News About Taxes and Expectations-Driven Business Cycles*

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December 6, 2012

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 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.
JEL Classification: E32; E62.

*I am grateful to Richard Arnott and Jang-ting Guo for helpful discussions and comments. I would also like to thank Marcelle Chauvet, Robert R. Russell, Richard Suen, and Yi-Chan Tsai for presentation suggestions. Of course, all remaining errors are my own.

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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 agents that are used in forming expectations regarding future economic fundamentals (such as productivity, preferences, tax rates, 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 about the future. In the standard one-sector RBC model signals about an upcoming productivity improvement make current consumption and current investment move in opposite directions. Intuitively, upon the arrival of the good news, agents want to increase consumption *via* a dominating positive wealth effect. Since leisure is a normal good, they simultaneously 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 opposite 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 status[1]; 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 in 1980's, the news-driven business cycles literature that emerged in early 2000s has so far 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 taxation legislative process. By its nature, this 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[2] 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 budget, amounting to roughly sixty percents of its revenue in the post-war era[3].

From an empirical point of view, early studies analyzing the impact of anticipation about tax rate 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

[1] In her model, consumption and status are complements and in equilibrium status is determined by the market value of the capital stock. Therefore, consumption and investment and consequently output and hours worked automatically co-move in Karnizova's model.

[2] Yang (2007) documents 27 major tax events in the U.S. for the period 1948-2005.

[3] Yang (2007) reports 66.4% in 1950 and 58.1% in 2006, based on Joint Committee on Taxation documents.

year interval. Mertens and Ravn (2011*b*) use the tax episodes identified by Romer and Romer (2010) to assess the impact of anticipated tax changes on the main macroeconomic 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 output volatility. Both Romer and Romer (2010) and Mertens and Ravn (2011*b*) 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 rate 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[4]. 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.

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 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) due to the higher labor hours, gives them incentives to decrease investment today and increase it only in the future when they can benefit from the higher marginal product of capital. In our model, the endogenous rate of capital utilization is an increasing function of current consumption and future investment. The combination of increased consumption and lower investment causes the utilization rate to increase in the current period. Overall, consumption and output increase and investment and hours worked decrease in the current period

[4]Beaudry and Portier (2007) present an example regarding the effects of news about income tax rates in a multi-sector framework.

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 macroeconomic 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 rate would actually be implemented. Again, current consumption increases due to a dominating positive wealth effect. However, in this case agents anticipate a strong increase in the future return on capital, due to both an indirect effect through increased labor hours and a direct effect through the lower tax rate. Therefore, it becomes optimal to undertake a significant increase in investment upon the new tax rate implementation. However, due to investment adjustment costs, large variations in investment are costly, which provides incentives for the agents to start investing immediately, so that they can fully 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 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 news about income tax rates can account for a significant share of the business cycle volatility. This is in agreement with the empirical work by Mertens and Ravn (2011*b*). However, the results are not perfectly comparable, since Mertens and Ravn (2011*b*) do not distinguish between labor and capital income 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 income tax rate fluctuations such as Chang (1992), Braun (1994), McGrattan (1994), or Yang (2005) who 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 our model. In Section 4 we simulate the model. We conclude in Section 5.

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. Output is the numeraire. The government imposes a set of 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 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, the labor income tax rate τ_{nt}, the 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 the 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 net-of-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

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

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

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

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

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

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 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 costs function $\varphi(\cdot)$, about which we know that $\varphi(1) = \varphi'(1) = 0$ and that $\varphi''(1) = \phi > 0$[5]. 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 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 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

[5] See Christiano, Eichenbaum, and Evans (2005) for more on the investment adjustment costs function.

(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).

Each period, the representative firm distributes to the representative household, in the form of dividends, the revenue generated 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 $1/c_t$[6]

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

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.

The first order conditions for the firm's problem are

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

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

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

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

[6] 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 $u(c_t) = \log c_t$.

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) 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 first order conditions in (3), (10), and (11) one can 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, 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

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

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 $\{c_t,\ n_t,\ i_t,\ d_t,\ k_{t+1},\ u_t\}_{t=0}^{\infty}$, 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 $\{n_t, k_{t+1}, i_t, u_t\}_{t=0}^{\infty}$ 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[7] 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.

