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Essays on Expectations-Driven Business Cycles

A Dissertation submitted in partial satisfaction of the requirements for the degree of

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in

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by

Anca-Ioana Sirbu

September 2012

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To the memory of my father.

To my mother and sister.

To Victor.
The standard one-sector real business cycle (RBC, henceforth) model with a constant returns-to-scale technology and perfectly competitive markets and driven solely by news shocks about productivity cannot generate expectations-driven business cycles, i.e., a joint expansion in output, consumption, investment, and hours worked in response to good news about the future.

Our objective is to find the most parsimonious departure from the standard one-sector RBC model able to generate qualitatively and quantitatively realistic business cycle fluctuations driven solely by news shocks about various fundamentals that have high potential in explaining the business cycle volatility.

In chapter 2, we analyze news shocks about productivity. First, we address Eusepi's (2009) analytical finding that a one-sector RBC model may exhibit positive co-movement between consumption and investment when the equilibrium wage-hours locus is positively-sloped and steeper than the household's labor supply curve. First, we show (numerically) that this condition does not imply expectations-driven business cycles will emerge in Eusepi's model, as a positive news shock about future productivity improvement leads to an aggregate recession in which output, consumption, investment,
and hours worked all fall in the announcement period. Further, we show that investment adjustment costs may be the element that a one-sector RBC model is missing in order to deliver both qualitatively and quantitatively realistic cyclical fluctuations.

In Chapter 3, we address the importance of news shocks about aggregate demand, such as a preference shock, that may affect the household's marginal utility of consumption. We show that a one-sector RBC model with (i) mild increasing returns-to-scale and (ii) variable capital utilization driven solely by news about preferences can generate qualitatively and quantitatively realistic aggregate fluctuations. In our model economy output, consumption, investment, and hours worked co-move only if the equilibrium wage-hours locus is positively-sloped and its slope is steeper than the slope of the labor supply curve.

In Chapter 4, we address news about income tax rates. We analyze an otherwise standard RBC model, enriched with (i) variable capital utilization and (ii) investment adjustment costs. This framework allows us to isolate the effects of news about labor and capital 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 calibrate the model to match the observed facts for the U.S. economy and simulate a version driven solely by news about capital income tax rates. The model generates not only qualitatively, but also quantitatively realistic cyclical fluctuations.
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Chapter 1

Introduction

The importance of expectations in driving business cycles is generally acknowledged. At the same time, it is known that a standard one-sector real business cycle (RBC, henceforth) 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 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 when the unique driving force is news about productivity. 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 make current consumption and cur-
rent 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, 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 opposite directions, which contradicts the empirical facts for the U.S. economy.

Similar to the RBC literature that developed in the 1980s, the news-driven business cycles literature that emerged starting early 2000s concentrated mainly on supply side shocks, such as a productivity shock. Beaudry and Portier (2004) were the first to obtain expectations-driven business cycles in a three-sector model, in which consumption and investment are complements and both are obtained via Cobb-Douglas technologies from labor and a fixed factor. Further, Tsai (2009), Dupor and Mehkari (2010), Wang (2010) and Gunn and Johri (2011) rely on costly technology adoption, production complementarities, sticky prices and knowledge capital respectively in order to generate realistic fluctuations. Other solutions rely on non-separable preferences and the existence of investment adjustment costs. Christiano, Ilut, Motto and Rostagno (2008) obtain expectations-driven business cycles in a model featuring (i) habit formation and (ii) investment adjustment costs. Jaimovich and Rebelo (2009) present a one-sector RBC model able to generate realistic business cycle fluctuations for which the key ingredients are: (i) a generalized form of preferences, allow-
ing 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. All these models are driven by news regarding future productivity or future investment technological progress.

Therefore, our objective is to find the most parsimonious departure from the standard one-sector RBC model able to generate qualitatively and quantitatively realistic business cycle fluctuations driven solely by news shocks about various fundamentals that have high potential in explaining the business cycle volatility. Qualitatively, we are interested in models able to generate co-movement of consumption, investment, hours worked, and output and at the same time an expansion of all these aggregates in response to good news about the future. On the quantitative dimension, we want the model generated investment series to have the highest volatility, followed by the volatility of output, labor and consumption, as supported by the post-war U.S. data. We consider news about the supply side, such as a productivity shock, news about the demand side, such as preference shocks, and news about income tax rates. In each chapter of this dissertation, we propose a solution to the above-mentioned problem. In sharp contrast to previous studies, all our solutions maintain the separability of preferences. Moreover, the solution presented in Chapter 4 also maintains the assumption of constant returns-to-scale in production at the aggregate level of the economy, while the solutions presented in Chapters 2 and 3 rely on an aggregate technology that exhibits increasing returns-to-scale.
In Chapter 2, we analyze news shocks about productivity. First, we address Eusepi’s (2009) analytical finding that a one-sector RBC model may exhibit positive co-movement between consumption and investment when the equilibrium wage-hours locus is positively-sloped and steeper than the household’s labor supply curve. We show (numerically) that this condition does not imply expectations-driven business cycles will emerge in Eusepi’s model, as a positive news shock about future productivity improvement leads to an aggregate recession in which output, employment, consumption and investment all fall in the announcement period. Further, we show that a one-sector RBC model that features increasing returns-to-scale and adjustment costs to capital investment is able to generate qualitatively and quantitatively realistic business cycle fluctuations. Intuitively, in a model with increasing returns-to scale alone, good news about future productivity brings about a recession in the current period, despite all aggregates moving in the same direction. The existence of investment adjustment costs makes big swings in investment very costly for the agents. This gives them incentives to start building their capital stock immediately instead of waiting until the news materializes and productivity improves. Due to the adjustments of the capital stock the agents anticipate a sharp decrease in the future return on capital, which makes future consumption look expensive relative to current consumption. As long as investment adjustment costs are sufficiently strong, this effect dominates and current consumption increases. Since both investment and consumption increase, then current output and current labor hours must also increase and it follows that this model can generate expectations-driven business cycles.

