News About Taxes and Expectations-Driven Business Cycles*

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Abstract

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, while 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 capable to generate qualitatively and quantitatively realistic business cycle fluctuations. Qualitatively, news about a permanent decrease in the capital income tax rate results in a simultaneous increase in output, consumption, investment, and hours worked. Quantitatively, statistical properties of the model generated macroeconomic aggregates are comparable with their empirical counterparts. In contrast with previous studies in expectations-driven business cycle literature, our results do not rely on non-separable preferences.

Keywords: Expectations-Driven Business Cycles; Tax Shocks.

JEL Classification: E32; E62.

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1 Introduction

This paper analyzes the possibility of expectations-driven business cycles to emerge in a one-sector real business cycle (RBC, henceforth) model if the unique driving force is news about future income tax rates. This framework allows us to isolate the effects of news about labor and capital income tax rate changes. We find that good news about labor income tax rates cannot generate expectations-driven business cycles, while good news about capital income tax rates can.

The importance of expectations in driving business cycles is generally acknowledged. At the same time, it is known that a standard one-sector RBC model driven solely by news shocks regarding future productivity cannot deliver realistic business cycle fluctuations. By news shocks we mean signals received by the agents that are used in forming expectations regarding the future economic fundamentals (such as productivity, preferences, taxes, etc.), allowing therefore for some sort of anticipation and helping the agents build expectations. In particular, Beaudry and Portier (2004, 2007) proved that it is impossible to obtain expectations-driven business cycles in the standard one-sector RBC 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. In the standard one-sector RBC model signals about a future productivity improvement makes current consumption and current investment move in opposite directions. Intuitively, upon the arrival of the good news, agents want to increase consumption \( \text{via} \) a dominating positive wealth effect. Since leisure is a normal good, simultaneously they want to increase its consumption as well, detrimental to hours worked. But given that capital is predetermined and there have been no changes in fundamentals yet, lower worked hours means lower output. Since output decreases and consumption increases, it must be the case that investment decreases. Therefore, good news about the future sets off an output recession today, and induces consumption on the one hand, and investment, hours worked, and output on the other hand to move in different directions, which contradicts the empirical facts for the U.S. economy.

Jaimovich and Rebelo (2009) present a one-sector RBC model able to generate realistic business cycle fluctuations. The key ingredients of their model are: (i) a generalized form
of preferences, which allows for the parametrization of the short-run wealth effect on labor supply; (ii) investment adjustment costs; and (iii) variable capital utilization. Karnizova (2010) proposes a model featuring: (i) agents with non-separable preferences in consumption and wealth; and (ii) adjustment costs to capital investment. Her model generates realistic business cycle fluctuations as well. As a common trait of these two models we notice the assumption of non-separable preferences and the existence of investment adjustment costs. Both models are driven by news regarding future productivity or future investment technological progress.

Similar to the business cycles literature that developed beginning early 80’s, the news-driven business cycles literature that emerged in early 2000s so far has mainly concentrated on supply side shocks, such as a productivity shock. However, an especially generous environment in news/signals release is represented by the income tax policy legislative process. By its nature, the legislative process provides agents with news, allowing them 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\(^1\) and important for all categories of agents. The importance of income taxation is twofold: on the one hand, this is a pervasive matter, affecting the great majority of the population; on the other hand, income taxes represent the most significant source of revenue for the federal government, amounting to roughly sixty percents of its revenue in the post-war era\(^2\).

From an empirical point of view, early studies analyzing the impact of anticipation about tax changes concentrated on the response of consumption. Poterba (1988) cannot find evidence that consumption expenditure is significantly affected by news about policy changes. Romer and Romer (2010) use a narrative approach for identifying the major post-war tax events from Congressional reports and presidential speeches. They find that a one percent of GDP tax increase triggers a three percent drop in GDP over a three year interval. Mertens and Ravn (2011b) use the tax episodes identified by Romer and Romer (2010) to assess the impact of anticipated tax changes on the main macroeconomic

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\(^2\)Yang (2007) reports 66.4% in 1950 and 58.1% in 2006, based on Joint Committee on Taxation documents.
aggregates. They find evidence that output, consumption, investment, and hours worked all react to both anticipated and unanticipated tax changes and that at business cycle frequencies tax shocks account for 20 to 25 percents of the output volatility. Both Romer and Romer (2010) and Mertens and Ravn (2011b) measure the tax shocks as changes in tax liabilities as percentage of GDP, and therefore do not distinguish between the individual impact of a capital or labor income tax change.