In our model, 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 k_t, past investment i_{t-1}, current consumption c_t, and current capital tax rate τ_{kt}, as well as on the next period's investment i_{t+1}. The intercept of the labor supply curve is a function of current consumption c_t and labor income tax rate τ_{nt}.

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

$$\widehat{w_t} = \widehat{c_t} + \frac{\tau_n}{1-\tau_n}\widehat{\tau_{nt}} + \gamma \widehat{n_t} \tag{15}$$

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

[7] 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

$$\widehat{w_t} = \frac{B + \alpha\phi(1+\beta)(c_{ss}/i_{ss})\widehat{c_t} + \alpha\phi\beta\widehat{i_{t+1}} - \alpha\frac{\tau_k}{1-\tau_k}\widehat{\tau_{kt}}}{((1+\theta)-\alpha) + \alpha\phi(1+\beta)(y_{ss}/i_{ss})} + \left[\frac{(1-\alpha)(1+\theta)}{((1+\theta)-\alpha) + \alpha\phi(1+\beta)(y_{ss}/i_{ss})} - 1\right]\widehat{n_t}, \tag{16}$$

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 $B = \alpha\theta\widehat{k_t} + \alpha\phi\widehat{i_{t-1}}$.

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.

This 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 current capital income tax rate. On the other hand, when we have only investment adjustment costs, output is a function of capital and labor and the intercept of the labor demand curve depends only on the predetermined capital. 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, 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 income 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 labor and capital 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 $\alpha = 0.36$, 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 the steady-state [8], the labor supply is infinitely elastic, i.e., $\gamma = 0$, as in Hansen (1985). Given the calibrated values for β and δ, $\theta = 0.796$. 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 $1958Q1 - 2009Q2$[9] 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 tax rate computations are supplied in the Data Appendix. Table 1 summarizes the parameters used.

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	21%	computed (Jones (2002))
τ_k	avg. capital income tax rate	37.5%	computed (Jones (2002))
ϕ	$\phi = \varphi''(1)$	0.96	match the actual σ_i/σ_y

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 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 investment in order to set $\varphi''(1) = \phi$. We use a Simulated Method of Moments to pin down this parameter. Details about the estimation are provided in the Quantitative Analysis section. This method recommends a value of $\phi = 0.96$.

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

[9] Tax rates series were computed using the method in Jones (2002).

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 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.

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 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 τ_{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, $w_4 n_4$ rises and so does the expected MPK. The increase in the expected lifetime labor income makes the agents willing 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 output depend positively on current consumption and labor hours, and future investment. In our case, the higher consumption and lower future investment 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 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. 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. 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 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 τ_{k4} 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 *via* the lower income tax rate; on the other hand there is an indirect effect that works *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 worked all increase, output clearly increases in the current period. Hence, good news about future capital income taxation generates expectations-driven business cycles.

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 for plausible degrees 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 8 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, the first order condition with respect to capital utilization in (10) becomes

$$u_t^{\theta} k_t = (1 - \tau_{kt}) \alpha \frac{y_t}{u_t}, \tag{17}$$

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. 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, 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 *via* a positive wealth effect, while the higher expected MPK_4 makes agents decrease consumption *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 macroeconomic aggregates generated in the model with their 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). This series follows the following first order autoregressive process

$$\overline{\tau_{kt+1}} = 0.95\overline{\tau_{kt}} + \chi_{kt} \tag{18}$$

where χ_{kt} is normally distributed with mean zero and standard deviation $\sigma_\chi = 0.0078$.

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

$$\left\{\tau_k^L, \tau_k^H\right\} = \{35.5\%, 39.5\%\} \tag{19}$$

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

$$\begin{bmatrix} 0.8989 & 0.1011 \\ 0.1011 & 0.8989 \end{bmatrix} \tag{20}$$

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 percents.