In Chapter 3, we address the importance of news shocks about aggregate demand,
such as preference shocks, that may affect the household’s marginal utility of consumption. We show that a one-sector RBC model with mild increasing returns-to-scale and variable capital utilization driven solely by news about preferences can generate qualitatively and quantitatively realistic aggregate fluctuations. In our model, output, consumption, investment, and hours worked co-move only if the equilibrium wage-hours locus is positively-sloped and steeper than the labor supply curve. Intuitively, upon the arrival of good news, current consumption increases due to a dominating positive wealth effect, which leads to a leftward shift of the labor supply curve in the current period. Consequently, hours worked increase and output as well, since capital is predetermined and no other changes in fundamentals occur in the current period. Due to increasing returns-to-scale in production, the increase in output is strong enough to support an increase in both consumption and investment. Therefore, in response to good news about future preference shocks, all macroeconomic aggregates increase. This result does not rely on non-separable preferences or investment adjustment costs.

In Chapter 4, we focus on news about income tax rates. By its nature, the income taxation 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 and affects all categories of agents. We analyze an otherwise standard one sector RBC model, enriched with variable capital utilization and investment adjustment costs, while maintaining the assumption of separable preferences. This framework allows us to isolate the effects of news about labor and capital 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 calibrate the model to match the observed facts for the U.S economy and simulate a
version driven solely by news about capital income tax rates. We find that the model can
account for a significant share of the business cycle volatility and that relative to output
volatilities and contemporaneous correlations with output in the model are very similar to
those observed for the U.S. economy.
Chapter 2

News-Driven Business Cycles and Increasing Returns

2.1 Introduction

Our objective in this chapter is to find the most parsimonious departure from the standard one-sector RBC model able to generate qualitatively and quantitatively realistic business cycle fluctuations driven solely by news shocks about productivity. We find that a model featuring increasing returns-to-scale and investment adjustment costs can.

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. More precisely, the model predicts that current consumption and current investment move in opposite directions upon the arrival of the news regarding an upcoming improvement in productivity. Intuitively, when the
good news arrives, agents want to increase consumption 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, we can identify two puzzles: on the one hand, there is a co-movement puzzle, since current consumption and current investment move in opposite directions. On the other hand, there is a pro-cyclicality puzzle, since good news about the future sets off an output recession today.

We start from Eusepi’s (2009) analytical finding that expectations-driven business cycles may be obtained in the standard one-sector RBC model by introducing external effects to firms’ production process. He concludes that the one-sector RBC model can exhibit positive co-movement between consumption and investment when the degree of production externalities is sufficiently strong to yield a positively-sloped equilibrium wage-hours locus which is steeper than the household’s labor supply curve. However, we show that Eusepi’s finding solves only part of the problem, since in a one-sector RBC model with sufficiently high increasing returns-to-scale, in response to good news about upcoming technological progress, output, consumption, investment and employment all fall during the announcement period. Therefore, Eusepi’s (2009) condition solves only the co-movement puzzle.

Motivated by this finding, in the second part of the chapter we go one step further and analyze what element(s) our model is missing in order to deliver realistic cyclical
fluctuations. We find that an otherwise standard one-sector RBC model with increasing returns-to-scale at the level determined by Eusepi’s analytical condition and investment adjustment costs can deliver expectations-driven business cycles. The existence of investment adjustment costs makes big swings in investment very costly for the agents, which gives them incentives to start building their capital stock immediately instead of waiting until the news materializes and productivity improves. Due to the adjustments of the capital stock the agents anticipate a sharp decrease in the future return on capital, which makes future consumption look expensive relative to current consumption. As long as investment adjustment costs are sufficiently strong, this effect dominates and current consumption increases. Since both investment and consumption increase, then current output and current labor hours must also increase and it follows that this model can generate expectations-driven business cycles. It is worth mentioning that compared to previous models that analyze news about the supply-side, this result does not rely on non-separable preferences.

The reminder of the chapter is organized as follows: In Section 2, we lay down the baseline model. In Section 3, we discuss the co-movement problem. In Section 4 we refer to the implications of introducing investment adjustment costs in the baseline model. We conclude in Section 5.

2.2 The Baseline Model

The model economy is a decentralized version of the one-sector RBC model with an aggregate production function that exhibits increasing returns-to-scale and in which a representative firm produces a single final good, by renting capital and hiring labor from a
representative household. The representative household owns the capital stock. It rents the
capital and also supplies labor to the representative firm, for which it gets in exchange the
return on capital and the wage respectively. All the proceeds from these sources are used
for acquiring consumption and investment goods.

2.2.1 Firms

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

$$y_t = x_t \theta_t k_t^\alpha n_t^{1-\alpha}, \quad 0 < \alpha < 1,$$

where $k_t$ and $n_t$ denote capital and labor inputs, respectively and $\theta_t$ represents the total
factor productivity, which is assumed to follow an autoregressive process of order one in
logarithms. The stochastic process for this productivity shock is specified as

$$\log \theta_t = \rho_\theta \log \theta_{t-1} + \chi_t, \quad 0 < \rho_\theta < 1,$$

$$\chi_t = \varepsilon_t^{\text{unanticipated}} + v_{t-4}^{\text{news}},$$

Innovations to productivity are labeled $\chi_t$ and are assumed to consist of both a
contemporaneous unanticipated impulse denoted $\varepsilon_t$ and an anticipated component $v_{t-4}$ that
has been announced or observed four periods beforehand and which influences the current
behavior of the forward-looking household. Therefore, we call this latter component a news
shock. Both random errors are normally distributed with zero mean and variance $\sigma^2$ and
respectively. We also assume that the anticipated and unanticipated components series are uncorrelated over time, and that there is no correlation between them.