Given these pieces of evidence, 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 future income tax rates. To this purpose, 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.

The combination of variable capital utilization and investment adjustment costs gives rise to a labor market in which the intercept of the labor demand curve depends on the predetermined capital stock, past investment, current consumption and current capital tax rate, as well as on the next period’s investment. The intercept of the labor supply curve is a function of current consumption and the labor income tax rate.

We first analyze the impact of an announcement today regarding a one percent permanent decrease in the labor income tax rate that is to be implemented after four quarters. We find that in the current period agents react by increasing consumption and decreasing investment and hours worked. As a result, there is a weak increase in output. Intuitively, when agents receive the good news about future labor income taxation, they anticipate an increase in both their labor income and the return on capital at the time when the news materializes. Due to a dominating positive wealth effect agents increase consumption and leisure today, and consequently decrease labor hours. Simultaneously, the anticipated increase of the marginal product of capital (MPK, henceforth) in the future due to the higher labor hours, gives them incentives to decrease investment today and increase it in the future when they can benefit from the higher marginal product of capital. Overall, consumption and output increase and investment and hours worked decrease in the current period and hence good news about the labor income tax rate cannot generate
expectations-driven business cycles.

The second experiment that we run focuses on the impact of an announcement today regarding a one percentage point permanent decrease in the capital income tax rate which is to be implemented in four quarters. We find that this announcement triggers an expansion in all four aggregates in the current period. Intuitively, upon the arrival of the news, agents anticipate an increase in both their labor income and the marginal product of capital at the time when the decrease in tax is actually implemented. Again, current consumption increases due to a dominating positive wealth effect. However, in this case the agents anticipate a strong increase in the future return on capital, due to both an indirect effect through labor hours and a direct effect through the lower tax. Therefore, it becomes optimal to strongly increase investment upon the tax implementation. However, due to investment adjustment costs, large variations in investment are costly, which makes the agents start investing immediately, so that they can enjoy the higher return in the future. Therefore, consumption and investment increase today, so does labor hours and consequently output must also increase. This means that 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 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 income tax shocks can account for a significant share of the business cycle volatility. This is in agreement with Mertens and Ravn (2011b). However, the results are not perfectly comparable, since Mertens and Ravn (2011b) do not distinguish between labor and capital tax rates and rather lump these two effects in an overall decrease in tax liability as a percentage of GDP.

This paper adds to the previous literature on the effects of tax fluctuations such as Chang (1992), Braun (1994), McGrattan (1994), or Yang (2005) which analyze the effects of distortionary corporate and personal income taxation in the context of a one-sector RBC model. Compared to previous studies, we are interested in assessing the effects of news regarding income tax rate changes. We focus on isolating the effect of news regarding labor and capital income tax rates, by simulating versions of the model driven solely by news
shocks. We find that good news about labor income tax rates cannot generate expectations-driven business cycles, while good news about capital income tax rates can.

The remaining part of the paper is organized as follows: In Section 2 we lay down the model and discuss the equilibrium and the labor market structure. In Section 3 we analyze the possibility of expectations-driven business cycles to emerge. In Section 4 we simulate the model. In Section 5 we conclude.

2 The Model

The model economy is inhabited by 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 also 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 household. The household uses these proceeds for acquiring consumption goods. The government imposes a set of distortional taxes on the private agents 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 and maximizing a discounted stream of expected utilities over its lifetime

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

where \( E \) is the conditional expectations operator, \( \beta \) is the discount factor, \( c_t \) stands for consumption, \( n_t \) for hours worked, \( \gamma \) denotes the inverse of the labor supply elasticity, and \( A > 0 \) represents a preference parameter.
The representative household derives income from three sources: (i) 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 $\tau_{nt}$. The wage $w_t$, the labor income tax rate $\tau_{nt}$, the dividends $d_t$, and the transfers $T_t$ are regarded by the households as being set beyond their 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

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

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

$$Ac_t n_t^2 = (1 - \tau_{nt})w_t.$$  \hfill (3)

