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NEWS ABOUT TAXES AND EXPECTATIONS-DRIVEN BUSINESS CYCLES

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This paper analyzes the possibility of expectations-driven business cycles to emerge in a one-sector real business cycle model if the unique driving force is news about future income tax rates. We find that good news about labor income tax rates cannot generate expectations-driven business cycles, whereas good news about capital income tax rates can. We show that a one-sector real business cycle model enriched with (i) variable capital utilization and (ii) investment adjustment costs and driven solely by news shocks about capital income tax rates is able to generate qualitatively and quantitatively realistic business cycle fluctuations. In contrast to numerous studies in the news-driven business cycle literature, our model maintains separable preferences.

Keywords: Expectations-Driven Business Cycles, Tax Shocks, News

1. INTRODUCTION

The importance of expectations in driving business cycles is generally acknowledged. At the same time, Beaudry and Portier (2004, 2007) showed that it is impossible to obtain expectations-driven business cycles in the standard one-sector real business cycle (RBC, henceforth) model with a constant returns-to-scale technology and perfectly competitive markets. Expectations-driven business cycles refer to a situation in which output, consumption, investment, and hours worked simultaneously increase in response to good news about the future. In particular, in the standard one-sector RBC model news about an upcoming productivity improvement makes current consumption and investment move in opposite directions. Intuitively, upon the arrival of the good news about future productivity agents want to increase consumption and leisure *via* a dominating positive wealth effect. With no change in fundamentals, lower labor hours along with a predetermined

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capital stock result in a decrease in current output and investment. Therefore, good news about the future sets off an output recession today, and even more, induces consumption on the one hand, and investment, hours worked, and output on the other hand to move in opposite directions, which is at odds with the empirical facts for the U.S. economy. Addressing this "co-movement puzzle" turned out to be a challenge in the context of the standard one-sector RBC model: Beaudry and Portier (2004) solve the puzzle by assuming multiple sectors in production, Tsai (2012) designs a model in which technology adoption is costly, Pavlov and Weder (2013) rely on countercyclical markups, whereas Jaimovich and Rebelo (2009) and Karnizova (2010) propose models in which nonseparable preferences are among the key ingredients.

Similar to the real business cycle literature that developed in 1980s, the news-driven business cycle literature that emerged in early 2000s concentrated initially on supply side shocks, such as a productivity shock.[1] However, an especially generous environment in news release is represented by the income taxation legislative process. In general, tax changes are characterized by "legislative lags," a period of debates over the exact form of the law or package, and "implementation lags," the interval spanning from the moment in which the tax bill is signed into law to the point where it becomes effective. Therefore, by its nature, this process provides agents with news, allowing to adjust their current behavior before the tax legislation takes effect. We choose to concentrate on news regarding income tax rates since this area is both rich in tax events[2] and important for all categories of agents. The importance of income taxation is twofold: It is a pervasive matter, affecting the great majority of agents; second, income taxes represent the most significant source of federal budget revenue—roughly 60% in the postwar era.[3]

The debates about the effects of tax changes on the economy have intensified over the past years. Despite the generally good anticipation and even foresight of tax changes, it is difficult to estimate their effects because of the linkages between the factors that call for these changes and the subsequent developments in the economy. Early studies[4] that deal with the effects of changes in the level of taxes on output do not take into account the linkages that may exist between some tax changes and output growth determinants, which eventually leads to biased estimates of tax policy effects. To overcome this pitfall, Romer and Romer (2010) use a narrative approach for identifying the major postwar tax events from Congressional Committees' reports, Economic Reports of the President, and presidential speeches. They focus on identifying the level changes in taxes and find that most episodes have a unique and clear motivation, such as offsetting a change in spending or other factor likely to affect output over a short span of time, or changes undertaken for the reduction of an inherited budget deficit or for achieving a long-run goal. From the identified motivations for tax level changes, only those in the last two categories can be considered exogenous and are legitimate observations for assessing the effect of tax changes on output. Appendix A enumerates the exogenous tax changes identified by Romer and Romer (2010). Using this new series of fiscal shocks, the authors find that changes in the level of taxes significantly impact output, as a 1% of gross domestic product (GDP) increase in tax liability triggers a 3% drop in GDP over a three-year interval. Mertens and Ravn (2012) use the tax episodes identified by Romer and Romer (2010) to assess the impact of anticipated tax changes on the main macroeconomic aggregates. They use a clear-cut timing convention based on implementation lags to classify tax changes as "unanticipated"[5] and "anticipated."[6] To notice here that this timing convention does not allow to account for anticipation during the period when the tax change is legislated or even before. The authors find that most exogenous tax changes identified by Romer and Romer (2010) are anticipated and that output, consumption, investment, and hours worked all react to both anticipated and unanticipated tax changes, tax shocks accounting for 20 to 25% of output volatility at business cycle frequencies. However, Romer and Romer (2010) and Mertens and Ravn (2012) do not distinguish between changes in capital and labor income tax rates and rather lump these two effects into an overall change in tax liability as percentage of GDP.

House and Shapiro (2006)[7] also emphasize the importance of anticipation about income tax rate changes. Focusing on the 2001 and 2003 Bush tax cut laws, they find that the "phased-in" character of these changes played a crucial role in the slow recovery of 2001, whereas the surprise implementation in advance of the tax cuts planned for 2004 and 2006 by the 2001 law played a prime role in the economic relaunch starting in mid-2003. Furthermore, knowing ahead about a labor income tax rate cut gave agents incentives to reduce labor supply and investment immediately and wait until the new tax rate is implemented. On the other hand, the forward-looking nature of investment encouraged economic actors to start investing and therefore stimulated economic activity immediately upon the announcement of the capital income tax cut. However, given the relatively stronger reduction in the labor tax rate,[8] as well as the fact that two-thirds of income comes from labor, the stimulating effect of a "phased-in" capital income tax rate reduction was offset by the effect of a "phased-in" labor income tax rate cut, resulting in an overall slowdown of the economy upon the announcement of the future tax rates. The immediate implementation of otherwise "phased-in" tax cuts had a stimulative effect on the economy in 2003. There are two aspects of interest here: On the one hand, anticipation can modify the overall effect of a tax change, and on the other hand, it is important to distinguish between capital and labor income tax rate changes.

Therefore, our objective in this paper is to find the smallest departure from the standard one-sector RBC model that generates realistic business cycles driven by news shocks regarding income tax rate levels. To this end, we analyze a one-sector RBC model with variable capital utilization and investment adjustment costs, while maintaining separability of preferences, in contrast to previous one-sector models driven solely by news shocks.[9] We concentrate on level effects of news about tax changes as in Romer and Romer (2010) and Mertens and Ravn (2012). Compared to these empirical studies, our framework allows us to distinguish between news about capital income tax rates and labor income tax rates. This paper differs from existing studies analyzing the effects of distortionary corporate and personal income taxation in the context of a one-sector RBC model[10] by concentrating on the effects of news about tax rates, rather than contemporaneous, unanticipated changes.

We first analyze the impact of an announcement today regarding a one percentage point permanent decrease in the labor income tax rate that is to be implemented in a year. We find that in the current period, due to a dominating positive wealth effect, agents react by increasing consumption and cutting-down hours worked. Investment also decreases in expectation of a higher marginal product of capital (MPK, henceforth), agents preferring to increase the utilization of the existing stock of capital. As a result, there is a weak increase in output. Therefore, good news about future labor income tax rates cannot generate expectations-driven business cycles. Next, we focus on the impact of news about a one percentage point permanent decrease in the capital income tax rate to be implemented in four quarters. We find that this announcement triggers an expansion in all four macroeconomic aggregates in the current period. Intuitively, agents anticipate an increase in both their labor income and the marginal product of capital at the time when the decrease in tax rate would actually be implemented. Again, current consumption increases due to a dominating positive wealth effect. Meanwhile, agents expect a strong increase in MPK, which makes them start investing immediately, to avoid investment adjustment costs in the future when the increased MPK is available. This results in higher capital services in the current period, which must be complemented with higher labor hours. Hence, output unambiguously increases and consequently good news about capital income tax rates can generate expectations-driven business cycles. Further, we evaluate the model in simulations by comparing the statistical properties of the macroeconomic aggregates generated in the model with their empirical counterparts. We simulate a version of our model subject to news about capital income tax rates and find that the model can account for roughly 30% of the business cycle volatility. Considering the consequences of the two types of news, aggregating their effects into an overall news about income tax changes might be misleading, as an increase in one macroeconomic aggregate in response to news about capital income tax rates might be offset by a decrease of the same macroaggregate in response to news about the labor income tax rate.

The remaining part of the paper is organized as follows: In Section 2, we lay down the model. In Section 3, we analyze the possibility of expectations-driven business cycles to emerge in our model. Section 4 discusses the importance of some features of the model. We simulate the model in Section 5 and conclude in Section 6.

2. THE MODEL

The model economy consists of three types of agents: households, firms, and a government. The representative household supplies labor to the representative firm, for which it receives wages in exchange. The household owns the representative firm from which it gets dividends. The representative firm owns the capital stock, hires labor in order to organize the production process, and pays wages and dividends to the representative household. The household uses these proceeds for acquiring consumption goods.[11] Output is the numeraire. The government imposes a set of taxes on households and firms and returns the entire revenue collected to the private sector via a lump-sum transfer. Therefore, in our model, taxation plays no other role but to be distortionary.

2.1. Households

The economy is populated by a unit measure of identical infinitely lived households, each having one unit of time endowment every period and maximizing a discounted stream of expected utilities over its lifetime

$$\max_{c_t, n_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[\log c_t - A \frac{n_t^{1+\gamma}}{1+\gamma} \right], \; 0 < \beta < 1, \gamma \geq 0, A > 0, \tag{1}$$

where E is the conditional expectations operator, β is the discount factor, c_t stands for consumption, n_t for hours worked, γ denotes the inverse of the labor supply elasticity, and $A > 0$ represents a preference parameter.