Agents get a signal, for example, a 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

$$\begin{aligned} \Pr ob(T_t &= H|\tau_{kt+4} = \tau_k^H) = a_1, \\ \Pr ob(T_t &= L|\tau_{kt+4} = \tau_k^L) = a_2, \end{aligned} \tag{21}$$

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

The 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

$$\Pr ob(\tau_{kt+4} = \tau_k^H|T_t = i, \tau_{kt}) = \frac{\Pr ob(T_t = i|\tau_{kt+4} = \tau_k^H) \Pr ob(\tau_{kt+4} = \tau_k^H|\tau_{kt})}{\sum_{j=L,H} \Pr ob(T_t = i|\tau_{kt+4} = \tau_k^j) \Pr ob(\tau_{kt+4} = \tau_k^j|\tau_{kt})} \tag{22}$$

Until now, all parameters have been set, except the parameter characterizing the strength of the investment adjustment costs, ϕ, 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 Γ 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, σ_i/σ_y, the relative to output volatility of consumption, σ_c/σ_y, and the contemporaneous correlation between hours worked and output ρ_{ny}. The choice of the first target is motivated by the fact that we want to pin down 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[10].

[10]Results are robust to the choice of targets.

For a given set of parameters Γ, we simulate the model $N = 500$ times for $T = 206$ periods (the length of the interval in each simulation is 280 periods, but from each simulation we drop the first 74 periods in order to minimize the effects of the initial conditions) each simulation. The estimate of Γ is

$$\widehat{\Gamma} = \arg\min \left(M_T^{Data} - M_{TN}^{Model}(\Gamma) \right) \Omega \left(M_T^{Data} - M_{TN}^{Model} \right) \tag{23}$$

where M_T^{Data} represents the vector of targets, calculated from actual data and $M_{TN}^{Model}(\Gamma) = \left(\frac{\sigma_i(\Gamma)}{\sigma_y(\Gamma)} \quad \frac{\sigma_c(\Gamma)}{\sigma_y(\Gamma)} \quad \rho_{ny}(\Gamma) \right)$ 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 Γ. The matrix Ω represents a weight matrix[11].

This procedure yields $\Gamma = (\phi \quad a_1 \quad a_2) = (0.96 \quad 1 \quad 1)$. The criterion in (23) supports the existence of precise signals. Mertens and Ravn (2011*b*) 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[12] tax policy changes. Therefore, our estimates seem reasonable.

The performance of the model is compared to the U.S. data for $1958Q1 - 2009Q2$[13].

In Table 2 we compare the US data statistics (volatilities and contemporaneous correlations with output) in the first column and the model-generated ones, displayed in the second column. For both U.S data and model-generated time series we first take natural logarithms and then detrend them using the Hodrick-Prescott filter[14].

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 Table 2. We notice that news about capital income tax rates can explain an important share of the output volatility. Moreover, the model does a good

[11] Matrix Ω was computed as the inverse of the variance-covariance matrix of these estimators from N simulations. This weight matrix insures that the $\widehat{\Gamma}$ estimate is both consistent and effeicient.

[12] Mertens and Ravn (2011*b*) 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)

[13] Details regarding the data can be found in the Appendix $A.1$. Data on tax receipts go back only to $1958Q1$.

[14] We use a smoothing parameter $\lambda = 1600$.

Table 1: Business Cycle Statistics

Moments	Data (58Q1-09Q2)	Model
Volatilities*(σ_x)**		
σ_y	1.57(1.00)	0.77(1.00)
σ_c	0.89(0.57)	0.41(0.53)
σ_i	7.31(4.66)	3.87(5.02)
σ_n	1.53(0.98)	0.45(0.59)
Contemporaneous Correlations with output (ρ_{xy})***		
ρ_{cy}	0.82	0.88
ρ_{iy}	0.91	0.93
ρ_{ny}	0.89	0.90

*numbers in parentheses are relative to output standard deviations

** σ_x represents the volatility of variable x

*** $\rho(x, y)$ represents the contemporaneous correlation of variable x with output y

job regarding the ranking of the volatilities: investment is the most volatile aggregate, followed by output, hours worked, and consumption. The relative to output volatilities of consumption and investment are very well matched, which was expectable, as these were among our targets. However, the model also matches fairly well the relative to output volatility of hours worked, which was not a target in the SMM procedure.

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 a very good job in matching all the contemporaneous correlations with output. In this case, only the correlation between hours worked and output was used as a target, and therefore we take the good match between empirical and model-generated contemporaneous correlations of consumption and investment with output as additional support for our model. Therefore, our model does generate not only qualitatively but also quantitatively realistic business cycle fluctuations.