The intratemporal condition in (3) equates the household’s marginal rate of substitution between consumption and leisure to the net of taxes 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

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

where $u_t$ represents the endogenous rate of capital utilization, $k_t$ represents the capital stock, and therefore $u_t k_t$ represents the 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
\[ k_{t+1} = (1 - \delta_t)k_t + i_t \left( 1 - \varphi \left( \frac{i_t}{i_{t-1}} \right) \right), \quad k_0, i_{-1} > 0 \text{ given}, \]

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

\[ \delta_t = \frac{\alpha^{1+\theta}}{1 + \theta}, \]

where \( \theta > 0 \) represents the elasticity of the marginal depreciation with respect to the utilization rate. As in most studies of variable capital utilization, the rate of depreciation \( \delta_t \) is assumed to be an increasing and convex function of the capital 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 costs function \( \varphi(\cdot) \), about which we know that \( \varphi(1) = \varphi'(1) = 0 \) and that \( \varphi''(1) = \phi > 0 \).

We postulate the following functional form for \( \varphi(\cdot) \)

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

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 what should be the capital stock \( k_{t+1} \) next period. The government imposes on firms a corporate tax 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 capital, and we further refer this tax as a capital tax and denote it \( \tau_{kt} \). 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. Atkinson and Stiglitz (1980) treat the “classical” tax system, in which the

\[^3\text{See Christiano, Eichenbaum, and Evans (2005) for more on the investment adjustment costs function.}\]
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).

Each period, the firm distributes to the households, in the form of dividends, the revenue generated during that period in excess to the 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 $1/c_t$

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

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.

The first order conditions for the firm’s problem are

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

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

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

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

8
along with the transversality conditions, where \( \mu_t \) 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 \( \mu_t \), (10) also becomes an intertemporal condition. Equations (11) and (12) represent the Euler equations that govern the household’s intertemporal consumption and investment choices.

From the above first order conditions one can clearly see that the labor income tax rate affects the intratemporal tradeoff between consumption and leisure at a given date \(t\), while the capital income tax rate affects the intertemporal tradeoffs.

### 2.3 Government

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

Hence, in each period \(t\), government’s lump-sum transfers are equal to

\[
T_t = \tau_{nt} w_t n_t + \tau_{kt} (y_t - w_t n_t) - \tau_{kt} \delta k_t,
\]

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

\[
ct + it = yt
\]
2.4 Competitive equilibrium

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

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 \( \{n_t, k_{t+1}, u_t\}_{t=0}^{\infty} \) to maximize (8), subject to (4), (5) and (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)).

2.5 Labor Market

In this section we derive the labor demand and supply\(^4\) curves. In order to get a better understanding of the mechanism at work in our experiments, we will look at both current (time \( t = 1 \)) and anticipated at time \( t = 1 \) future (time \( t = 4 \)) labor markets. In what follows, a hat on a variable represents its log-deviation from the deterministic steady state.

The labor supply curve can be obtained by log-linearizing (3) around the deterministic steady-state. The labor supply curve writes

\[
\hat{w}_t = \hat{c}_t + \frac{\tau_n}{1 - \tau_n} \hat{n}_t + \gamma \hat{n}_t
\]  

(15)

Since \( \gamma \geq 0 \), the labor supply curve is upward sloping. An increase (decrease) in current consumption or labor income tax rate will shift the labor supply curve leftwards (rightwards).

\( ^4\)For more on the labor market approach, see Wang (2010).
The labor demand curve can be derived by log-linearizing (9) around the deterministic steady-state, and using (4), (10), (12), and (14) in log-linearized form. The labor demand curve is given by

$$c_w t = B + \alpha \phi(c_{ss}/i_{ss})\hat{c}_t + \alpha \phi\beta \hat{i}_{t+1} - \alpha \frac{r_k}{1 - r_k} \hat{r}_{kt} + \left[ \frac{(1 - \alpha)(1 + \theta)}{(1 + \theta) - \alpha + \alpha \phi(1 + \beta)(y_{ss}/i_{ss})} - 1 \right] \hat{n}_t,$$

(16)

where $c_{ss}, i_{ss}$ and $y_{ss}$ denote the deterministic steady-state level of consumption, investment and output respectively and $B$ lumps terms containing predetermined variables, with $B = ((1 + \theta) - \alpha)\hat{k}_t + \alpha \phi\hat{i}_{t-1}$.