In addition, \( x_t \) denotes productive externalities that are taken as given by the individual firm, and postulated to take the form

\[
x_t = \left( K_t^\alpha N_t^{1-\alpha} \right)^\eta, \quad \eta > 0,
\]

where \( K_t \) and \( N_t \) are the economy-wide levels of physical capital and labor services. In a symmetric equilibrium, all firms make the same decisions such that \( k_t = K_t \) and \( n_t = N_t \), for all \( t \). As a result, one can substitute (2.4) into (2.1) to obtain the social technology that displays increasing returns-to-scale

\[
y_t = \theta_t k_t^{\alpha(1+\eta)} n_t^{(1-\alpha)(1+\eta)},
\]

where \( \alpha(1 + \eta) < 1 \) to rule out sustained economic growth. To notice here that when \( \eta = (>)0 \), the social technology in (2.5) exhibits aggregate constant (increasing) returns-to-scale in capital and labor. Under the assumption that factor markets are perfectly competitive, the first-order conditions for the firm’s profit maximization problem yield

\[
r_t = \frac{y_t}{k_t}, \quad \text{(2.6)}
\]

\[
w_t = (1 - \alpha) \frac{y_t}{n_t}, \quad \text{(2.7)}
\]

where \( r_t \) is the capital rental rate and \( w_t \) is the real wage. In this formulation, \( \alpha ((1 - \alpha) \) represent the capital (labor) share of national income.
2.2.2 Households

The economy is also 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

\[ E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{c_t^{1-\sigma}}{1-\sigma} - A \frac{n_t^{1+\gamma}}{1+\gamma} \right], \quad 0 < \beta < 1, \sigma > 0, \gamma \geq 0 \text{ and } A > 0, \tag{2.8} \]

where \( \beta \) is the discount factor, \( c_t \) is consumption, \( \sigma \) represents the inverse of the intertemporal elasticity of substitution in consumption, with \( \sigma = 1 \) corresponding to logarithmic utility, and \( \gamma \) denotes the inverse of the intertemporal elasticity of substitution in labor supply. Households derive income from providing capital and labor services to firms. Hence, the budget constraint faced by the representative household is

\[ c_t + i_t = r_t k_t + w_t n_t, \tag{2.9} \]

where \( i_t \) stands for gross investment that relates to the accumulation of capital stock through

\[ k_{t+1} = (1 - \delta) k_t + i_t, \quad k_0 > 0 \text{ given}, \tag{2.10} \]

where \( \delta \in (0, 1) \) is the capital depreciation rate.

The first-order conditions for the household’s dynamic optimization problem are given by

\[ Ac_t n_t^\gamma = w_t, \tag{2.11} \]

\[ \frac{1}{c_t^\sigma} = \beta E_t \left[ \frac{1}{c_{t+1}^\sigma} (1 - \delta + r_{t+1}) \right], \tag{2.12} \]

\[ \lim_{t \to \infty} \beta^t \frac{k_{t+1}}{c_t} = 0, \tag{2.13} \]
where (2.11) is an intratemporal condition that equates the household’s marginal rate of substitution between consumption and leisure to the real wage, (2.12) is the standard Euler equation for intertemporal consumption choices, and (2.13) is the transversality condition.

2.3 Expectations-Driven Business Cycles

In this section we discuss the possibility of expectations-driven business cycles to emerge in our model. We first derive the analytical condition that governs the co-movement between the main macroeconomic aggregates. Then, assuming that this condition is satisfied, we proceed to a quantitative analysis.

2.3.1 Analytical Result

We notice here that in our model having consumption and investment moving in the same direction means that the co-movement puzzle is solved, as output will also co-move with the two macroeconomic aggregates. Since capital is predetermined and no other changes in fundamentals happen in the current period, the changes in output must come from changes in labor hours. Therefore, the condition(s) under which consumption $c_t$ and investment $i_t$ co-move, insure condition(s) that all macroeconomic aggregates move in the same direction. Per Beaudry and Portier’s (2004, Appendix A; 2007) temporary equilibrium approach, we use equations (2.5), (2.6), (2.7), (2.9) and (2.11) together with $k_t$ being pre-determined to obtain the analytical expression of $\frac{dc_t}{di_t}$ as follows:

$$\frac{dc_t}{di_t} = \frac{1}{\frac{\sigma}{\alpha} \left[ \frac{(1-\alpha)(1+\eta)}{(1-\alpha)(1+\eta)-1-\gamma} \right] - 1}, \quad (2.14)$$

13
which governs the sign of co-movement between consumption and investment when period-\(t\) goods and labor markets clear.

In (2.14), since \(\sigma > 0, 0 < \alpha < 1, \) and \(\eta \geq 0,\) if the ratio inside the parentheses is negative, then \(\frac{dc}{dt} < 0.\) Therefore, \(\frac{dc}{dt} > 0\) is possible only if

\[
(1 - \alpha)(1 + \eta) - 1 > \gamma, \tag{2.15}
\]

which states that the equilibrium wage-hours locus is positively sloped and that its slope is steeper than the slope of the household’s labor supply curve.