The representative household derives income from three sources: (i) wage w_t for labor services, (ii) dividends from owning the representative firm, labeled d_t, and (iii) lump-sum transfers from the government, denoted T_t. The labor income is taxed by the government at rate τ_{nt}. The wage w_t, labor income tax rate τ_{nt}, dividends d_t, and the transfers T_t are regarded by the household as being set beyond its control and therefore are taken as given. In each period t, the household uses its income to finance consumption and consequently faces the following period by period budget constraint:

$$c_t = (1 - \tau_{nt}) w_t n_t + d_t + T_t. \tag{2}$$

The first-order condition to be satisfied by the household each period is given by

$$A c_t n_t^{\gamma} = (1 - \tau_{nt}) w_t. \tag{3}$$

The intratemporal condition in (3) equates the household's marginal rate of substitution between consumption and leisure to the after-tax real wage.

2.2. Firms

The economy is populated by a continuum of identical perfectly competitive firms, with the total number normalized to one. Each firm produces output y_t using the following Cobb–Douglas production function:

$$y_t = (u_t k_t)^{\alpha} \; n_t^{1-\alpha}, 0 < \alpha < 1, \tag{4}$$

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where u_t represents the endogenous rate of capital utilization, k_t is the capital stock, therefore $u_t k_t$ denotes capital services used in the production process, and n_t represents labor hours.

The representative firm owns the capital stock and therefore makes the investment decision. The capital stock accumulates according to

$$k_{t+1} = (1-\delta_t)k_t + i_t\left[1-\varphi\left(\frac{i_t}{i_{t-1}}\right)\right], \quad k_0,\ i_{-1} > 0 \text{ given}, \tag{5}$$

where i_t represents gross investment and $\delta_t \in (0, 1)$ is the endogenous rate of capital depreciation, which is postulated to take the form

$$\delta_t = \frac{u_t^{1+\theta}}{1+\theta}, \tag{6}$$

where $\theta > 0$ represents the elasticity of marginal depreciation with respect to utilization rate. As in most studies of variable capital utilization, the capital depreciation rate δ_t is assumed to be an increasing and convex function of the variable utilization rate. Therefore, a higher utilization rate allows for higher capital services in production, and at the same time accelerates its depreciation. In (5) we also allow for the possibility that one unit of investment transforms into less than one unit of capital. This idea is captured by the investment adjustment cost function $\varphi(\cdot)$, about which we know that $\varphi(1) = \varphi'(1) = 0$ and that $\varphi''(1) = \phi > 0$.[12] We postulate the following functional form for $\varphi(\cdot)$:

$$\varphi\left(\frac{i_t}{i_{t-1}}\right) = \frac{\phi}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2. \tag{7}$$

Assuming perfect competition in the labor market, firms take the wage w_t as given and make decisions regarding how much labor n_t to hire, how intensively, u_t, they should utilize the existing capital stock, and how much to invest and hence, what should be the capital stock k_{t+1} next period. The government imposes a corporate tax on firms to which is subject the entire firm's revenue net of labor costs. Since the costs with labor are deducted and output is obtained exclusively from labor and capital services, this share of income can be attributed to the latter production factor, and we further refer this tax as a capital tax and denote it as τ_{kt}. Investment expenditures cannot be deducted entirely in the period in which they are undertaken since by its nature investment generates benefits over multiple periods. Therefore, the firm is allowed to deduct from the taxable income only the expenditures corresponding to the depreciation of capital over that period of time. Atkinson and Stiglitz (1980) treat the "classical" tax system, in which the corporate income tax base is revenue less labor costs (gross profits) less true economic depreciation less interest payments. Since in our setting firms cannot borrow, the issue of interest deductibility does not appear and our notion of corporate tax corresponds to the one in Atkinson and Stiglitz (1980).

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Each period, the representative firm distributes to the representative household, in the form of dividends, d_t, the revenue generated in excess of labor and investment costs and after covering its tax obligations. Therefore, the objective of the firm is to maximize the following discounted stream of expected dividends. Since the household is the owner of the firm and the firm acts in the household's best interest, for discounting the dividends we use the household's marginal utility of consumption, given here by $1/c_t$[13]

$$\max_{n_t, i_t, k_{t+1}, u_t} E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{c_t} \underbrace{[(1-\tau_{kt})(y_t - w_t n_t) - i_t + \tau_{kt}\delta k_t]}_{d_t}, \tag{8}$$

subject to the production function in (4), the capital accumulation equation (5), and the depreciation rate in (6). The government taxes only the undepreciated capital. The term $\tau_{kt}\delta k_t$ accounts for the capital depreciation allowance, where $\delta \in (0, 1)$ represents the steady-state depreciation rate.[14]

The first-order conditions for the firm's problem are

$$w_t = (1-\alpha)\frac{y_t}{n_t}, \tag{9}$$

$$\mu_t u_t^{\theta} k_t = (1-\tau_{kt})\alpha \frac{y_t}{u_t}\frac{1}{c_t}, \tag{10}$$

$$\mu_t = \beta E_t \left\{ (1-\delta_{t+1})\,\mu_{t+1} + \frac{1}{c_{t+1}}\left[(1-\tau_{kt+1})\alpha \frac{y_{t+1}}{k_{t+1}} + \delta\tau_{kt+1} \right] \right\}, \tag{11}$$

$$\frac{1}{c_t} = \mu_t \left[1 - \varphi\left(\frac{i_t}{i_{t-1}}\right) - \varphi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}} \right] + \beta E_t \left[\mu_{t+1}\varphi'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2 \right], \tag{12}$$

along with the transversality conditions, where μ_t represents the Lagrange multiplier associated with (5), which is a function of past, current, and future investment (i_{t-1}, i_t, and i_{t+1}, respectively) and current consumption c_t. Equation (9) states that the firm hires labor up to the point where its marginal product is equal to the real wage. Equation (10) represents the first-order condition for capital utilization and equates the marginal gain (additional output) and marginal loss (higher depreciation) of a change in the rate of capital utilization u_t. To notice here that through the presence of μ_t, (10) becomes an intertemporal condition. Equations (11) and (12) represent the Euler equations that govern the firm's intertemporal capital and investment choices. It can be shown that due to the interaction between variable capital utilization and investment adjustment costs, the multiplier μ_t and further the utilization rate u_t depend positively on current consumption and investment, c_t and i_t, respectively, and future investment i_{t+1} among others.[15] Intuitively, in order

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to increase production and therefore capital services, firms in our model can either increase the utilization rate of the existing capital stock at the cost of a higher depreciation or increase investment in new capital for which they have to bear investment adjustment costs. Therefore, at each point in time our firms compare these two costs and choose investment i_t and the utilization rate of capital u_t.

From the first-order conditions in (3), (10), and (11), one can see that the labor income tax rate affects the intratemporal trade-off between consumption and leisure at a given date t, whereas the capital income tax rate affects the intertemporal trade-offs.

2.3. Government

The government collects taxes on labor and capital services and returns all revenues to the private agents in a lump-sum way. Therefore, taxes have no other role in our model but to create distortions.

Hence, in each period t, lump-sum government transfers are equal to

$$T_t = \tau_{nt} w_t n_t + \tau_{kt}(y_t - w_t n_t) - \tau_{kt}\delta k_t, \tag{13}$$

which states that the government transfers back to the households the entire amount collected from labor and capital income taxation, where the last term in (13) represents the capital depreciation allowance.

By combining equations (2), (13), and using the definition of dividends, we obtain the aggregate resource constraint as

$$c_t + i_t = y_t. \tag{14}$$

2.4. Competitive Equilibrium

A competitive equilibrium for this economy consists of sequences of allocations $\{c_t, n_t, i_t, d_t, k_{t+1}, u_t, y_t\}_{t=0}^{\infty}$, prices $\{r_t, w_t\}_{t=0}^{\infty}$, and policies $\{\tau_{nt}, \tau_{kt}, T_t\}_{t=0}^{\infty}$ such that, given initial conditions $k_0, i_{-1} > 0$, the following conditions hold:

1. Given prices $\{r_t, w_t\}_{t=0}^{\infty}$, and policies $\{\tau_{nt}, \tau_{kt}, T_t\}_{t=0}^{\infty}$, households choose $\{c_t, n_t\}_{t=0}^{\infty}$ to maximize (1), subject to (2).
2. Given prices $\{r_t, w_t\}_{t=0}^{\infty}$, and policies $\{\tau_{nt}, \tau_{kt}, T_t\}_{t=0}^{\infty}$, firms choose $\{n_t, k_{t+1}, i_t, u_t\}_{t=0}^{\infty}$ to maximize (8), subject to (4)–(6).
3. The government budget constraint (13) holds.
4. All markets (goods and labor) clear, i.e., (14) holds and $n_t^d = n_t^s$ (labor demand equals labor supply).

3. EXPECTATIONS-DRIVEN BUSINESS CYCLES

In this section we analyze the effects of news about a future decrease in the labor and capital income tax rates in a calibrated version of the model.

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TABLE 1. Parameters

Parameter	Description	Value	Source
α	Capital income share	0.36	Hansen (1985)
β	Discount factor	0.985	King et al. (1988)
δ	Steady-state depreciation rate	0.013	s.t. $k_{ss}/y_{ss} = 2.4$
γ	Inverse labor supply elasticity	0	Indiv labor [Hansen (1985)]
A	Preference parameter	1.734	s.t. $\overline{n} = 1/3$
θ	Mg. depreciation elasticity	0.796	Computed based on β,δ
τ_n	Avg. labor income tax rate	0.21	Computed [Jones (2002)]
τ_k	Avg. capital income tax rate	0.375	Computed [Jones (2002)]
ϕ	$\phi = \varphi''(1)$	0.88	Match the actual σ_i/σ_y

3.1. The News Process and Calibration

Following Beaudry and Portier (2004), we postulate the stochastic process for the exogenous tax shock fed into our numerical experiments as follows: The economy starts at its steady state in period zero. In period 1, households receive news that there will be a permanent one percentage point decrease in the capital/labor income tax rate from period 4 onward. In period 4, the news materializes and the tax rate permanently decreases by one percentage point.