Regarding the slope of the demand curve, since $0 < (1 - \alpha)(1 + \theta) < ((1 + \theta) - \alpha)$ and $\alpha \phi(1 + \beta)(y_{ss}/i_{ss}) > 0$, the first ratio is clearly higher than zero and smaller than one and consequently we have a downwards sloping demand curve. Moreover, the intercept of the demand curve is a function of the predetermined capital stock, past investment, current consumption and capital income tax rate and future investment. Any change in the current and future-period variables causes a shift in the labor demand curve. An increase (decrease) in current consumption or future investment and a decrease (increase) of the current capital tax rate triggers a rightwards (leftwards) shift of the labor demand curve. Since the capital stock and past investment are predetermined, they do not change in the current period and consequently cannot cause a shift in the labor demand curve.

The structure of the labor demand curve is due to the combination of variable capital utilization and investment adjustment costs. In a model featuring only variable capital utilization, from (10) we notice that a change in the capital income tax rate alters its marginal product and therefore leads to a change in the utilization rate. The utilization rate and further the technology can be expressed as a function of capital, labor and the capital income tax rate. The intercept of the labor demand curve depends in this case on the predetermined capital and the capital income tax rate. On the other hand, when we have only investment adjustment costs, output is a function of capital and labor only. Therefore, if these features are separated, the intercept of the labor demand curve is a function of
the capital stock which is predetermined in the current period and, possibly, the capital income tax rate. Hence, in our situation, when the two features are combined, variable capital utilization makes the intercept of the labor demand curve a function of the current capital income tax rate. At the same time, the combination of variable capital utilization and investment adjustment costs makes the utilization rate an increasing function of current consumption and future investment, and therefore the intercept of the labor demand curve will depend on them as well. As a consequence, the labor demand intercept is a function of the predetermined capital stock and past investment, current consumption, current capital tax rate, and future investment, this way leaving room for richer dynamics.

3 Expectations-Driven Business Cycles

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

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 a signal that there will be a permanent one percentage point decrease in the capital/labor income tax rate from period 4 onwards. 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 US economy. The time period in our model economy is one quarter. The capital share in income is set to 0.36, the discount factor \( \beta = 0.985 \), which corresponds to an annual average of 6.5 percents return to capital, as in King, Plosser, and Rebelo (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 steady-state, the labor supply is infinitely elastic, i.e., \( \gamma = 0 \), as in Hansen (1985). Given the calibrated values for \( \beta \) and \( \delta \), \( \theta = 0.796 \). The preference parameter \( A = 1.734 \), so that labor hours equal one third in the steady-state. Capital and labor tax rates are computed as averages for the interval 1958Q1-2009Q2 and are set to \( \tau_k = 37.5\% \) and \( \tau_n = 21\% \) respectively, which represent averages over the interval we consider. Labor and capital income tax rates series are computed as average tax rates based on the tax receipts from the National Income and Product Accounts. Details about tax rate computations are supplied in Appendix A1. Table 1 below summarizes the parameters used.

### Table 1: Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>Capital income share</td>
<td>0.36</td>
<td>Hansen (1985)</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Discount factor</td>
<td>0.985</td>
<td>King, et al. (1988)</td>
</tr>
<tr>
<td>( \delta )</td>
<td>Steady-state depreciation rate</td>
<td>0.013</td>
<td>s.t. ( \frac{k}{\bar{y}} = 2.4 )</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>Inverse labor supply elasticity</td>
<td>0</td>
<td>Indiv labor (Hansen (1985))</td>
</tr>
<tr>
<td>( A )</td>
<td>Preference parameter</td>
<td>1.734</td>
<td>s.t. ( \bar{\pi} = 1/3 )</td>
</tr>
<tr>
<td>( \theta )</td>
<td>Marginal depreciation elasticity</td>
<td>0.796</td>
<td>Computed based on ( \beta, \delta )</td>
</tr>
<tr>
<td>( \tau_n )</td>
<td>Average labor income tax rate</td>
<td>21%</td>
<td>Computed (Jones (2002))</td>
</tr>
<tr>
<td>( \tau_k )</td>
<td>Average capital income tax rate</td>
<td>37.5%</td>
<td>Computed (Jones (2002))</td>
</tr>
<tr>
<td>( \phi )</td>
<td>( \phi = \varphi''(1) )</td>
<td>1</td>
<td>Match the actual ( \sigma_i/\sigma_y )</td>
</tr>
</tbody>
</table>

All parameters except the parameter characterizing the investment adjustment costs 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 micro-studies 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 investment in order to set \( \phi = \varphi''(1) \).