5 Conclusions

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. In contrast to many models in the expectations-driven business cycles literature, our model does not rely on non-separable preferences. 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, while 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.

There are several interesting extensions of this paper that we intend to pursue in the near future. First of all, it would be interesting to analyze the robustness of our results to 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 recent years. Secondly, it would be interesting to consider a more realistic tax system, i.e., one which mimics more closely the U.S. tax system both in terms of progressivity and the taxes to which economic agents are subject.

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: 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 nonistitutional 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.t 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

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

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 (τ_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 (τ_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 (τ_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).

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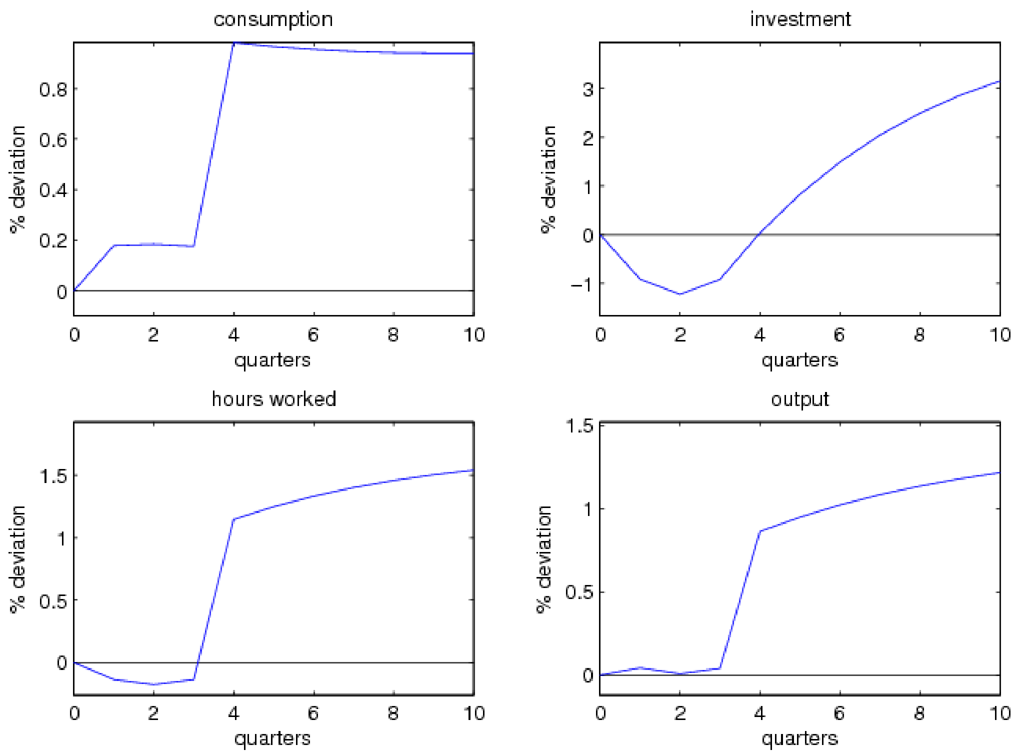

Figure 1: Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the labor income tax rate by 1 percentage point starting $t = 4$.

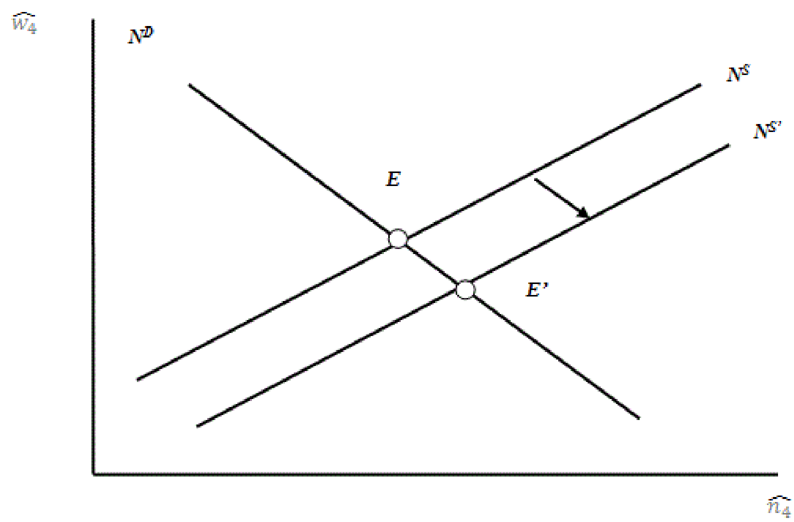

Figure 2: Anticipated (at $t = 1$) time $t = 4$ labor market for an announcement made at $t = 1$ about a permanent decrease in the labor income tax rate by 1 percentage point starting $t = 4$.