In order to solve the model, we log-linearize the equations characterizing the equilibrium by taking a first-order Taylor series approximation around the deterministic steady state. In addition, we adopt the following parameterization commonly used in the business cycle literature, which is consistent with the observed features of the U.S. economy. The time period in our model economy is one quarter. The capital share in income is set to $\alpha = 0.36$, the discount factor $\beta = 0.985$, which corresponds to an annual average of 6.5% return on capital, as in King et al. (1988), the steady-state capital depreciation rate is set to $\delta = 0.013$, so that it insures a capital to output ratio equal to 2.4 in the steady state,[16] the labor supply is infinitely elastic, i.e., $\gamma = 0$, as in Hansen (1985). Given the calibrated values for β and δ, it follows that $\theta = 0.796$. The preference parameter $A = 1.734$, so that labor hours equal one-third in the steady state. Capital and labor income tax rates are computed as averages for the interval 1958Q1–2009Q2[17] and are set to $\tau_k = 37.5\%$ and $\tau_n = 21\%$, respectively. The computation of the labor and capital income tax rates is based on tax receipts from the National Income and Product Accounts. Details about computation of tax rates, along with their graphical representation are supplied in Appendix B. Table 1 summarizes the parameters used.

All parameters except that characterizing the investment adjustment cost function, $\phi = \varphi''(1)$, could be set according to observed features of the U.S. economy. Since for this parameter there is no observable counterpart or microstudies available to tell us an appropriate value, we follow Baxter and Crucini (1995) and Baxter and Farr (2005) and use information regarding the relative to output volatility of

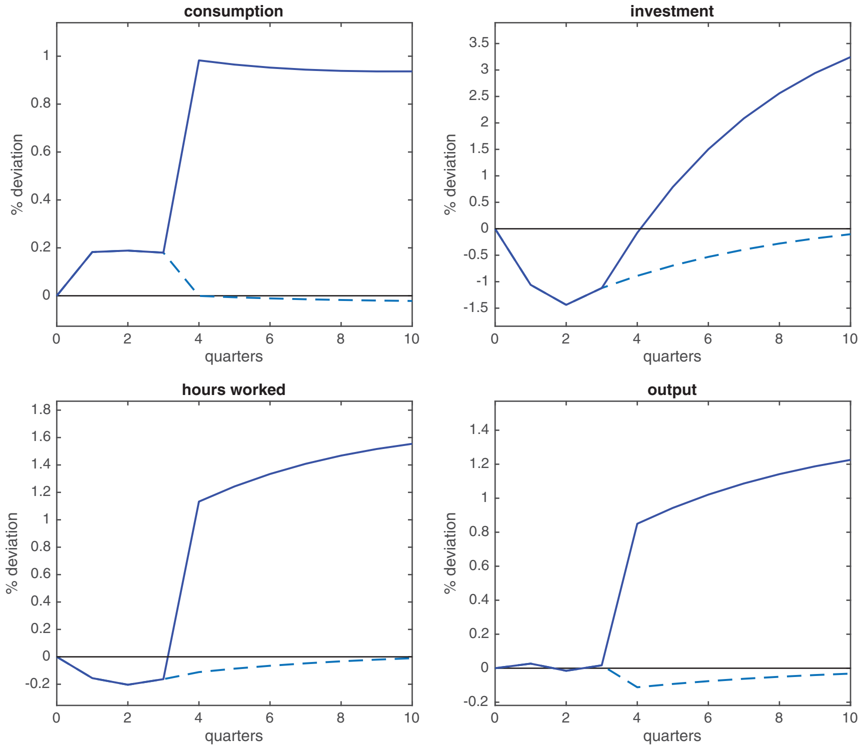

FIGURE 1. Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the labor income tax rate by 1 percentage point starting $t = 4$. Solid line—the news materializes. Dashed line—the news fails to materialize.

investment in order to set $\varphi''(1) = \phi$. We use a simulated method of moments to pin down this parameter. Details about estimation are provided in Section 5. This method recommends a value of $\phi = 0.88$.

3.2. Dynamic Responses

Labor income tax. In this section we are interested in assessing the impact on the economy of an announcement made by the government today, in period $t = 1$, regarding a permanent decrease by one percentage point of the labor income tax rate which is to become effective at time $t = 4$. In addition, there is no change in the tax rate on capital income. The news materializes and starting $t = 4$ the labor income tax rate permanently decreases by one percentage point.

The solid line in Figure 1 presents the impulse responses of the economy to the good news about labor income tax rate. We notice that consumption and output increase on impact, while investment and hours worked decrease. The smooth profile of investment is due to the existence of investment adjustment costs, which

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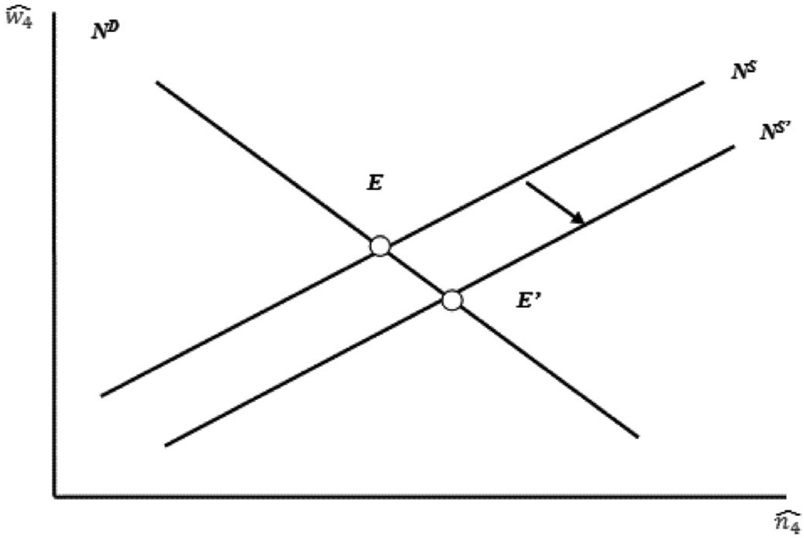

FIGURE 2. Anticipated (at $t = 1$) time $t = 4$ labor market for an announcement made at $t = 1$ about a permanent decrease in the labor income tax rate by 1 percentage point starting $t = 4$.

means that agents prefer a gradual adjustment to a one-time change in investment. However, when the news materializes at $t = 4$, all macroeconomic aggregates increase. In order to understand this result, it is crucial to understand what agents anticipate will happen in the time $t = 4$ labor market once they get the news at time $t = 1$. This is depicted in Figure 2. A lower labor income tax rate means an expected higher return on labor at time $t = 4$ and therefore incentives for agents to work more. In Figure 2 this is represented by a rightward shift of the labor supply curve, which results in a new labor market equilibrium at E', characterized by a lower wage and higher labor hours, but overall expected labor income goes up. Also, higher labor hours lead to a higher expected marginal product of capital at time $t = 4$, MPK_4. The increased expected lifetime labor income makes agents willing to increase current consumption c_1 through a positive wealth effect. The perspective of a higher MPK_4 lowers the price of future consumption, making current consumption look relatively more expensive, giving agents incentives to decrease consumption and increase investment in the current period through a substitution effect. Figure 3 depicts the current period labor market diagram. Simulations show that the wealth effect dominates and current consumption c_1 increases.[18] Since consumption and leisure are complements, labor hours n_1 drops, resulting in a leftward shift of the labor supply curve in Figure 3. Time $t = 1$ investment decreases and remains below its steady-state level until the news materializes at time $t = 4$ and the higher MPK_4 gives agents incentives to start increasing it again. The rate of capital utilization u_1, which we recall depends

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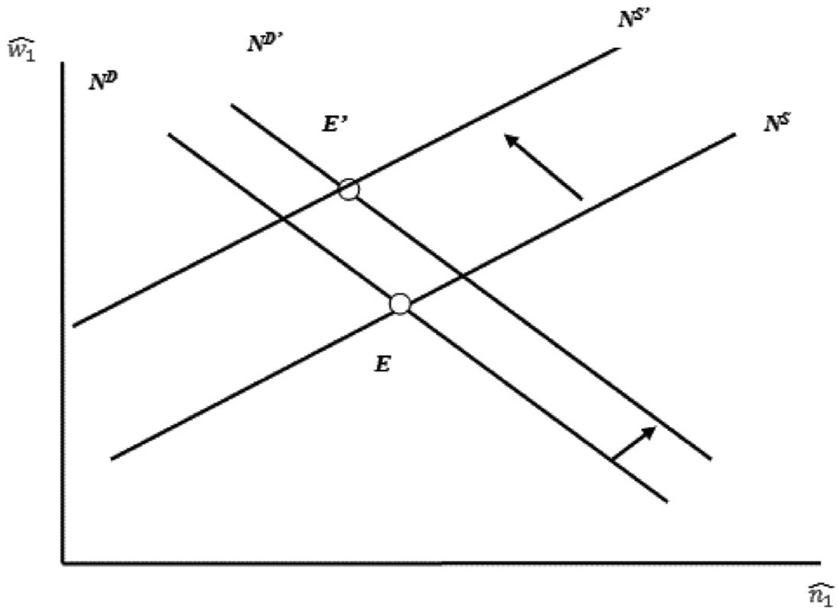

FIGURE 3. Time $t = 1$ labor market for an announcement made at $t = 1$ about a permanent decrease in the labor income tax rate by 1 percentage point starting $t = 4$.

positively on c_1, i_1, and i_2, increases. Since k_1 is predetermined, capital services in production $k_1 u_1$ increase, which triggers an increase in the labor demand, represented by a rightward shift of the labor demand curve in Figure 3. Overall, the equilibrium in the time $t = 1$ labor market shifts from point E to a new equilibrium E', characterized by higher wages and lower labor hours. The increase in the utilization rate u_1 along with the decrease in hours worked n_1 results in a small increase in output y_1 at time $t = 1$.