### 3.2 Dynamic Responses

#### 3.2.1 Labor Tax

In this subsection 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 one percentage

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5. This corresponds to a value of \( \delta = 0.0225 \) in an economy without taxation.

6. Tax rates series were computed using the method in Jones (2002).
point decrease in 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.

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. In order to understand this result it is crucial to understand what agents anticipate that will happen in the time $t = 4$ labor market once they get the news at time $t = 1$. This is depicted in Figure 2. This being understood, what happens in the time $t = 1$ labor market unravels in a very natural way. From (15), the intercept of the labor supply curve is positively related to the labor income tax rate and therefore when the agents get the news about the decrease in the labor income tax rate, they anticipate that a lower $\tau_{n4}$ will shift the labor supply curve at $t = 4$ rightwards, which results in the equilibrium shifting from $E$ to $E'$ in Figure 2. The new equilibrium is characterized by a lower wage $w_4$ and higher hours worked $n_4$. Overall, labor income, $w_4n_4$ rises. The marginal product of capital is a function of consumption, future investment, and labor hours and therefore increases as well. The increase in the expected lifetime labor income makes the agents want to increase consumption and decrease investment today 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. Since the wealth effect dominates, current consumption $c_1$ increases. Investment at time $t = 1$ decreases until the news materializes and the higher $MPK_4$ gives agents strong incentives to start increasing it again. Figure 3 depicts the time $t = 1$ labor market. The increase in consumption, causes a leftwards shift in the labor supply curve and simultaneously a rightward shift of the labor demand curve. However, the drop in the next period’s investment tempers the shift in the labor demand curve, and consequently the shift in the demand curve is relatively less important than the shift in the labor supply curve and the equilibrium shifts from point $E$ to point $E'$ in the current period. The new equilibrium is characterized by lower labor hours $n_1$ and a higher wage $w_1$. We know that the current utilization rate and therefore current output depend positively on current con-
consumption and labor hours, and future investment. In our case, the higher consumption and lower future investment and labor hours bring about an increase in the current utilization rate, which along with the drop in hours worked trigger a small increase in current output.

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.

### 3.2.2 Capital Income Tax

**The Mechanism** In this section we want to assess the impact on the economy of an announcement made by the government today in period $t = 1$ regarding a permanent one percentage point decrease 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. The news materializes and starting $t = 4$ the capital income tax rate permanently decreases by one percentage point.

Figure 4 depicts the response of the economy to the above experiment. We can clearly see that upon the arrival of the good news about the capital income tax rate there is an economic expansion as all aggregates increase on impact. To understand the mechanism at work, we rely again on the labor market diagrams. Figure 5 depicts what agents anticipate that will happen in the time $t = 4$ labor market once they get the news at time $t = 1$. From (16), the intercept of the labor demand curve is negatively related to the capital income tax rate and therefore when the agents get the news about the decrease in the capital income tax rate, they anticipate that a higher $k_4$ will shift the labor demand curve at $t = 4$ rightwards, which results in the equilibrium shifting 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 labor income, $w_4 n_4$. Due to the increased hours, the agents anticipate a higher $MPK$ at time $t = 4$. 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 the income effect dominates, we observe an increase in current
consumption, which means a leftwards shift in the labor supply curve, and a simultaneous rightwards shift in the labor demand curve at time $t = 1$. Figure 6 depicts the time $t = 1$ labor market. The anticipated increase in the future $MPK$ is very strong. This is the result of two effects: on the one hand, there is a direct effect \textit{via} the lower income tax rate; on the other hand there is an indirect effect that works \textit{via} the increased labor hours. In the case of a labor income tax rate, only the latter effect was present and consequently the expected increase in $MPK$ was smaller. Therefore, agents expect that at $t = 4$ when the news materializes it will 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. The increase in next period’s investment causes an even further rightwards shift of the labor demand curve. This makes the shift in the labor demand curve relatively stronger than the shift in the labor supply curve, causing the equilibrium to shift from point $E$ to $E'$ in Figure 6. The new equilibrium has higher wages and higher labor hours. Since consumption, investment, and hours all increase, output clearly increases in the current period. Hence, good news about future capital income taxation generates expectations-driven business cycles.

