive, placed on the stabilization of the output gap and the nominal interest rate are λ_x and λ_i.

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. Since central banks cannot manipulate private agents' beliefs, private expectations are taken as given. The first order conditions are:

$$\pi_t + \varphi_{2t} = 0$$

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

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

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

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

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

To find an analytical solution, according to the method of undetermined coefficients, I posit the following decision rules for inflation and the output gap: $\pi_t = a_1 g_t + a_2 u_t$ and $x_t = a_3 g_t + a_4 u_t$.

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:

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

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

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

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

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

The variances of inflation and the output gap are: $\sigma_\pi^2 = (a_1)^2 \sigma_g^2 + (a_2)^2 \sigma_u^2$ and $\sigma_x^2 = (a_3)^2 \sigma_g^2 + (a_4)^2 \sigma_u^2$.

The derivatives with respect to τ are: $\frac{d\sigma_\pi^2}{d\tau} = 2\left[a_1\sigma_g^2 \frac{da_1}{d\tau} + a_2\sigma_u^2 \frac{da_2}{d\tau}\right]$ and $\frac{d\sigma_x^2}{d\tau} = 2\left[a_3\sigma_g^2 \frac{da_3}{d\tau} + a_4\sigma_u^2 \frac{da_4}{d\tau}\right]$.

Since all structural parameters are strictly positive, 0<τ<1, 0<β<1, 0<ρ_g<1 and 0<ρ_u<1, it can be shown that the derivatives $\frac{da_1}{d\tau}$, $\frac{da_2}{d\tau}$, $\frac{da_3}{d\tau}$ and $\frac{da_4}{d\tau}$ are strictly positive. Nevertheless, the behavior of the variances of macroeconomic aggregates as a function of τ depends upon the signs of the coefficients a_1, a_2, a_3 and a_4.

3. RESULTS

To evaluate the impact of changes in τ on macroeconomic volatility and welfare, I simulate the model using the following benchmark parameterization. The parameters are calibrated according to Gianonni and Woodford (2003b). I set β=0.99, (1/σ) =0.16, k=0.024, λ_x=0.048, λ_i=0.236 $\rho_u = \rho_g$=0.35 as baseline values. The variances of the shocks are σ_g^2 = 0.35 and σ_u^2=0.17.

I normalize all variances and the central bank's loss associated with the absence of taxation to 1. Therefore, Table 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 the result of an increase in τ.

Table - 1: Volatilities and Loss

Tax Rate	Relative Volatility			Loss
τ	x_t	π_t	i_t	L
0.1	1.0032	1.0001	0.8125	1.0002
0.3	1.0085	1.0002	0.4941	1.0007
0.5	1.0126	1.0003	0.2531	1.0010
0.7	1.0153	1.0004	0.0913	1.0012
0.9	1.0166	1.0005	0.0102	1.0013

Source: Developed by the author

Since the demand channel will work less and less as τ increases and interest rate fluctuations are costly according to the loss function, the central bank does not move around the interest rate so much for high tax rates. As a result, inflation and the output gap are more volatile, while the interest rate does not respond to macroeconomic shocks.

The implications of changes in τ for macroeconomic volatility depend upon specific parameter values. I studied the behavior of relative volatilities and losses for some alternative sets of parameters. For the sake of brevity, Figure 1 reports the results for some plausible alternative parameter configurations described in Table 2.

The set of alternative parameterization does not reflect calibrations based on data from any specific country. The focus here is to explore the behavior of the model under alternative set of parameters to complement the analytical results presented. In other words, the paper does not intend to explore a realistic situation, since the model studied is not complex enough for such investigation.

It would be, however, a very interesting exercise to explore a much richer model with relevant nominal and real frictions and calibrate or estimate its parameters, using Bayesian techniques, to specific countries.

Emerging Markets, especially Brazil, which has a high average taxation rate, are good candidate to perform such empirical and quantitative exercise. Nevertheless, this avenue is beyond the goals of this paper. Therefore, the analysis of the effects of taxation in specific settings aimed to resemble de macroeconomic environment of specific countries belong to my agenda for future research.

Table - 2: Sensitivity Analysis

Parameterization	λ_x	λ_i	ρ_u	ρ_g	k
P1	0.048	0.236	0.9	0.9	0.024
P2	0.1	0.236	0.9	0.9	0.024
P3	0.048	0.6	0.9	0.9	0.024
P4	0.048	0.236	0.9	0.9	0.04

Source: Developed by the author

The magnitude of the impact of changes in τ on welfare and volatilities depends upon particular parameter configurations. However, the volatilities of inflation and the output gap are increasing functions of τ, and the interest rate volatility decreases as the result of an increase in τ. These results seem to be robust in the range of parameters studied.