Hence, good news about future labor income taxation cannot generate expectations-driven business cycles, since consumption and output rise and investment and hours worked drop on impact.

The dashed line in Figure 1 presents the response of the economy to the announcement at $t = 1$ of a permanent decrease of one percentage point of the labor income tax rate to be implemented at $t = 4$ and a nonmaterialization of the news, i.e., the labor income tax rate remains at 21%. Again, there is no change in the tax rate on capital income. In this case, the immediate response of the economy at $t = 1, 2, 3$ is identical to that in the case of news confirmation, as agents have the same information. However, since the news fails to materialize at $t = 4$ and there is no subsequent change in fundamentals, the steady state remains unchanged and therefore all macroeconomic aggregates start reverting to it. Without the perspective of a higher labor income in the future, consumption drops immediately at $t = 4$. Labor hours and investment which dropped during the

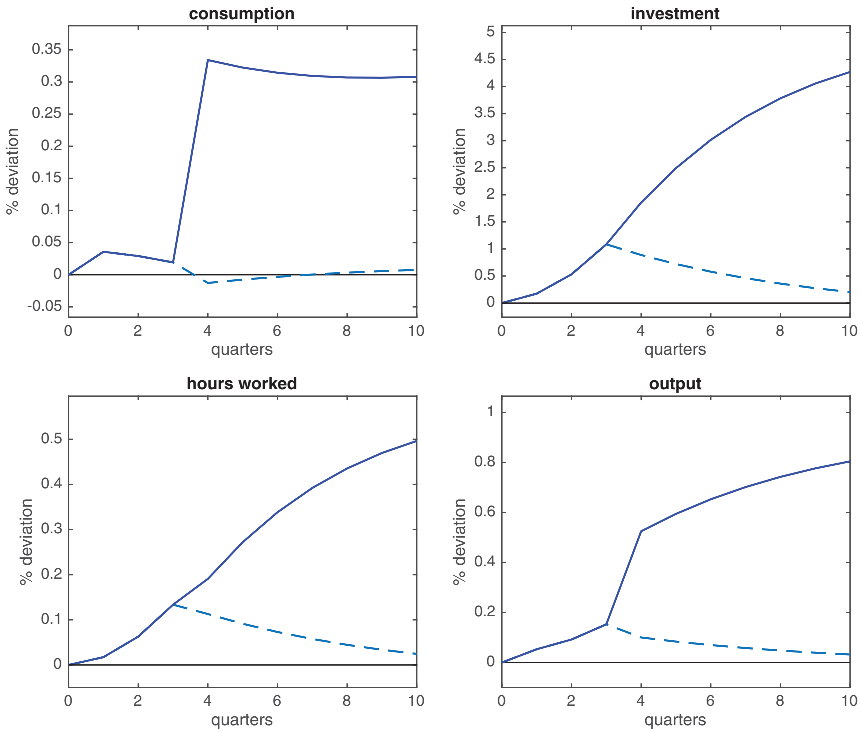

FIGURE 4. Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$. Solid line—the news materializes. Dashed line—the news fails to materialize.

early periods start to increase. Due to adjustment costs, the response of investment has a smooth profile. Overall, consumption drops, investment and labor hours remain for a few quarters below steady state, which results in a small drop in output at $t = 4$ followed by a gradual return to the steady-state level.[19]

Capital income tax. In this section we want to assess the impact on the economy of an announcement made by the government today at $t = 1$ regarding a permanent decrease by one percentage point in the capital income tax rate which is to be implemented at time $t = 4$. In addition, there is no change in the tax rate on labor income throughout this experiment. The news materializes and starting $t = 4$ the capital income tax rate permanently decreases by one percentage point.

The solid line in Figure 4 depicts the response of the economy to the above experiment. One can see that upon the arrival of the good news about the capital income tax rate there is an economic expansion, as all macroeconomic aggregates increase on impact. To understand the mechanism at work, we rely again on the labor market diagrams. Figure 5 depicts what agents anticipate would happen in the time $t = 4$ labor market once they get the news at time $t = 1$. A lower capital

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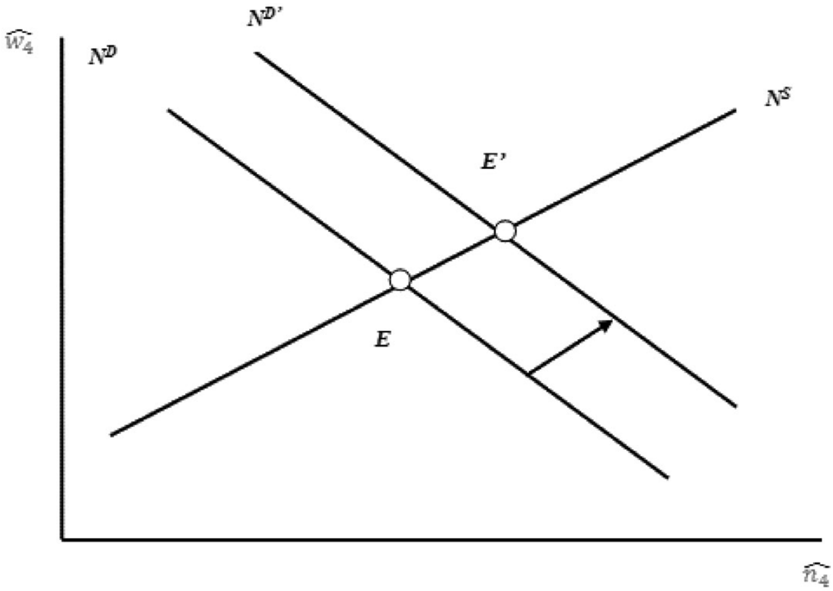

FIGURE 5. Anticipated (at $t = 1$) time $t = 4$ labor market for an announcement made at $t = 1$ about a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$.

income tax rate means a higher expected net return on capital when the new tax is implemented. Since capital is predetermined, the only way in which agents could take advantage of the higher return is by increasing the rate at which they utilize the existing capital, which results in higher capital services in production that must be complemented by higher labor hours, i.e., a rightward shift of the labor demand curve at $t = 4$ and a shift in the equilibrium from E to E' in Figure 5. The new equilibrium is characterized by a higher wage w_4 and higher hours worked n_4, which clearly results in a higher expected labor income, $w_4 n_4$. Increased labor hours and utilization makes agents anticipate a higher MPK_4. Figure 6 presents the current period ($t = 1$) labor market diagram. The perspective of a higher labor income makes agents increase current consumption *via* a positive wealth effect, while a higher expected MPK_4 makes current consumption relatively more expensive compared to future consumption, and therefore agents want to decrease consumption today *via* a substitution effect. Since in our case income effect dominates,[20] we observe an increase in current consumption c_1 and current leisure, and therefore a reduction in labor hours n_1, i.e., a leftward shift of the labor supply curve at time $t = 1$. Compared to the previous experiment, the anticipated increase in MPK_4 is very strong. This is the result of two forces: On the one hand, there is a direct effect *via* the lower capital income tax rate; on the other hand, there is an indirect effect that works *via* the increased labor hours and utilization. In the case of news about the labor income tax rate, only the latter effect was

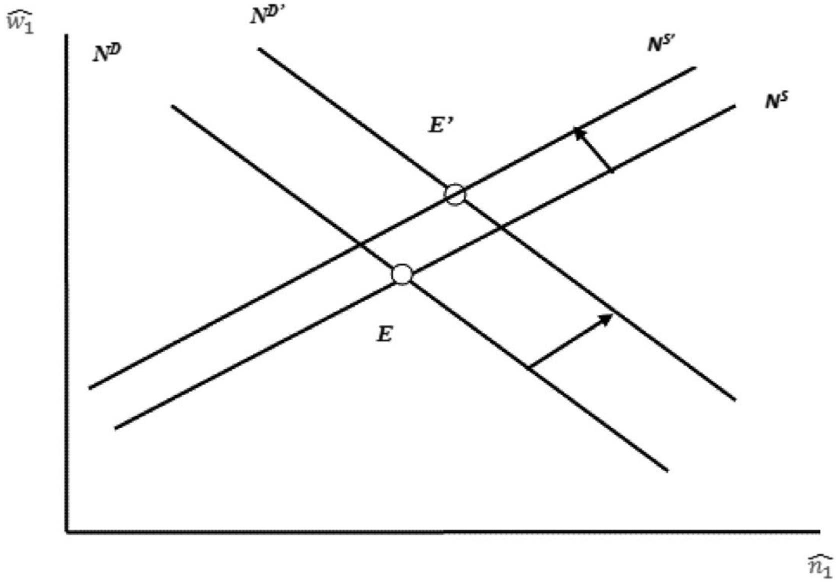

FIGURE 6. Time $t = 1$ labor market for an announcement made at $t = 1$ about a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$.

present and consequently the expected increase in MPK was smaller. Therefore, agents expect that at $t = 4$ when the news materializes it would be optimal to increase investment strongly, but since they have to bear adjustment costs, big jumps in investment are costly, which makes it optimal for them to start investing immediately at $t = 1$ and subsequent periods. The increase in current consumption c_1 and investment i_1, and future investment i_2, all point in the direction of a higher capital utilization rate u_1 and therefore higher capital services k_1u_1, that must be complemented with higher labor hours, i.e., a rightward shift of the time $t = 1$ labor demand curve in Figure 6. The shift in the labor demand curve is relatively stronger than the shift in the labor supply curve, causing the equilibrium to shift from point E to E', which is characterized by higher wages and higher labor hours n_1. Since consumption, investment, and hours worked all increase, output y_1 clearly increases in the current period. Hence, good news about future capital income taxation does generate expectations-driven business cycles.