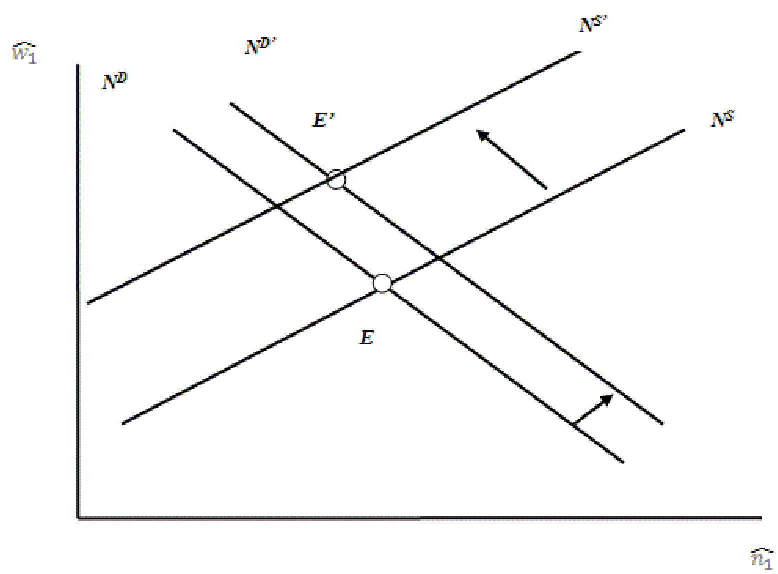

Figure 3: Time $t = 1$ labor market for an announcement made at $t = 1$ about a permanent decrease in the labor income tax rate by 1 percentage point starting $t = 4$.

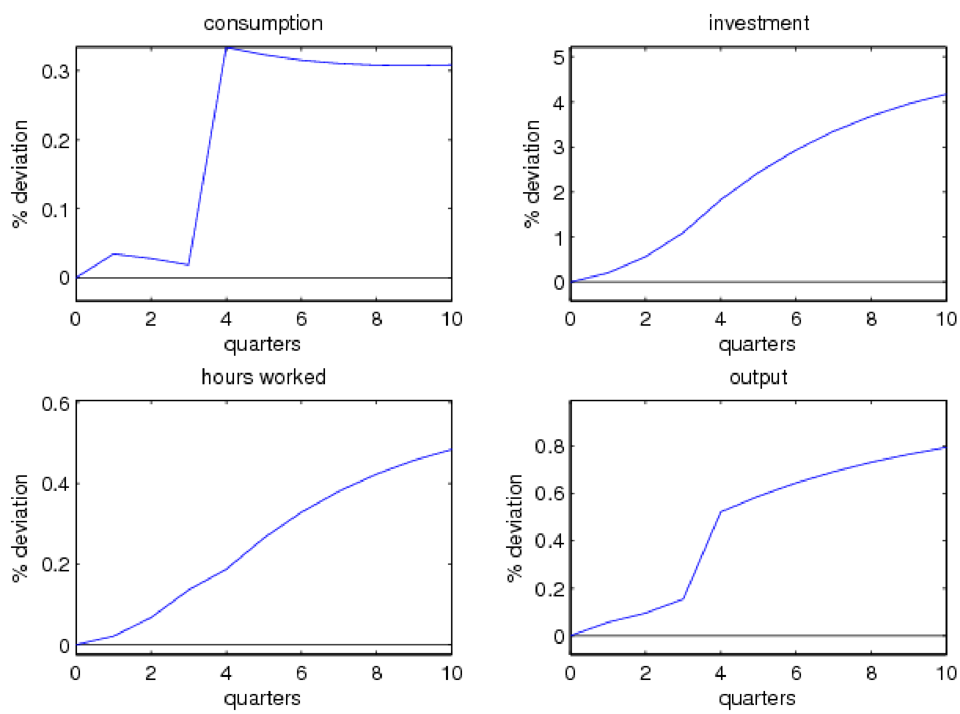

Figure 4: Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$.