If (2.15) holds, then \((1 - \alpha)(1 + \eta) > (1 - \alpha)(1 + \eta) - 1 - \gamma > 0\) and therefore

\[
0 < \frac{(1 - \alpha)(1 + \eta)}{(1 - \alpha)(1 + \eta) - 1 - \gamma} < 1.\]

We can then distinguish two cases:

Case 1: If \(\sigma \geq 1,\) since \(y_t > c_t > 0\) and as long as (2.15) holds, we have that \(\frac{dc}{dt} > 0.\) Therefore, in this case (2.15) is both necessary and sufficient (“if and only if”) condition for co-movement.

Case 2: If \(\sigma < 1,\) then we may have \(\frac{w}{c_t} \left[ \sigma \frac{(1 - \alpha)(1 + \eta)}{(1 - \alpha)(1 + \eta) - 1 - \gamma} \right] < 1\) and in this case \(\frac{dc}{dt} < 0.\) Therefore, in this case (2.15) is only a necessary, but not sufficient (“only if”) condition for co-movement.

Hence, in our model (2.15) is a necessary condition for co-movement. Eusepi’s (2009) model is a particular case of our model, in which preferences are logarithmic in consumption, i.e., \(\sigma = 1.\) He points out that (2.15) is also a necessary condition for the model economy to display equilibrium indeterminacy as in Benhabib and Farmer (1994). Therefore, the theoretical conditions for a one-sector RBC model to exhibit positive co-movement between key macroeconomic aggregates and indeterminate equilibria are tightly connected.
2.3.2 Dynamic Responses

In this section we quantitatively examine agents’ response to optimistic expectations about productivity growth in a calibrated version of the model, while maintaining saddle-path stability and equilibrium uniqueness. As in Beaudry and Portier (2004), the stochastic process for exogenous technology shocks fed into our numerical experiments are postulated as follows: in period zero, the economy is at its steady state. In period $t = 1$, the households receive a signal that there will be a one-percent permanent increase in the total factor productivity from period 4 (denoted as $\theta_4$) onwards. In period $t = 4$ the news materializes and the productivity permanently increases by one percent. In addition, we adopt the following quarterly parameterization that is commonly used in the real business cycle literature: $\alpha = 0.36$, $\beta = 0.985$, $\gamma = 0$ (i.e. indivisible labor), and $\delta = 0.025$. As a benchmark case we will consider $\sigma = 1$, i.e., the logarithmic preferences (as in Eusepi (2009)).

Given the choice of the $\alpha$ and $\gamma$ parameter values, the condition in (2.15) requires returns-to-scale of at least $1.5625$ ($\eta_{\text{min}} = 0.5625$) for our model to exhibit co-movement between the main macroeconomic aggregates. This level of returns-to-scale falls within the range of uncorrected aggregate returns-to-scale estimates reported by Basu and Fernald (1997, Table 2.1). Burnside, et al. (1995) obtain an estimate of 0.98 for aggregate returns-to-scale, with a standard error of 0.34 after accounting for the cyclical variation in the utilization of physical capital, while more recent estimates by Laitner and Stolyarov (2004), estimate a $1.09 - 1.11$ range, with an upper bound of no more than 1.20 for aggregate returns-to-scale. Having in mind all these estimates, we acknowledge that the degree of
increasing returns-to-scale needed for co-movement in our model economy may be regarded as too large and therefore not plausible. In this case, the quantitative results below should be considered from a methodological point of view as shedding light on disentangling the co-movement puzzle in the one-sector RBC model.

Figure 2.1 presents the impulse response functions of our model economy when subjected to the above exogenous productivity process under $\eta = 0.58$ for the purpose of clear illustration and $A = 2.47$ such that the steady-state hours worked are equal to one third. We notice that despite consumption and investment (along with output and labor hours) moving in the same direction, good news about future productivity leads to an aggregate recession in $t = 1$, which lasts until period 4 when the news materializes and all macroeconomic variables increase above their steady-state level. Therefore, Eusepi’s (2009) work implies that a one-sector RBC model with sufficiently strong increasing returns-to-scale in production does not display Pigou or expectations-driven business cycles which entail simultaneous expansions of output, consumption, investment, and hours worked in response to good news about productivity.

Next, we concentrate on the economic intuition behind the aggregate recession in period $t = 1$. In order to understand the mechanism, it is crucial to understand what the agents standing today and getting the news anticipate will happen at time $t = 4$, when it materializes. Figure 2.2 depicts the anticipated time $t = 4$ labor market. The equilibrium wage-hours locus is upward sloping and intersects the labor supply curve from below. The equilibrium wage-hours locus can be obtained by taking logarithms on equation (2.7) and making use of (2.1)$^1$, while the labor supply curve can be obtained by taking

---

$^1$The equilibrium wage-hours locus writes
logarithms on equation (2.11). When the agents receive the news of an increase in total factor productivity, they anticipate that a higher \( \theta_4 \) causes the equilibrium wage-hours locus to shift leftward. The resulting excess supply for labor moves the equilibrium from \( E \) to \( E' \), which will lower the expected real wage \( w_4 \) and hours worked \( n_4 \). As a consequence, the household expects a reduction in lifetime (labor) income, and hence chooses to decrease its consumption in \( t = 1 \) through a dominating negative wealth effect. This causes a rightwards shift in the labor supply curve in the current period. The new equilibrium is characterized by lower real wage and lower hours worked and therefore output. Agents also postpone investment until they can enjoy the benefits of a higher productivity.