The dashed line in Figure 4 presents the response of the economy to the announcement at $t = 1$ of a permanent decrease of one percentage point of the capital income tax rate to be implemented at $t = 4$ and a nonmaterialization of the news, i.e., the capital income tax rate remains at 37.5% after $t = 4$. Again, there is no change in the tax rate on labor income. In this case, the immediate response of the economy at $t = 1, 2, 3$ is identical to that in the case of news confirmation, as agents have the same information. However, when the news fails to materialize at $t = 4$, there is no change in fundamentals and in the steady state of the economy.

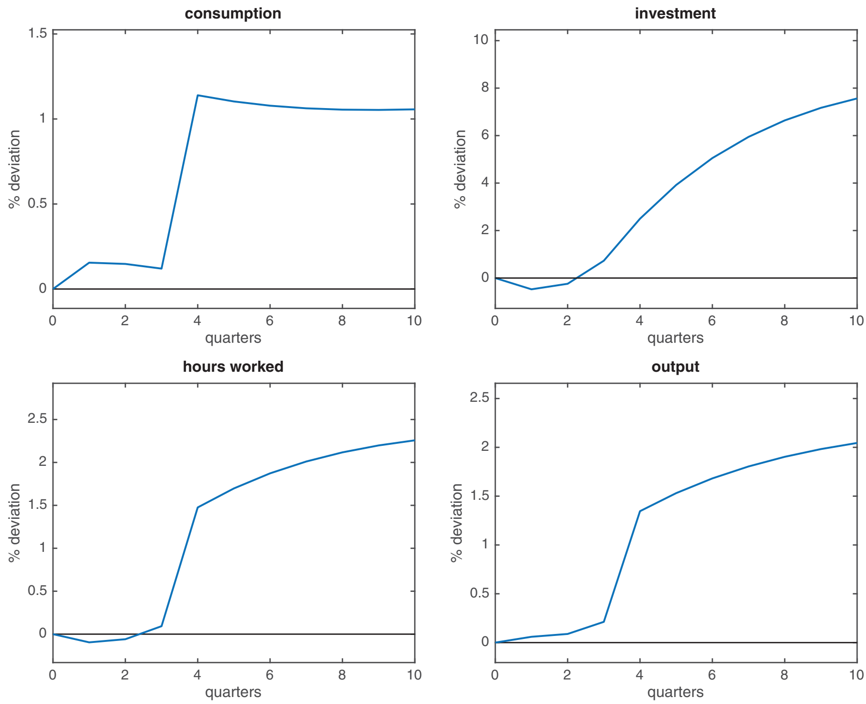

FIGURE 7. Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the personal income tax rate by 1 percentage point starting $t = 4$. The news materializes.

With all macroaggregates on the rise in the initial periods, they all start falling on impact: Consumption drops immediately at $t = 4$, while adjustment costs lead to a gradual return to the initial steady state of investment and consequently of output and labor hours.[21]

Income tax. It is known that tax reforms involve changes in both capital and labor income tax rates. Therefore, a natural question that arises regards the response of the economy to an overall income tax change. In this section we use the parameters set before in Table 1. In addition, we use the average personal tax rate computed using the method in Jones (2002).[22] Based on this, we compute an average personal income tax rate of $\tau = 14.54\%$ over the 1958Q1–2009Q2 interval and we assume that labor and capital income are taxed at the same rate.

Figure 7 presents the response of the model economy to an announcement made by the government at $t = 1$ regarding a permanent decrease by one percentage point in the personal income tax rate which is to be implemented at time $t = 4$. The news materializes and starting $t = 4$ the personal income tax rate permanently decreases by one percentage point. Upon the arrival of the news, consumption c_1 and income y_1 both increase, while investment and labor hours experience a very

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small decrease. This result was expected given the response of the economy to changes in labor and capital income tax rates: Consumption and output increase upon the arrival of both types of news, whereas investment and hours drop at the arrival of news about labor income tax rates and start increasing if news is about capital income tax rates. Existing empirical literature about anticipation effects of tax changes has not reached an agreement regarding the response of the main macroeconomic aggregates. For example, Poterba (1988) cannot find evidence that consumption expenditure is significantly affected by news about policy changes. On the other hand, Mertens and Ravn (2012) find positive effects on all macroeconomic aggregates in the case of surprise tax changes[23] and negative effects for the anticipated[24] tax changes. However, we notice here that their strict timing convention based on implementation lags does not allow to take into account any sort of anticipation that may happen before a tax change is legislated. Overall, capital and labor income tax changes have different effects on consumption, investment, hours worked and output, and lumping these two effects into an overall income tax change might be misleading.

4. FEATURES OF THE MODEL

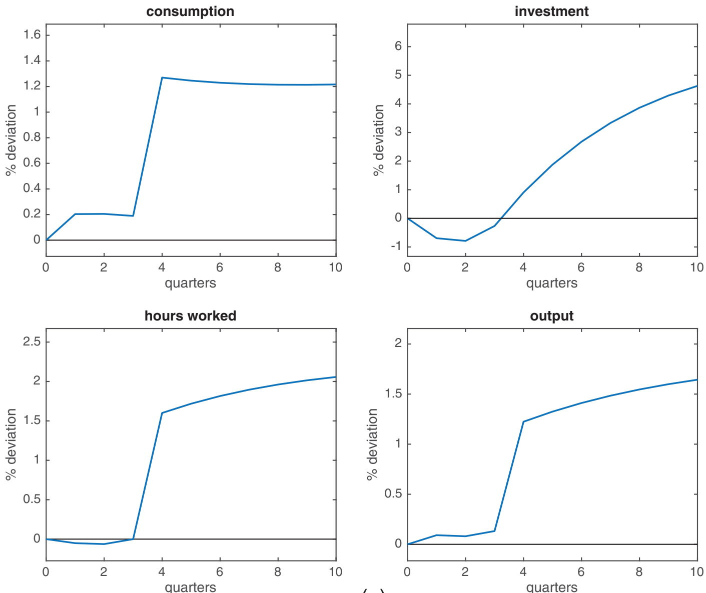
In this section we address the importance of the main features of the model: separable preferences, variable capital utilization, and investment adjustment costs, in delivering expectations-driven business cycles.

4.1. Separable Preferences

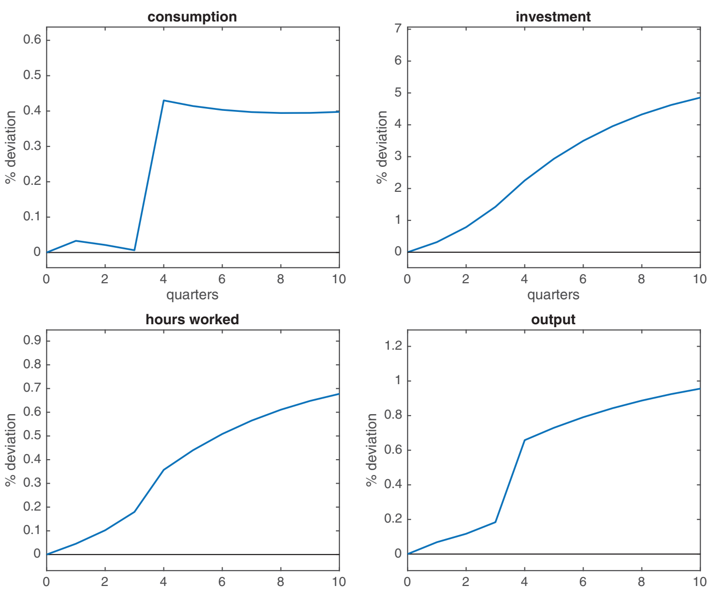
For understanding our results in preceding sections, we have constantly referred to the relative importance of the income and substitution effects. For both labor and capital income tax rates, we have seen that consumption increases upon arrival of the good news due to a dominating positive wealth effect. One may wonder if our results survive if we increase the household's intertemporal elasticity of substitution in consumption (IES, henceforth). For this purpose, we consider a generalized constant-relative-risk aversion formulation of preferences. The household's period utility function is given by

$$U_t = \frac{c_t^{1-\sigma} - 1}{1-\sigma} - A\frac{n_t^{1+\gamma}}{1+\gamma}, \quad \sigma > 0, \sigma \neq 1, \gamma \geq 0 \text{ and } A > 0, \qquad \textbf{(15)}$$

where σ represents the inverse of the IES $\left(= \frac{1}{\sigma}\right)$. While most previous studies have adopted values of $\sigma > 1$, i.e., an IES lower than unity, recent empirical studies also find evidence supporting values of IES above 1. Mulligan (2002) finds evidence of an IES higher than one, while Vissing-Jorgensen and Attanasio (2003) report point estimates of IES of 1.03 and 1.44, using six and one instrumental variables, respectively, for all stock holders. Figures 8a and 8b present the response of the economy to news regarding a permanent one percentage point decrease in labor and



(a)



(b)

FIGURE 8. a (top) and b (bottom): Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the labor (top) and capital (bottom) income tax rate by 1 percentage point starting $t = 4$, $\sigma = 0.7$. The news materializes.

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capital income tax rates, respectively, if $\sigma = 0.7$, i.e., IES $= 1.44$ approximately. The remaining parameters are identical to those listed in Table 1.

Figures 8(a) and (b) show that increasing the IES does not alter the qualitative conclusions of our model: Good news about labor income tax rates leads to a decrease in hours and investment and an increase in consumption and output upon arrival [Figure 8(a)], whereas good news about capital income tax rates leads to an increase in all macroeconomic aggregates on impact, therefore expectations-driven business cycles emerge [Figure 8(b)].