\textbf{The Features of the Model} In this section we address the importance of the two features of the model, variable capital utilization and investment adjustment costs, in delivering expectations-driven business cycles. We show that both features of the model are crucial 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 7 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. Intuitively, at time $t = 1$, the 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. This gives agents incentives to cut down current consumption. At time $t = 1$, the lower consumption causes a rightwards shift of the labor supply curve. Therefore, the new equilibrium is characterized by higher labor hours and as a consequence by higher output. Since output increases and consumption falls, investment necessarily increases. Hence, expectations-driven business cycles cannot emerge. Furthermore, we mention that introducing investment adjustment costs to this version of the model does not help us restore the result. Investment adjustment costs will only smooth investment, but in all cases consumption falls and investment goes up.

Next, we consider a version of the model with variable capital utilization, but no investment adjustment costs. Figure 8 depicts the impulse response functions for this case. The arrival of the good news causes an increase in consumption and a decrease in the other three aggregates. Without adjustment costs, the first order condition with respect to the capital utilization rate in (10) becomes

$$u_t^\psi k_t = (1 - \tau_{kt})\frac{y_t}{u_t},$$

which clearly 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. Further, the intercept of the labor demand curve will depend positively on the predetermined capital stock and negatively on the capital income tax rate. Therefore, the agents standing at time $t = 1$ anticipate that at time $t = 4$ the decrease in the capital income tax rate causes the labor demand curve to shift rightwards. The new (anticipated) equilibrium point is characterized by a higher wage, higher labor hours and higher marginal product of capital due to both lower tax and higher labor hours. The expected higher labor income makes agents increase current consumption \textit{via} a positive wealth effect, while the higher expected $MPK_4$ makes agents decrease consumption \textit{via} a substitution effect. The wealth effect dominates and current consumption increases, which causes a leftwards shift of the labor supply curve in the current period. This results in a decrease in labor hours, output
and consequently investment. Therefore, introducing only one of the two features of the model precludes us from obtaining expectations-driven business cycles.

4 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 aggregates generated in the model with their empirical counterparts. The simulation method used to evaluate our model relies on Jaimovich and Rebelo (2009).

In order to simulate the model, we first compute average capital income tax rates using the method in Jones (2002). This series follows the following first order autoregressive process

\[ \frac{1}{\tau_{kt+1}} = 0.95\tau_{kt} + \chi_{kt} \]  

(18)

where \( \chi_{kt} \) is normally distributed with mean zero and standard deviation \( \sigma = 0.0078 \).

Using Adda-Cooper(2003) discretization method we approximate the AR(1) process (18 ) by a two-point Markov chain with support

\[ \{ \tau^L_k, \tau^H_k \} = \{35.5%, 39.5\% \} \]  

(19)

where the \( L \) superscript stands for low tax and a \( H \) superscript stands for high tax, and transition matrix

\[
\begin{bmatrix}
0.8989 & 0.1011 \\
0.1011 & 0.8989
\end{bmatrix}
\]  

(20)

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

Agents get a signal, for example, the presidential address, passage of a tax bill by the House of Representatives or the 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 a low tax rate. We denote this signal by $T_t \in \{L, H\}$ and consider

$$\Pr ob(T_t = H | \tau_{kt+4} = \tau_k^H) = a_1,$$
$$\Pr ob(T_t = L | \tau_{kt+4} = \tau_k^L) = a_2,$$

where $a_1, a_2 \in [0, 1]$, where 0 means that the signal is not informative at all and 1 means that we have a precise signal.