Overall, in our benchmark model (same with Eusepi’s (2009) one-sector RBC economy), a positive news shock about future technological progress triggers a recession in the current period, which is not consistent with the empirical evidence. Furthermore, we find that the impulse response functions with empirically plausible non-unitary values of \( \sigma \) are qualitatively identical to those depicted in Figure 2.1. In all cases, agents’ bright expectations about upcoming productivity growth generate a macroeconomic recession in which output, consumption, investment and labor hours all fall in the announcement period. For illustration, in Figure 2.3 we present the results for \( \sigma = 0.8 \), with a corresponding \( A = 2.50 \).

In conclusion, the one-sector RBC model with increasing returns-to-scale and separable preferences, cannot support realistic business cycle fluctuations. However, increasing returns-to-scale in production turn out to help fixing the co-movement puzzle. In the re-

\[
\log (w_t) = a + \alpha (1 + \eta) \log (k_t) + ((1 - \alpha)(1 + \eta) - 1) \log (n_t), \text{where } a \text{ is a constant.}
\]

\( ^2 \)The labor supply writes

\[
\log (w_t) = \log A + \log c_t + \gamma \log (n_t)
\]

\( ^3 \)See Beaudry and Portier [2006].
minder of the chapter we investigate the condition(s) under which a one-sector RBC model is able to generate qualitatively and quantitatively realistic cyclical fluctuations driven solely by agents’ changing expectations about future productivity.

2.4 Investment Adjustment Costs

In an attempt to obtain realistic fluctuations within a one-sector RBC model, Beaudry and Portier (2004) enriched a standard one-sector RBC model with investment adjustment costs. The existence of adjustment costs makes it very expensive for the agents to postpone investment until the increased productivity materializes. This gives them incentives to start increasing investment today and consequently reinforces the substitution effect that in a standard model dictates the agents to cut current consumption. Therefore, current consumption decreases which shifts the labor supply curve to the right in the current period, resulting in an increase in hours worked and hence in output. Since output increases and consumption decreases, investment must increase and a standard one-sector RBC model with investment adjustment costs cannot support expectations-driven business cycles.

Based on our result in the previous section and on the Beaudry and Portier (2004) finding, in this section we analyze the possibility of expectations-driven business cycles to emerge in a one-sector RBC model with increasing returns-to-scale and investment adjustment costs.
2.4.1 The Economy

We incorporate investment adjustment costs into the model presented in the previous section. This way, equation (2.10) governing the evolution of capital becomes

\[ k_{t+1} = (1 - \delta)k_t + \varphi \left( \frac{i_t}{k_t} \right), \quad k_0, > 0 \text{ given,} \quad (2.16) \]

where \( i_t \) represents gross investment and \( \delta \in (0, 1) \) represents the rate at which the capital depreciates. In (2.16) 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 it is increasing and concave (i.e., \( \varphi'(\cdot) > 0 \) and \( \varphi''(\cdot) < 0 \)) and that \( \varphi \left( \frac{i_{ss}}{k_{ss}} \right) = \frac{i_{ss}}{k_{ss}}, \) i.e., there are no adjustment costs in the steady-state, \( \varphi' \left( \frac{i_{ss}}{k_{ss}} \right) = 1, \) i.e., the steady-state value of Tobin’s \( q \) is equal to one\(^4\), where \( i_{ss} \) and \( k_{ss} \) denote the steady-state level of investment and capital stock respectively. The investment adjustment cost function is postulated to take the following form

\[ \varphi \left( \frac{i_t}{k_t} \right) = \frac{\delta^\xi (i_t/k_t)^{1-\xi} - \delta \xi}{1 - \xi}, \quad \xi > 0. \quad (2.17) \]

The key parameter that needs to be specified in order to fully characterize \( \varphi(\cdot) \) is the inverse of the elasticity of the investment-capital ratio with respect to Tobin’s \( q \),

\[ \xi = -\varphi'' \left( \frac{i_{ss}}{k_{ss}} \right) \frac{i_{ss}}{k_{ss}} / \varphi' \left( \frac{i_{ss}}{k_{ss}} \right), \]

which primarily affects the investment volatility.

The firm’s problem and the corresponding first order conditions remain unchanged.

The first order conditions for the household’s problem are given by (2.1), which governs the intratemporal labor-leisure choice, the transversality condition in (2.13) and

\[ \frac{1/c_t^\sigma}{\varphi' (i_t/k_t)} = \beta E_t \left[ \frac{1}{c_{t+1}^\sigma} \left( 1 - \delta + \varphi \left( \frac{i_{t+1}}{k_{t+1}} \right) \right) - \varphi' \left( \frac{i_{t+1}}{k_{t+1}} \right) \left( \frac{i_{t+1}}{k_{t+1}} \right) + r_{t+1} \right], \quad (2.18) \]

\(^4\)See Hayashi (1982) for more details regarding this formulation of investment adjustment costs
which is the Euler equation that governs the intertemporal trade-offs between different date consumption goods.

The existence of investment adjustment costs does not alter the expression for $\frac{dc}{dt}$ in (2.14) that governs the co-movement of consumption and investment. This means that we have again that for $\sigma \geq 1$, the macro-aggregates co-move “if and only if” (2.15) holds and that for $\sigma < 1$, (2.15) is only a necessary (“only if”) condition for co-movement.

In sum, we notice that in a one-sector RBC model with increasing returns-to-scale and investment adjustment costs, there is a tight connection between the condition that the main macroeconomic aggregates exhibit positive co-movement in response to news shocks and the condition for the existence of indeterminate equilibria.