4.2. Variable Capital Utilization and Investment Adjustment Costs

We show that both variable capital utilization and investment adjustment costs are essential features in deriving the result. In order to understand each element's role, we will discuss versions of the model with constant capital utilization and no investment adjustment costs, constant capital utilization and investment adjustment costs, and variable capital utilization and no investment adjustment costs.

First, we analyze a version of the model with constant capital utilization and no investment adjustment costs, i.e., we return to a standard RBC model with taxation driven by news about capital income tax rates. Figure 9 depicts the impulse response functions for this scenario. In this situation, consumption declines and investment, hours worked, and output increase when the good news is announced. [25] Intuitively, at time $t = 1$ our agents anticipate that at time $t = 4$ there will be an increase in the after-tax return on capital due to the lower capital income tax rate, which makes future consumption look relatively cheaper compared to present consumption. We keep in mind that at $t = 4$ firms in our model do not have anymore the flexibility to increase production by varying the utilization rate and the increase in capital and labor will happen only in subsequent periods, therefore the income effect is weaker in this case. Overall, agents cut down on current consumption and also on leisure and consequently increase hours worked and output, as capital is predetermined. Since output increases and consumption falls, investment necessarily increases. Increased labor hours and predetermined capital means an immediate increase in MPK, an incentive for agents to continue to increase investment. Hence, expectations-driven business cycles cannot emerge under constant capital utilization and no investment adjustment costs. Furthermore, we mention that introducing investment adjustment costs to this version of the model does not help us to obtain expectations-driven business cycles. Investment adjustment costs will only smooth investment, but for reasonable values of investment adjustment costs, consumption falls and investment goes up.

Next, we consider a version of the model with variable capital utilization, but no investment adjustment costs. Figure 10 depicts the impulse response functions for this case. The arrival of good news causes an increase in consumption and a decrease in the other three macroeconomic aggregates. Without adjustment costs,

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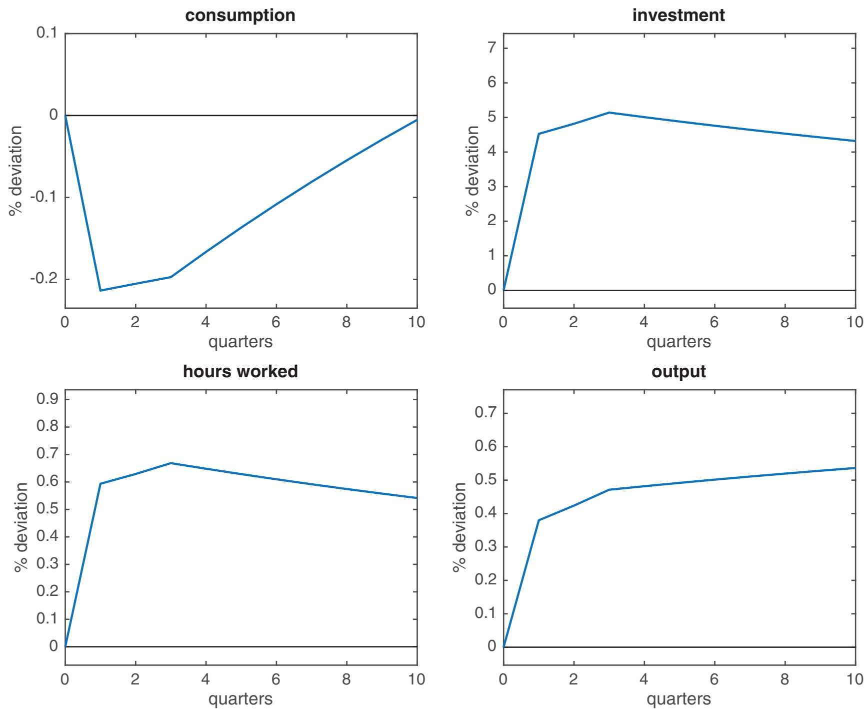

FIGURE 9. Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$, model with constant capital utilization and no adjustment costs (consumption reaches the new steady state after about 20 quarters). The news materializes.

the first-order condition with respect to capital utilization in (10) becomes

$$u_t^{\theta} k_t = (1 - \tau_{kt})\alpha \frac{y_t}{u_t}, \tag{16}$$

which shows that the marginal gain obtained by a more intense utilization of the existing capital stock increases if the capital income tax rate decreases. Moreover, in this case one can write the utilization rate as a function of capital, labor, and the capital income tax rate and obtain the reduced-form technology as a function of the same arguments.[26] Again, similar to our benchmark case, when agents get the news about the capital income tax cut at $t = 1$, they anticipate that at $t = 4$, in order to take advantage of the higher net return, firms will increase the utilization of existing capital and along with this increase their demand for labor, which results in higher expected labor income $w_4 n_4$ and MPK_4. Due to a dominating positive income effect, agents increase current consumption c_1 and current leisure and decrease hours worked n_1. Due to lower labor hours and predetermined capital, output y_1 decreases. Absent adjustment costs, agents find it optimal to postpone

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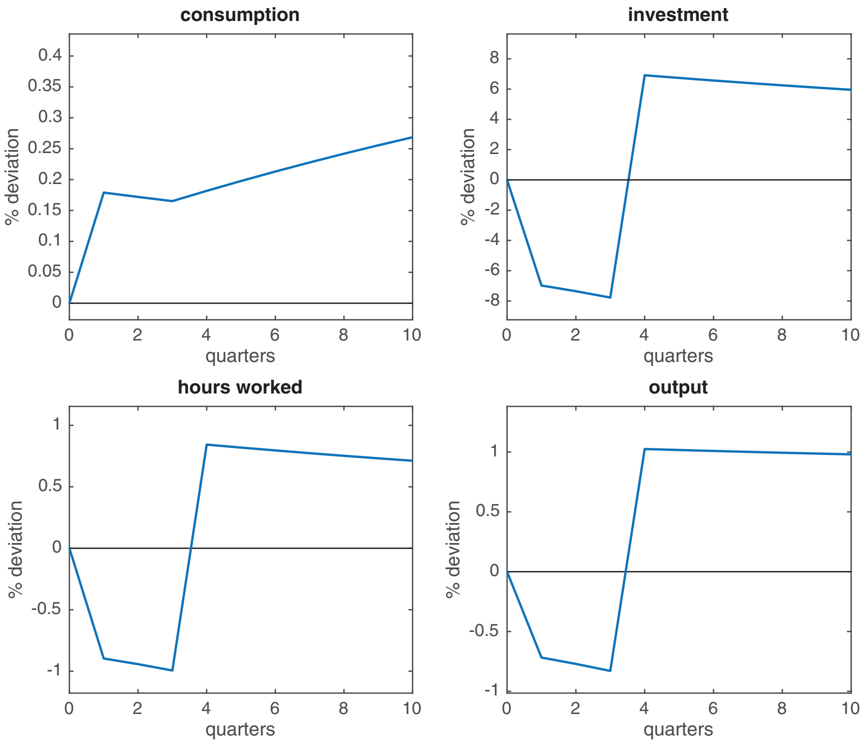

FIGURE 10. Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$, model with variable capital utilization and no investment adjustment costs (consumption reaches the new steady state after about 20 quarters). The news materializes.

investment until $t = 4$, when they can enjoy the higher return on capital, i.e., investment falls on impact.

Therefore, introducing only one of the two features of the model precludes us from obtaining expectations-driven business cycles.

5. QUANTITATIVE ANALYSIS

In this section we evaluate the performance of the model driven by news shocks about future capital income tax rates. We do so by comparing the statistical properties of the macroeconomic aggregates generated in the model with the Hodrick-Prescott (H-P, henceforth) filtered U.S. empirical counterparts. The simulation method used to evaluate our model relies on Jaimovich and Rebelo (2009).

We first compute average capital income tax rates using the method in Jones (2002). Using this series, we estimate an autoregressive of order one process. The process was estimated using observations from 1976Q1 to 2009Q2. Romer and

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Romer (2010) find that numerous tax changes before 1975 were motivated by factors correlated with output. However, the situation changes starting 1976, after which date, with very few exceptions, tax changes can be considered exogenous. The estimated AR(1) process is given by[27]

$$\tau_{kt+1} = \underset{(0.0149)}{0.0456} + \underset{(0.0400)}{0.8768}\tau_{kt} + \chi_{kt} \tag{17}$$

$$\sigma_\chi = 0.0074 \qquad \text{DW} = 2.07.$$

Using Adda and Cooper (2003) discretization method, we approximate the AR(1) process (17) by a two-point Markov chain with support

$$\left\{\tau_k^L, \tau_k^H\right\} = \{36.27\%, 38.73\%\}, \tag{18}$$

where the L superscript stands for low tax and the H superscript stands for high tax, and transition matrix

$$\begin{bmatrix} 0.8403 & 0.1597 \\ 0.1597 & 0.8493 \end{bmatrix}. \tag{19}$$

The transition matrix shows that once we are in a certain state, high or low, there is a high chance of staying there (about 85%), with the probability of transitioning between states being around 15%.

Agents get a signal, for example, a presidential address, passage of a tax bill by the House of Representatives or Senate, or even the enactment of a law. Each period they get signals/news regarding the capital income tax rate four periods ahead, i.e., if there will be a high or low tax rate. We denote this signal by $T_t \in \{L, H\}$ and consider

$$\begin{aligned} \text{Prob}(T_t = H|\tau_{kt+4} = \tau_k^H) &= a_1, \\ \text{Prob}(T_t = L|\tau_{kt+4} = \tau_k^L) &= a_2, \end{aligned} \tag{20}$$

with $a_1, a_2 \in [0 \;\; 1]$, denoting the precision of the signal and where $a_i = 1, i = 1, 2$ means that agents receive a perfect signal.