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

$$\Pr ob(\tau_{kt+4} = \tau_k^H | T_t = i, \tau_{kt}) = \frac{\Pr ob(T_t = i | \tau_{kt+4} = \tau_k^H) \Pr ob(\tau_{kt+4} = \tau_k^H | \tau_{kt})}{\sum_{j=L,H} \Pr ob(T_t = i | \tau_{kt+4} = \tau_k^j) \Pr ob(\tau_{kt+4} = \tau_k^j | \tau_{kt})}$$

(22)

Until now, all parameters have been set, except the parameter characterizing the strength of the investment adjustment costs, $\phi$, and those characterizing the precision of the signal received by the agents, $a_1$ and $a_2$, for which there are no a priori estimates. In order to pin down these parameters, we use a Simulated Method of Moments (SMM, henceforth).

We define a vector $\Gamma = (\phi \quad a_1 \quad a_2)$ containing the parameters that need to be pinned down. The idea of the SMM is to choose the vector of parameters $\Gamma$ such that we minimize the distance between the empirical moments and those generated in the model. We choose as targets the relative to output volatility of investment, $\sigma_i/\sigma_y$, the relative to output volatility of consumption, $\sigma_c/\sigma_y$, and the contemporaneous correlation between hours worked and output $\rho_{ny}$. The choice of the relative to output volatility of investment is motivated by the fact that we want to estimate the parameter characterizing the strength of the investment adjustment costs. The precision parameters do not impose the choice of particular targets and therefore we choose a consumption-related target and one related to labor hours.
For a given set of parameters $\Gamma$, we simulate the model $N = 500$ times for $T = 202$ periods (the length of the interval in each simulation is 280 periods, but from each simulation we drop the first 58 periods in order to minimize the effects of the initial conditions). The estimate of $\Gamma$ is

$$\hat{\Gamma} = \arg \min \left( M_{T}^{Data} - M_{TN}^{Model}(\Gamma) \right) \Omega \left( M_{T}^{Data} - M_{TN}^{Model} \right)$$

(23)

where $M_{T}^{Data}$ represents the vector of targets, calculated from actual data and $M_{TN}^{Model}(\Gamma) = \left( \frac{\sigma_i(\Gamma)}{\sigma_y(\Gamma)}, \frac{\sigma_c(\Gamma)}{\sigma_y(\Gamma)}, \rho_{ny}(\Gamma) \right)$ denotes the vector of model generated relative to output volatility of investment and consumption respectively and contemporaneous labor-output correlation, constructed as averages over the $N$ simulations for a particular parameter vector $\Gamma$. The matrix $\Omega$ represents a weight matrix $^7$.

This procedure yields $\Gamma = (\phi \ a_1 \ a_2) = (0.96 \ 1 \ 1)$. The criterion in (23) supports the existence of precise signals. Mertens and Ravn (2011b) find a median implementation lag (i.e., the interval between the enactment of the law and the moment when the tax liability changes) of 6 quarters for the case of anticipated$^8$ tax policy changes. Therefore, our estimates seem reasonable.

The performance of the model is compared to the U.S. data for 1958Q1 – 2009Q2. Details regarding the data can be found in the Appendix A1.

In Table 2 we compare the US data statistics (volatilities and contemporaneous correlations with output respectively) and the model generated ones. The first column presents the U.S. data statistics, while the second column presents the statics for the calibrated model. For both U.S data and the model generated ones we first take natural logarithms of the series and then detrend them using the Hodrick-Prescott filter$^9$.

Regarding the volatilities, since we can expect that not the entire business cycle volatility is due to income tax rates shocks, we focus on relative to output volatilities, reported in parentheses. We notice that news about capital income tax rates can explain an important share of the output volatility. Moreover, the model does a very good job regarding the

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$^7$ Matrix $\Omega$ was computed as the inverse of the variance-covariance matrix of these estimators from $N$ replications. This weight matrix insures that the $\hat{\Gamma}$ estimate is both consistent and efficient.

$^8$ Mertens and Ravn (2011b) consider that a policy change is anticipated as long as the interval between the enactment of the law and the moment when the tax liability changes is greater than 1 quarter (90 days).

$^9$ We use a smoothing parameter $\lambda = 1600$. 

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ranking of the volatilities: investment is the most volatile aggregate, followed by output, hours, and consumption. Notice here that the relative to output volatilities of consumption and investment are very well matched.