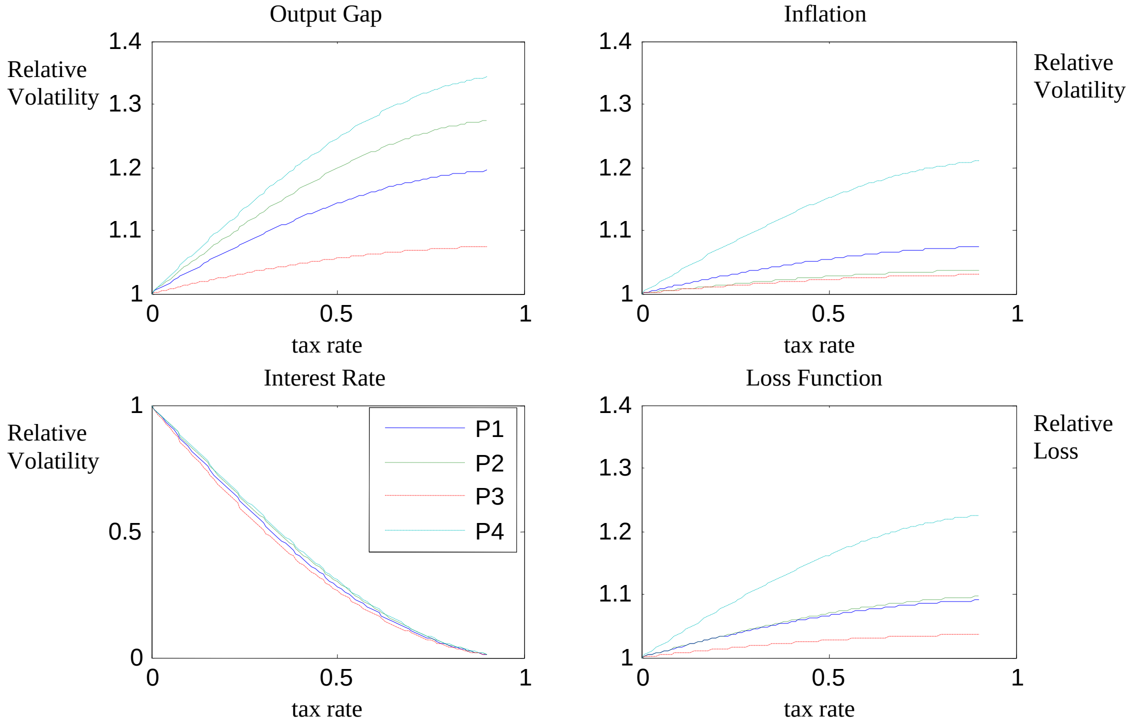

Figure 1: Sensitivity Analysis
Source: Developed by the author

4. CONCLUSIONS

This paper studies how interest income taxation affects aggregate dynamics when the central bank chooses its policy optimally under discretion. Numerical simulations show that high tax rates reduce economic welfare and increase the volatilities of inflation and the output gap. These results are a direct consequence of the inability of the nominal interest rate to affect the real interest rate as the nominal income tax rate increases. In this context, monetary policy looses its effectiveness and is unable to respond to aggregate shocks. Consequently, high levels of interest income taxes reduce welfare, increase the volatilities of inflation and the output gap, and hinder the promotion of macroeconomic stability through monetary policy design.

APPENDIX

This appendix describes in some details the model used in this paper.

A) The Representative Consumer

The lifetime utility is: $U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\gamma}{1-\chi} \left(\frac{M_t}{P_t} \right)^{1-\chi} - \upsilon \frac{N_t^{1-\varphi}}{1+\varphi} \right)$

The variable C_t stands for aggregate consumption, $\frac{M_t}{P_t}$ for real balances and N_t is the amount of labor offered by the representative consumer in the job market. The inverse of the parameter σ is the relative risk aversion of the agent. The parameters γ and χ determine the money demand of the agent. In addition, the parameters υ and φ control labor supply. The parameter β, between zero and one, is the inter-temporal discount factor.

The representative consumer maximizes U, subject to the following budget constraint:

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

The variables B_t and M_t stand for the nominal bond and money holdings. The letters W_t and P_t represent nominal wages and prices. The letter i_t is the nominal interest rate on bonds. The government gets revenue from the interest rate income, by taxing it at a constant rate τ, between zero and one.

The consumer maximizes U subject to the budget constraint. This maximization generates the Euler equation: $(1 + i_t (1-\tau)) = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \right]$

The log-linear approximation of this equation corresponds to the expression (1) in the second section of the paper. I add to the equation related to that approximation, a stochastic demand shock g_t.

B) The Representative Firm

There is a continuum of firms, indexed by j, which operate a linear technology, according to the linear production function $Y_t(j) = A_t N_t(j)$. They produce differentiated goods, which compose a final aggregate consumption good, represented by C_t.

The environment is that of monopolistic competition, therefore the firm can choose its price. Following the Calvo (1983) scheme of pricing, a particular firm may reset its price with a probability given by $1-\theta$ in any given time, independently of the time elapsed since the last price was set. Therefore, a fraction $1-\theta$ of the firms set prices, while another fraction of θ keep their previous prices, without any change.

Firms maximize the discounted profits, taking into account that they will not be able to change the prices, unless they receive a green light to do so with probability $1-\theta$.

The derivation of the supply side of the model is standard and Advanced Macroeconomics textbook describe it in details. For instance, the algebra can be found in chapter 3 of Gali(2008). In the neighborhood of zero steady state inflation, the New Keynesian Phillips Curve characterizes inflation dynamics according to equation:

$$\pi_t = \beta E_t(\pi_{t+1}) + \lambda mc_t$$

The variable mc_t stands for the real marginal cost.

The expression for the parameter λ is $\lambda = \dfrac{(1-\beta\theta)(1-\theta)}{\theta}$.

The parameter λ is strictly decreasing in θ, a measure of the degree of nominal price rigidity.

In fact, with a linear technology, the real marginal cost is proportional to the output gap x_t. By adding a cost-push shock, equation (2) obtains.

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