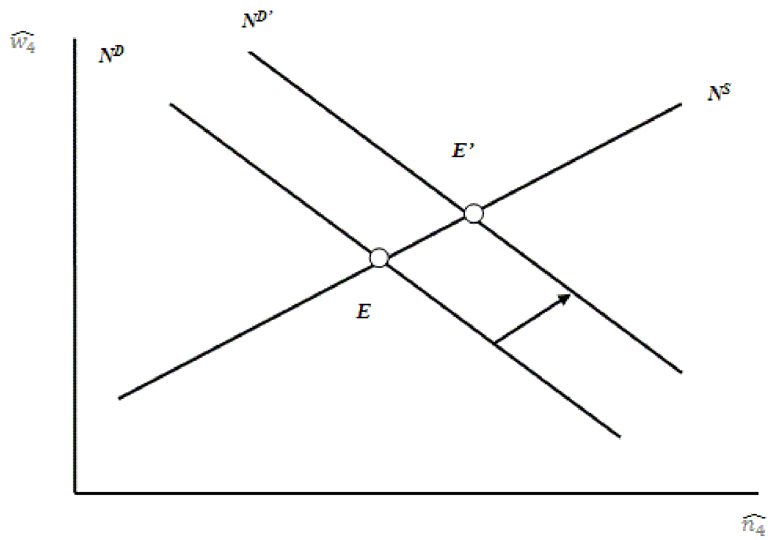

Figure 5: Anticipated (at $t = 1$) time $t = 4$ labor market for an announcement made at $t = 1$ about a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$.

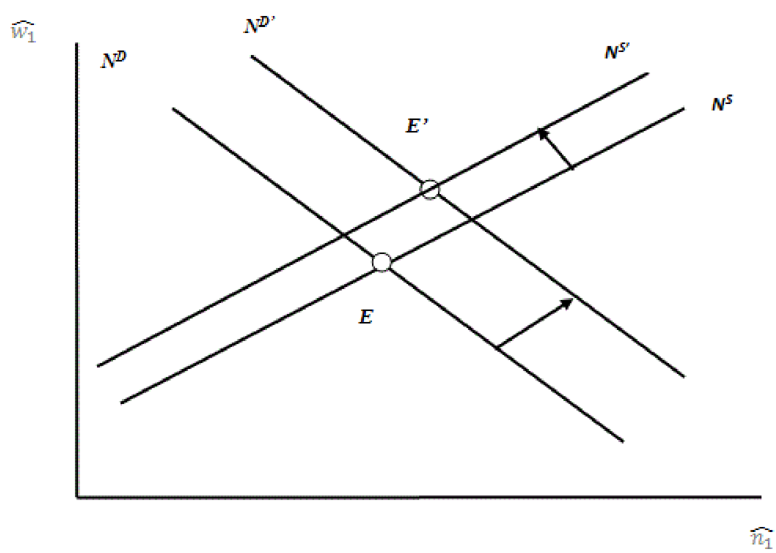

Figure 6: Time $t = 1$ labor market for an announcement made at $t = 1$ about a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$.