2.4.2 Expectations-Driven Business Cycles

In this subsection we quantitatively examine the response of the macroeconomic aggregates to agents’ optimistic expectations about an upcoming change in productivity in a calibrated version of our model, while maintaining saddle-path stability and equilibrium uniqueness. The stochastic exogenous process for productivity fed into our numerical experiments is the one described in Section 2.3.2.

As before, in the benchmark case we consider logarithmic preferences, i.e., the inverse of the intertemporal elasticity of substitution between consumption at different dates $\sigma = 1$. The reminder of the parameters are those specified in the previous section. Now all parameters are set except the parameter characterizing the investment adjustment costs function, $\xi = -\phi'' \left( \frac{\dot{y}}{k_{ss}} \right) \frac{\dot{y}}{k_{ss}} / \phi' \left( \frac{\dot{y}}{k_{ss}} \right)$, for which there is no empirical counterpart in the observed features of the U.S. economy. The benchmark specification requires a value
of $\xi = 0.98$ such that expectations-driven business cycles emerge. Beaudry and Portier (2004) use $\xi = 0.5$ in their numerical exercise. For this reason, we also present impulse response functions for this case. In this situation, we need $\sigma = 0.8$ such that our model supports expectations-driven business cycles. This value is slightly lower than the usual value of $\sigma = 1$ used in the business cycles literature. However, it is consistent with recent empirical estimates in the literature, such as Vissing-Jorgensen and Attanasio (2003) and Mulligan (2002).

Figure 2.4 presents the impulse response functions for our benchmark economy to the above one-time positive innovation to future productivity under $\eta = 0.58$ for the purpose of clear illustration. As can been seen from Figure 2.4, an optimistic expectational shock triggers a macroeconomic boom with simultaneous expansions of output, consumption, investment and hours worked in period 1, after the announcement of a good news is made. At $t = 1$, all macroeconomic aggregates increase, even though there has been no change in productivity yet. When the news materializes, they experience a further increase. Initial responses are small in magnitude which was expectable since in the case of a productivity shock during the pre-materialization periods there is only an indirect effect on the macroeconomic aggregates via labor supply and capital accumulation. However, once the productivity actually increases, it directly affects output and this can be seen in the significant jump that occurs in period $t = 4$. Since initial responses are small in magnitude, we present a zoomed picture for $t = 0, 1, 2, 3$ in Figure 2.5. That is, our benchmark one-sector RBC model specification with increasing returns-to-scale and investment adjustment costs is able to generate qualitatively realistic business cycles driven solely by agents’ changing...
expectations about future productivity.

Figure 2.6 presents impulse response functions to the above one-time positive innovation to future productivity for our model specification with $\sigma = 0.8$, $\xi = 0.5$, and $\eta = 0.58$. The responses are qualitatively identical to those for our benchmark case. Upon the arrival of the good news, output, consumption, investment and hours worked all increase, even though there has been no change in productivity yet. Further, once the news materializes at $t = 4$, there is a significant increase in all macroeconomic aggregates. Since initial responses are small in magnitude, we present a zoomed picture for $t = 0, 1, 2, 3$ in Figure 2.7. Therefore, expectations-driven business cycles emerge in our model for this set of parameters as well.

Intuitively, large variations in investment are very costly for the agents, for which reason it is optimal for them to start investing immediately instead of waiting for the materialization of the news. Due to the adjustments of the capital stock, the agents anticipate a decrease in the future return on capital. This causes the wage-hours locus to shift further to the left in Figure 2.2. The lower expected labor income (due to lower hours worked and lower wage) makes the agents decrease current consumption via a negative wealth effect. The lower expected return on capital makes future consumption look more expensive relative to current consumption, and gives agents incentives to increase current consumption. As long as investment adjustment costs are sufficiently strong, this effect dominates and current consumption increases. Since both investment and consumption increase, then current output and current labor hours must also increase and it follows that this model can generate expectations-driven business cycles.
2.4.3 Simulation Results

In this subsection we examine the performance of the model compared to the empirical counterparts. More precisely, we compare the statistical business cycle properties of the model with those obtained from the H-P filtered cyclical components of the logarithmic U.S. quarterly time series for the period 1954Q1 – 2009Q2. The solution method that we adopt is as follows: we start by deriving the unique interior steady state of our model, and then take a log-linear approximation to the equilibrium conditions in its neighborhood. For the baseline case (τ = 1), the minimum value of ξ necessary for the model to exhibit expectations-driven business cycles (ξ_{min} = 0.98), is quite high, which slows down investment too much and makes consumption very volatile. For this reason, in this section we present simulation results for the case τ = 0.8, and ξ = 0.5. The remaining parameters α, β, γ, δ, η, and A remain unchanged as those in the previous subsection. We follow King, Plosser and Rebelo (1988) and set the persistence parameter for the productivity shock λ to be 0.97, and the standard error of its innovations σ_λ to be 0.0072.