Economic agents use the signal and the current realization of the tax rate to make inferences in a Bayesian fashion about the future value of the tax rate

$$\begin{aligned} &\text{Prob}(\tau_{kt+4} = \tau_k^H|T_t = i, \tau_{kt}) \\ &= \frac{\text{Prob}(T_t = i|\tau_{kt+4} = \tau_k^H)\text{Prob}(\tau_{kt+4} = \tau_k^H|\tau_{kt})}{\sum_{j=L,H} \text{Prob}(T_t = i|\tau_{kt+4} = \tau_k^j)\text{Prob}(\tau_{kt+4} = \tau_k^j|\tau_{kt})}. \end{aligned} \tag{21}$$

Mertens and Ravn (2012) find that the median anticipation lag for the anticipated tax changes identified by Romer and Romer (2010) is equal to six quarters. In our benchmark case, we will consider that agents get a perfect signal, i.e., $a_1 = a_2 = 1$. In order to see the effect of news quality and of a possible asymmetry in terms

TABLE 2. Business cycle statistics

Moments	Data (58Q1–09Q2)	Benchmark	Alternative 1	Alternative 2
	Volatilities*(σ_x)**			
σ_y	1.57 (1.00)	0.50 (1.00)	0.47 (1.00)	0.44 (1.00)
σ_c	0.89 (0.57)	0.30 (0.60)	0.30 (0.64)	0.30 (0.70)
σ_i	7.31 (4.66)	2.31 (4.66)	2.09 (4.46)	1.89 (4.25)
σ_n	1.53 (0.98)	0.27 (0.54)	0.24 (0.51)	0.22 (0.49)
	Contemporaneous correlations with output (ρ_{xy})***			
ρ_{cy}	0.82	0.89	0.90	0.90
ρ_{iy}	0.91	0.91	0.89	0.87
ρ_{ny}	0.89	0.86	0.83	0.79

*numbers in parentheses are relative to output standard deviations.
**σ_x represents the volatility of variable x.
***ρ_{xy} represents the contemporaneous correlation of variable x with output y.

of materialization of good and bad news, we present simulation results for two alternative cases: $a_1 = 1$, $a_2 = 0.95$, and $a_1 = a_2 = 0.95$. Next, we use a Simulated Method of Moments to pin down ϕ, the parameter characterizing the strength of investment adjustment costs. In particular, ϕ is chosen such that we minimize the distance between the relative to output volatility of investment σ_i/σ_y observed in the data and that generated in the model. We simulate the model $N = 500$ times for $T = 206$ periods[28] each simulation. This procedure yields a mild value of $\phi = 0.88$.

Table 2 presents a set of H-P-filtered second moments (volatilities and contemporaneous correlations with output) for our model economy and U.S. data for the period 1958Q1–2009Q2.[29] The top panel contains information regarding the volatility of macroeconomic aggregates, whereas the bottom panel summarizes information regarding their contemporaneous correlation with output. The second column presents the performance of the U.S. economy, the third column the performance of the model in the benchmark specification with $a_1 = a_2 = 1$, whereas the fourth and fifth columns present the two alternative specifications, Alternative 1 ($a_1 = 1, a_2 = 0.95$) and Alternative 2 ($a_1 = a_2 = 0.95$), respectively. Since we cannot expect that the entire business cycle volatility is due to news shocks about income tax rates, we focus on relative to output instead of absolute volatilities, reported in parentheses.

In the benchmark case, the model is able to explain roughly 30% of the output volatility, which is in line with the findings in Mertens and Ravn (2012). The model does a good job in matching the relative to output volatility of consumption, while labor hours appear to be a bit lower in our model compared to the data. We keep in mind that the relative to output volatility of investment has been used as a target and cannot be used in evaluating the performance of the model. Regarding the contemporaneous correlations with output, we notice that consumption, investment, and hours worked are all strongly procyclical, as observed in the data and that the model does a good job on this dimension. Also, by inspecting the performance of alternatives 1 and 2, we can see that the business cycle properties of the model are preserved and do not depend crucially on the precision of the signal. The lower the precision of the news, the lower the investment to output volatility. Intuitively, when given a less precise signal, agents will be more cautious in making investment decisions, slowing down the entire activity, i.e., the absolute volatility of output also goes down.

Therefore, our model does generate not only qualitatively but also quantitatively realistic business cycle fluctuations.

6. CONCLUDING REMARKS

This paper analyzes the possibility of expectations-driven business cycles to emerge in a one-sector real business cycle model if the unique driving force is news about future income tax rates. We analyze an otherwise standard RBC model, enriched with variable capital utilization and investment adjustment costs. This framework allows us to isolate the effects of news about labor and capital income tax rate changes. Our main finding is that good news about labor income tax rates cannot generate expectations-driven business cycles, whereas good news about capital income tax rates can. We simulate a version of our model driven solely by news about capital income tax rates and find that our model is able to generate not only qualitatively but also quantitatively realistic aggregate fluctuations.

Further challenges in assessing the effect of tax changes, especially in the context of the last recession we have witnessed, are raised by the volatility of fiscal news.[30] Fernandez-Villaverde et al. (2015) find evidence of time-varying volatility in the tax and government spending processes and that fiscal volatility shocks bring about a decrease in consumption, investment, output, and hours worked, which remain low for several quarters. Leeper et al. (2012)[31] find that the fiscal policy news is a time-varying process, where periods of news abundance alternate with periods of news scarcity. Moreover, Leeper and Walker (2011) and Leeper et al. (2013) show that the quantitative effects of foresight depend on how the information flows are modeled. We intend to investigate the impact of these features on our results in a future project.

NOTES

1. Few papers address the importance of news about aggregate demand shocks: Beaudry and Lucke (2009) and Schmitt-Grohé and Urîbe (2012) support their empirical plausibility, whereas Ramey (2011, Section IV.B) and Guo et al. (2015) analyze expectational shocks about government spending and government spending and consumption demand, respectively, within a theoretical framework.
2. Yang (2007) documents 27 major tax events in the United States for the period 1948–2005.
3. Yang (2007) reports 66.4% (1950) and 58.1% (2006), based on Joint Committee on Taxation documents.
4. See Blanchard and Perrotti (2002).
5. If the implementation lag is smaller than a quarter.
6. If the implementation lag is higher than a quarter.

7. The working paper version—House and Shapiro (2004)—presents a more extensive analysis of the labor and capital income tax cut effects.

8. 5% cut in the labor income tax rate (1.8 percentage points from 36.2 to 34.4%) versus a 2.7% cut in the capital income tax rate (0.5 percentage point from 18.3 to 17.8%), per House and Shapiro (2004).

9. Beaudry and Portier (2007) analyze the effect of news about an overall income tax rate and find that expectations-driven business cycles arise only in a multisector framework with cost complementarities.

10. See Chang (1992), Braun (1994), and McGrattan (1994). Yang (2005) addresses foresight in a model that also features contemporaneous unanticipated technology shocks.

11. We favor this ownership structure in our presentation over the more traditional one—in which households own the factors of production and rent them to firms—because in this setup one can clearly see that what we call capital tax rate in the model corresponds, indeed, to the corporate tax rate in the tax code. However, it can be shown that the two formulations are equivalent, i.e., the first-order conditions are the same.

12. These conditions say that there are no adjustment costs in the steady state and that adjustment costs are at their minimum in the steady state. See Christiano et al. (2005) for more on the investment adjustment costs function.

13. The same objective function for the firm can be obtained from the standard asset pricing equation. In this case, the expected value of the firm would be determined by the future stream of dividends discounted by the stochastic discount factor, i.e., the value of the firm at time t is $V_t = E_t\left[\sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{u'(c_\tau)}{u'(c_t)} d_\tau\right]$, where $u(c_t) = \log c_t$.

14. The applicable tax laws allow to list as an expense each period a share δ of the existing capital stock. This share is stated by a law and, in general, it differs from the true economic depreciation.

15. We retain here only those variables that have not already been determined in previous periods.

16. This corresponds to a value of $\delta = 0.0225$ in an economy without taxation.

17. Tax rates series were computed using the method in Jones (2002).

18. This result remains true even if we increase the intertemporal elasticity of substitution. See Section 4.1 for a generalized form of preferences.

19. One can regard the failure to materialize at $t = 4$ of the good news about labor income taxes as a surprise bad news in that period, which triggers agents' immediate response.

20. This result remains true even if we increase the intertemporal elasticity of substitution. See Section 4.1 for a generalized form of preferences.

21. One can regard the failure to materialize at $t = 4$ of the good news about capital income tax rates as a surprise bad news, which triggers agents' immediate downward adjustment in all macroeconomic aggregates.

22. Details about data and computations, along with a graphical representation of the series can be found in Appendix B.

23. Characterized by no implementation lag.

24. Those with positive implementation lags.

25. We recall that the co-movement problem was noted by Beaudry and Portier (2004) for the standard RBC model driven by news about technology. One could expect to encounter the same problem here, as capital income taxation has similar effects with a productivity shock: both affect the expected MPK, which eventually leads to the interplay between income and substitution effects.

26. It can be shown that $u_t = [(1-\tau_{kt})\alpha k_t^{\alpha-1} n_t^{1-\alpha}]^{\frac{1}{(1+\theta)-\alpha}}$ and $y_t = \alpha^{\frac{\alpha}{(1+\theta)-\alpha}} (1-\tau_{kt})^{\frac{\alpha}{(1+\theta)-\alpha}} k_t^{\frac{\alpha\theta}{(1+\theta)-\alpha}} n_t^{\frac{(1-\alpha)(1+\theta)}{(1+\theta)-\alpha}}$.

27. Standard errors are given in parentheses.

28. In simulations, we extend the length of the sample by roughly one-third, i.e., we consider 280 periods, the additional periods from each simulation are dropped in order to minimize the effects of initial conditions.

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29. Details regarding the data can be found in Appendix C. Data on tax receipts go back only to 1958Q1.