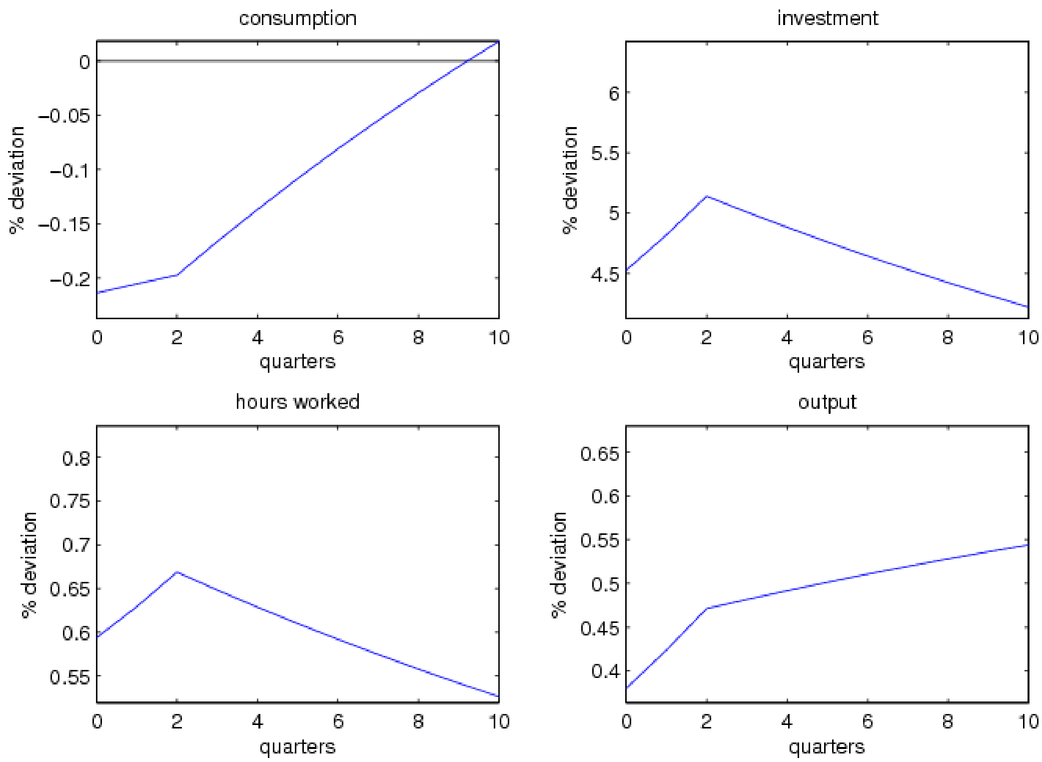

Figure 7: Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$, model with constant capital utilization and no adjustment costs (consumption and output reach the new steady-state after about 20 quarters).

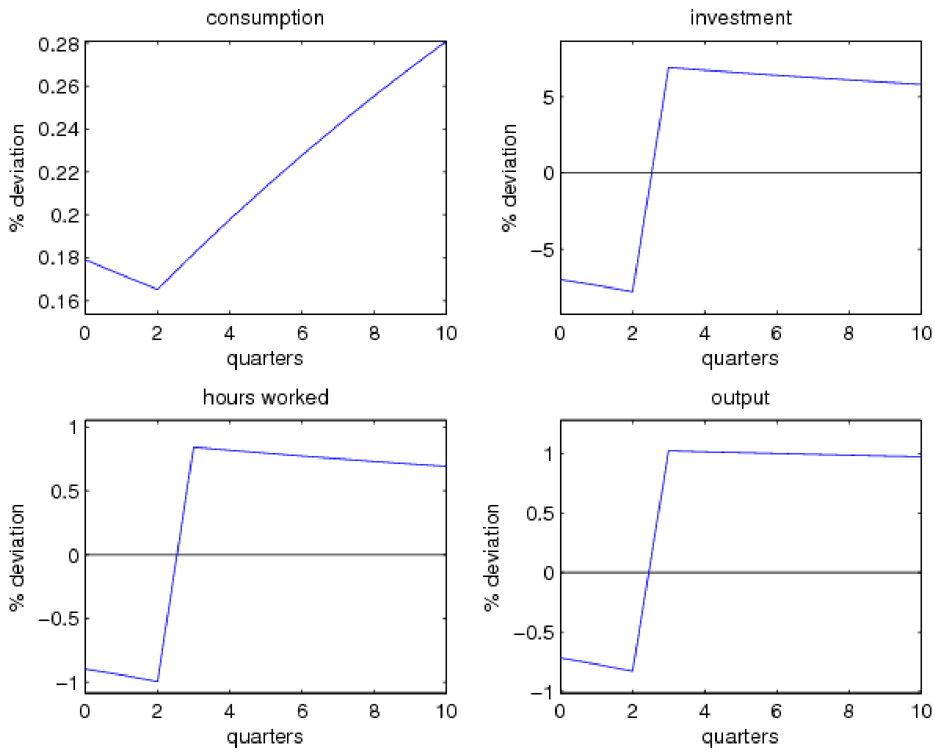

Figure 8: Impulse response functions for a an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$, model with variable capital utilization and no adjustment costs (consumption reaches the new steady-state after about 20 quarters).