Since there is no direct evidence on the volatilities of the unanticipated and news components for the innovations to preference shocks (i.e., σ_ε and σ_ν), we will use a Simulated Method of Moments to calibrate these parameters, as in Beaudry and Portier (2004) and Karnizova (2010). We choose σ_ε to minimize the squared error between output volatility of the actual data σ_y (= 1.603%) and that of model-generated time series averaged across simulations. Given the parameterization described above, we simulate the model N = 1,000 times of length T = 222 periods, the number of observations that we had available for the

5Details about the U.S. data used in our quantitative analysis can be found in the Appendix A.1.
U.S. economy data (simulations are carried for 300 periods, but we drop the first 78 periods to minimize the influence of the initial conditions) and choose $\sigma_\varepsilon$ such that

$$\sigma_\varepsilon = \arg\min \left( \sigma_y - \frac{1}{N} \sum_{i=1}^{N} \sigma_{y,i} \right)^2,$$  

(2.19)

where $\sigma_{y,i}$ represents the standard deviation of output from the $i$-th simulation. Then, the volatility of the anticipated component, $v_t$, for the random error of the productivity can then be pinned down uniquely by $\sigma_v = \sqrt{\sigma_\varepsilon^2 - \sigma_\chi^2}$, where $\sigma_\chi = 0.0072$. This computational procedure yields that the news component accounts for an important share of the productivity shock variance, where $\sigma_\varepsilon = 0.0044$ and $\sigma_v = 0.0057$ and the relative importance of the news component in our simulations is $\frac{\sigma^2_v}{\sigma_\chi^2} = 0.63$. Therefore, the criterion in (2.19) strongly supports the importance of the anticipation effects, indicating that the anticipated component accounts for almost two thirds of the variance of the productivity shock.

Table 2.1 presents the H-P filtered second moments for the U.S. economy (the first column) and from our model economy (second column). In parentheses, we also report relative to output standard deviations. The statistics in the second column are sample means from numerical simulations. Simulations show that investment has the highest volatility, followed by output and also that consumption is less volatile than output. These facts are consistent with the US economy data. Relative to output, investment is less volatile and, consumption is more volatile than shown by the data. These features are due to the inclusion of adjustment costs to capital investment, which tend to slow down investment and therefore make it less volatile relative to output and consumption than in the data. The model predicts a volatility for labor hours which is lower than that observed in the data. In addition, the model predicts that all variables are strongly pro-cyclical and their
Table 2.1: Business Cycle Statistics

<table>
<thead>
<tr>
<th>Volatilities* ($\sigma_x$)**</th>
<th>Moments Data (58Q1-09Q2)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_y$</td>
<td>1.603(1.00)</td>
<td>1.388(1.00)</td>
</tr>
<tr>
<td>$\sigma_c$</td>
<td>0.872(0.54)</td>
<td>1.243(0.89)</td>
</tr>
<tr>
<td>$\sigma_i$</td>
<td>7.506(4.68)</td>
<td>1.899(1.37)</td>
</tr>
<tr>
<td>$\sigma_n$</td>
<td>1.588(0.99)</td>
<td>0.395(0.29)</td>
</tr>
</tbody>
</table>

Contemporaneous Corr with output ($\rho_{xy}$)***

<table>
<thead>
<tr>
<th></th>
<th>Moments Data (58Q1-09Q2)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho_{cy}$</td>
<td>0.801</td>
<td>0.999</td>
</tr>
<tr>
<td>$\rho_{iy}$</td>
<td>0.913</td>
<td>0.996</td>
</tr>
<tr>
<td>$\rho_{ny}$</td>
<td>0.893</td>
<td>0.996</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 $y$

correlations with output are close to those observed in the US data. Overall, this model specification does a fair job in matching the business cycle statistics.

### 2.5 Concluding Remarks

The standard one-sector RBC model with a constant returns-to-scale technology and perfectly competitive markets and driven by news shocks about productivity cannot deliver realistic business cycles because of two issues: on the one hand, there is a *co-movement puzzle*, as aggregate consumption, investment, hours worked, and output do not move in the same direction; on the other hand, there is a *pro-cyclicality puzzle*, as good news about the future bring about a recession today. In this chapter we propose a model that is able to resolve the two puzzles and generate both qualitatively and quantitatively realistic cyclical fluctuations. Our model has two key ingredients:(i) increasing returns-to-scale at
the aggregate level of the economy and (ii) adjustment costs to capital investment. Both elements are absolutely necessary in obtaining realistic results: in a model with investment adjustment costs and constant returns-to-scale (or not sufficiently strong returns-to-scale), the aggregates do not co-move (as shown by Beaudry and Portier (2004)), while increasing returns alone can only fix the co-movement puzzle, as in this case, all the aggregates go in the same direction, but the “wrong” one. In sharp contrast to previous one-sector RBC models able to deliver realistic cyclical fluctuations when the unique driving fore is news shocks about productivity, our model relies on separable preferences.
Figure 2.1: Impulse Response Functions for the model with increasing returns-to-scale and no investment adjustment costs, $\sigma = 1$
Figure 2.2: Anticipated (at \( t = 1 \)) time \( t = 4 \) labor market
Figure 2.3: Impulse Response Functions for the model with increasing returns-to-scale and no investment adjustment costs, $\sigma = 0.8$
Figure 2.4: Impulse Response Functions for the model with increasing returns-to-scale and investment adjustment costs, $\sigma = 1$, $\xi = 0.98$. 
Figure 2.5: \( t = 0, 1, 2, 3 \); Impulse Response Functions for the model with increasing returns-to-scale and investment adjustment costs, \( \sigma = 1, \xi = 0.98 \)
Figure 2.6: Impulse Response Functions for the model with increasing returns-to-scale and investment adjustment costs, $\sigma = 0.8$, $\xi = 0.5$
Figure 2.7: $t = 0, 1, 2, 3$; Impulse Response Functions for the model with increasing returns-to-scale and investment adjustment costs, $\sigma = 0.8, \xi = 0.5$
Chapter 3

News About Aggregate Demand and the Business Cycle

3.1 Introduction

Our objective in this chapter is to find the most parsimonious departure from the standard one-sector RBC model able to generate qualitatively and quantitatively realistic business cycle fluctuations driven solely by news shocks about aggregate demand. We find that a one-sector RBC model with variable capital utilization and mild increasing returns-to-scale is able to generate realistic aggregate cyclical fluctuations when driven by news shocks to future consumption demand. It is worth noticing that compared to existing studies in the news-driven business cycle literature, our result does not rely on non-separable preferences or investment adjustment costs.