30. Bloom (2014) finds that both macroeconomic and microeconomic uncertainty vary tremendously over time, increasing in recessions and dampening during economic booms and that the increase in uncertainty in 2008 had a significant contribution to the economic contraction during the Great Recession.

31. They identify news about tax policy from the differentiated tax treatment of municipal and treasury bonds.

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APPENDIX A: EXOGENOUS TAX CHANGES (1948–2007)

This table summarizes the exogenous tax changes identified by Romer and Romer (2010). Tax changes are listed chronologically by effective date.

Legislation	Effective date	Size (Percent of GDP)
Revenue Act of 1948	1948Q2	−3.74
	1948Q3	1.83
Social Security Amendments of 1947	1950Q1	0.27
Social Security Amendments of 1950	1954Q1	0.35
Expiration of Excess Profits and Temporary Income Tax	1954Q1	−0.35
Internal Revenue Code of 1954	1954Q3	−1.13
	1954Q4	0.72

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Tax Rate Extension Act of 1958	1958Q3	−0.11
Federal-Aid Highway Act of 1959	1959Q4	0.12
Social Security Amendments of 1958	1960Q1	0.36
Changes in Depreciation Guidelines and Revenue	1962Q3	−0.69
Act of 1962	1962Q4	0.45
	1962Q4	−0.61
	1963Q1	0.45
	1963Q1	0.10
Social Security Amendments of 1961	1963Q1	0.33
Revenue Act of 1964	1964Q2	−2.55
	1964Q3	1.25
	1965Q1	−0.65
Excise Tax Reduction of 1965	1965Q3	−0.24
	1966Q1	−0.23
Tax Adjustment Act of 1966	1966Q2	0.12
Public Law 90-26	1967Q3	−0.66
	1967Q4	0.46
Social Security Amendments of 1967	1971Q1	0.33
Tax Reform Act of 1969	1971Q1	−0.09
Reform of Depreciation Rules	1971Q1	−0.25
Tax Reform Act of 1969	1972Q1	−0.09
Revenue Act of 1971	1972Q1	−1.23
	1972Q2	0.55
Tax Reform Act of 1976	1976Q4	013
	1977Q1	−0.04
Tax Reduction and Simplification Act of 1977	1977Q3	−1.02
	1977Q4	0.66
1972 Changes to Social Security	1978Q1	0.13
Revenue Act of 1978	1979Q1	−0.77
Social Security Amendments of 1977	1979Q1	0.36
	1980Q1	0.06
Crude Oil Windfall Profit Tax Act of 1980	1980Q2	0.30
	1981Q1	0.13
Social Security Amendments of 1977	1981Q1	0.56
Economic Recovery Tax Act of 1981	1981Q3	−0.84
	1981Q4	0.56
Social Security Amendments of 1977	1982Q1	0.05
Crude Oil Windfall Profit Tax Act of 1980	1982Q1	0.13
Economic Recovery Tax Act of 1981	1982Q1	−1.53
Tax Equity and Fiscal Responsibility Act of 1982	1983Q1	0.78
Economic Recovery Tax Act of 1981	1983Q1	−1.69
	1984Q1	−1.28
Social Security Amendments of 1983	1984Q1	0.32
Deficit Reduction Act of 1984	1984Q3	0.20
Social Security Amendments of 1983	1985Q1	0.21
	1986Q1	0.10

Tax Reform Act of 1986	1986Q4	0.50
	1987Q1	−0.16
	1987Q3	−0.42
	1988Q1	−0.15
Omnibus Budget Reconciliation Act of 1987	1988Q1	0.22
Social Security Amendments of 1983	1988Q1	0.31
	1990Q1	0.18
Omnibus Budget Reconciliation Act of 1990	1991Q1	0.60
Omnibus Budget Reconciliation Act of 1993	1993Q3	1.02
	1993Q4	−0.59
	1994Q1	0.19
Tax Payer Relief Act and Balanced Budget Act of 1997	2000Q1	0.02
	2002Q1	0.01
Economic Growth and Tax Relief Reconciliation Act of 2001	2002Q1	−0.80
Jobs and Growth Tax Relief Reconciliation Act of 2003	2003Q3	−2.86
	2004Q3	1.70
	2005Q1	0.56

Source: Romer and Romer (2010) and Mertens and Ravn (2012).

APPENDIX B: TAX RATE COMPUTATION

Capital and labor tax rate: Capital and labor income tax rates are computed as average tax rates following the methodology in Jones (2002), which is summarized below:

1. Compute the average personal income tax rate (τ_p)

$$\tau_p = \frac{\text{FIT} + \text{SIT}}{\text{W} + \text{PRI}/2 + \text{CI}}$$

$$\text{CI} = \text{PRI}/2 + \text{RI} + \text{CP} + \text{NI},$$

where
FIT = federal income taxes (NIPA Table 3.2, line 3).
SIT = state and local income taxes (NIPA Table 3.3, line 3).
W = wages and salaries (NIPA Table 1.12, line 3).
CI = capital income.
PRI = proprietor's income (NIPA Table 1.12, line 9).
RI = rental income (NIPA Table 1.12, line 12).
CP = corporate profits (NIPA Table 1.12, line 13).
NI = net interest (NIPA Table 1.12, line 18).
Below we graph the average personal income tax rate for the United States for the period 1958Q1–2009Q2.

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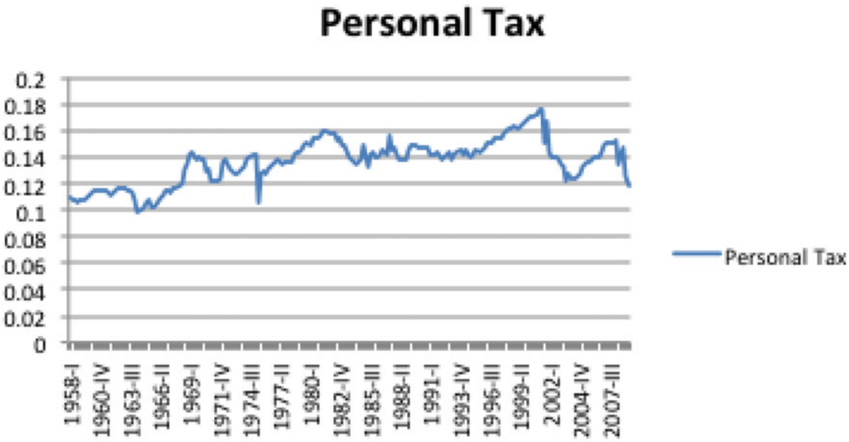

2. Compute the labor tax rate (τ_l).

$$\tau_l = \frac{\tau_p(\mathrm{W} + \mathrm{PRI}/2) + \mathrm{CSI}}{\mathrm{EC} + \mathrm{PRI}/2},$$

where
CSI = total contributions to government social insurance (NIPA Table 3.1, line 7).
EC = total compensation of employees (NIPA Table 1.12, line 2).
Below we graph the average labor income tax rate for the United States for the period 1958Q1–2009Q2.

3. Compute the capital tax rate (τ_k)

$$\tau_k = \frac{\tau_p \mathrm{CI} + \mathrm{CT} + \mathrm{PT}}{\mathrm{CI} + \mathrm{PT}},$$

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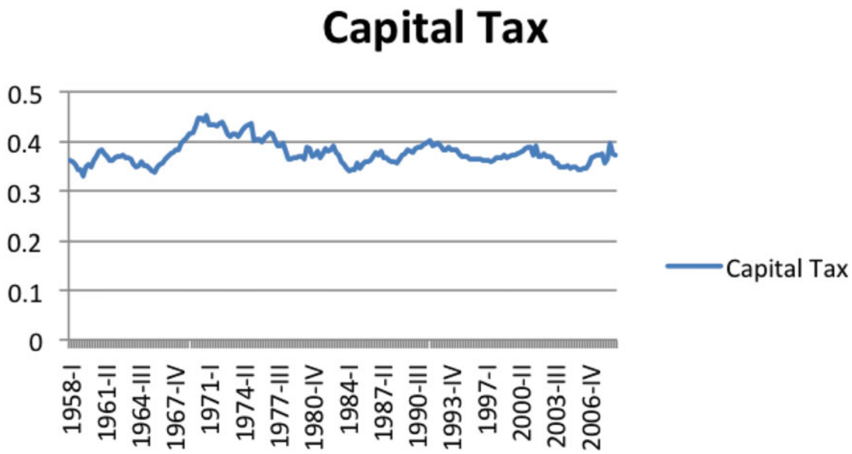
where
CT = corporate taxes (NIPA Table 3.1, line 5).
PT = property taxes (NIPA Table 3.3, line 8).
Below we graph the average capital income tax rate for the United States for the period 1958Q1–2009Q2.



APPENDIX C: DATA

This appendix supplies detailed information about the US data used in this paper. The data cover the interval 1958Q1–2009Q2.

Output: GDP, NIPA Table 1.1.5 (line 1), in current dollars.

Consumption: Personal consumption expenditures for nondurables and services, NIPA Table 1.1.5 (line 5+line 6), in current dollars.

Investment: Gross private investment, NIPA Table 1.1.5 (line 7), in current dollars.

Price deflator: Implicit GDP deflator, NIPA Table 1.1.9 (line 1).

We use the GDP deflator in order to convert to real terms the nominal consumption, investment, and output series.

Population: Civilian noninstitutional population 16+, from Bureau of Labor Statistics, CNP16OV.

Total hours worked: Hours of wage and salary workers on nonfarm private sector payrolls, seasonally adjusted; Bureau of Labor Statistics (ftp://ftp.bls.gov/pub/special.requests/opt/tableb10.txt) for the post-1964, and Valerie Ramey's website (http://weber.ucsd.edu/~vramey/research.html#data) for the pre-1964 years.

The variable X in per capita terms is labeled x and was computed as

$$x = \ln\left(\frac{X}{\text{Population}}\right).$$

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