Regarding the contemporaneous correlations with output, we notice that consumption, investment and hours worked are all strongly pro-cyclical, as observed in the data. The model does particularly well in matching the hours and investment correlations with output.
### Table 2: Business Cycle Moments

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data (58Q1-09Q2)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volatilities*($\sigma_x$)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_y$</td>
<td>1.57(1.00)</td>
<td>0.77(1.00)</td>
</tr>
<tr>
<td>$\sigma_c$</td>
<td>0.89(0.57)</td>
<td>0.41(0.53)</td>
</tr>
<tr>
<td>$\sigma_i$</td>
<td>7.31(4.66)</td>
<td>3.87(5.02)</td>
</tr>
<tr>
<td>$\sigma_n$</td>
<td>1.53(0.98)</td>
<td>0.45(0.59)</td>
</tr>
<tr>
<td>Contemporaneous Correlations with output ($\rho_{xy}$)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_{cy}$</td>
<td>0.82</td>
<td>0.88</td>
</tr>
<tr>
<td>$\rho_{iy}$</td>
<td>0.91</td>
<td>0.93</td>
</tr>
<tr>
<td>$\rho_{ny}$</td>
<td>0.89</td>
<td>0.90</td>
</tr>
</tbody>
</table>

*numbers in parentheses are relative to output standard deviations  
** $\sigma_x$ represents the volatility of variable $x$  
*** $\rho(x, y)$ represents the contemporaneous correlation of variable $x$ with output $y$

Therefore, our model does generate plausible business cycle fluctuations.

### 5 Conclusion and Extensions

The standard one-sector RBC model driven only by news shocks to future productivity cannot generate expectations-driven business cycles. We find that good news about labor income tax rates cannot generate expectations-driven business cycles, while good news about capital income tax rates can. We show that a one-sector RBC model driven by news shocks about capital income tax rates is capable to generate qualitatively and quantitatively realistic business cycle fluctuations. The ingredients of our model are (i) separable utility; (ii) variable capital utilization; and (iii) investment adjustment costs. The last two elements are commonly used ingredients in the news driven business cycles literature. However, the separability of preferences distinguishes our model from other models in the literature driven only by news shocks. We calibrate the model to U.S. data and single out the impact of news about labor and capital income tax rates. Key for understanding our finding is to realize what agents standing today anticipate that will happen in the future when the news materializes and the change in tax rate is implemented. We also simulate a version of our model driven by news shocks to capital income tax rates and find that the moments for the model generated aggregates are very similar to those in the data.
One interesting extension of this analysis is to analyze the robustness of the results for alternative forms of capital taxation. For example, the government may allow for accelerated depreciation, instead of true depreciation. This corresponds to the “bonus depreciation” provision from which the U.S agents could benefit over the last years, for a limited period.

6 Data Appendix

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

Output: Gross domestic product, NIPA Table 1.1.5 (line 1), in current dollars
Consumption: Personal consumption expenditures for non-durables 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: The 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

Hours Worked: are computed as follows:

\[ HoursWorked = AverageHours \times Employment \]

where AverageHours = nonfarm business, all persons, average annual hours. Average nonfarm business hours are from BLS (1964Q1-2010Q4) and for the interval before 1964, from Valerie Ramey’s website. Employment = Total nonfarm employment, seasonally adjusted, from Bureau of Labor Statistics, PAYEMS

Per capita variables are computed as

\[ x = \ln \left( \frac{X}{Population} \right) \]
**Capital and Labor Tax Rate:** The 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 ($\tau_p$)

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

$$CI = PRI/2 + RI + CP + NI$$

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)

2. Compute the labor tax rate ($\tau_l$)

$$\tau_l = \frac{\tau_p[W + PRI/2] + CSI}{EC + PRI/2}$$

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)

3. Compute the capital tax rate ($\tau_k$)

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

where
$CT=$corporate taxes (NIPA Table 3.1, line 5)

$PT=$property taxes (NIPA Table 3.3, line 8)
References


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 $t = 4$
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 starting by 1 percentage point starting $t = 4$.

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 $t = 4$. 
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 $t = 4$. 
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 $t = 4$.

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 $t = 4$. 
Figure 7: 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 and output reach the new steady-state after about 20 quarters)
Figure 8: Impulse response functions for a 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 adjustment costs (consumption reaches the new steady-state after about 20 quarters)