A well-known fact about the standard RBC model with a constant returns-to-
scale technology and perfectly competitive markets is that it fails to generate expectations-driven business cycles, in the sense of Beaudry and Portier (2004, p. 1189), i.e., cyclical fluctuations characterized by “a joint increase of consumption, investment, output and hours following a good news.” In particular, in the standard model the announcement of technology improvements at some future date generates a recession today. The theory’s failure boils down to a dominating positive wealth effect triggered by expected technology improvements. This effect induces people to increase consumption and leisure today and since today’s technology remains unaffected, employment decreases and consequently output must fall. Therefore, in the case of good news about future productivity, the model predicts a recession today, and at the same time it fails to generate co-movement between the main macroeconomic aggregates, as supported by the US economy data.

So far, the literature on news-driven business cycles concentrated on news regarding the supply side, such as improvements in productivity. This chapter addresses the real business cycle model subjected to news about future demand shocks, such as preference shocks\(^1\), which affect the household’s marginal utility of consumption by augmenting the urge to consume. The households derive utility only from that part of consumption that exceeds a certain benchmark. Therefore, a positive shock can also be interpreted as a time-varying minimum or subsistence consumption requirement. Changes in this minimum requirement are exogenously given for all households. An alternative interpretation relies on the observation that this preference shock introduces a wedge between the marginal rate of substitution between consumption and leisure and the marginal product of labor

\(^1\)We choose to concentrate on preference shocks, since news shocks about government spending, the other commonly addressed exponent of the demand shocks class, has been treated both empirically and theoretically in Ramey (2010).
and therefore is referred as the “labor wedge.” We analyze a one-sector RBC model with mild increasing returns-to-scale and variable capital utilization driven solely by news about preferences. Our result shows that by introducing mildly increasing returns-to-scale into an otherwise standard one-sector RBC model we can generate both qualitatively and quantitatively realistic business cycle fluctuations. The degree of increasing returns needed for expectations-driven cycles to arise in one sector models is 0.16. These scale economies are close to recent empirical evidence, such as Laitner and Stolyarov (2004), so, the result does not rely on unrealistic assumptions. To notice here that the presence of increasing returns-to-scale at the aggregate level of the economy does not imply indeterminacy of equilibrium. We first show analytically that in our model output, consumption, investment and hours worked co-move only if the equilibrium wage-hours locus is positively sloped and its slope is steeper than the slope of the labor supply curve. Intuitively, in our model present consumption increases due to a dominating positive wealth effect, which leads to a leftward shift of the labor supply curve in the current period. Consequently, hours worked increase and output as well, since capital is predetermined and no other changes in fundamentals occur in the current period. Due to increasing returns-to-scale in production, the increase in output is strong enough to support an increase in both consumption and investment. As a consequence, in response to good news about future preference shocks, all macroeconomic aggregates increase.

Finally, our result arises for only a minimal departure from the standard one-sector RBC model, since no investment adjustment costs or non-separable preferences are required. As presented in Chapter 1, the models that allow for realistic cyclical fluctua-
tions when driven only by news shocks rely on non-separable preferences and investment adjustment costs, multiple sectors in production, costly technology adoption, production complementarities, and knowledge capital among others.

The remaining part of this chapter proceeds as follows: In Section 2, we lay down the model. In Section 3 we analytically investigate when expectations driven business cycles can emerge in our setting and quantitatively examine a calibrated version of our model. Section 4 concludes.

3.2 The Economy

The economy is a decentralized version of the one-sector RBC model with an aggregate production function that exhibits increasing returns-to-scale. The economy is populated by two types of agents: a representative household and a representative firm. The representative household owns the representative firm and supplies labor, taking the real wage as given. The firm makes decisions about production, investment, and capital utilization.

3.2.1 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

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \log(c_t - \Delta_t) - A \frac{n_t^{1+\gamma}}{1+\gamma} \right], \quad 0 < \beta < 1, \quad \gamma \geq 0 \quad \text{and} \quad A > 0 \quad (3.1)$$

---

2See Introduction (Chapter 1) for a more detailed list with references
subject to the budget constraint

\[ c_t = w_t n_t + \pi_t \] (3.2)

where \( E \) is the conditional expectations operator, \( \beta \) is the discount factor, \( c_t \) is consumption, \( n_t \) represents hours worked, \( w_t \) is the real wage, \( \pi_t \) represents profits paid out by the firm as dividends, \( \gamma \) denotes the inverse of the labor supply elasticity and \( A \) is a preference parameter. The variable \( \Delta_t \) represents a random shock to preferences that alters preferences to allow for shifts to the marginal utility of consumption, as in Baxter and King (1991).

The dynamics for \( \Delta_t \) are described by an autoregressive process of order one

\[ \log \frac{\Delta_t}{\Delta_{t-1}} = \rho_{\Delta} \log \frac{\Delta_{t-1}}{\Delta_{t-2}} + \chi_t, \quad 0 < \rho_{\Delta} < 1, \] (3.3)

\[ \chi_t = \underbrace{\varepsilon_t}_{\text{unanticipated}} + \underbrace{v_{t-4}}_{\text{news}} \] (3.4)

where \( \rho_{\Delta} \in [0, 1] \) is a persistence coefficient, with \( \rho_{\Delta} = 0 \) corresponding to noisy news and \( \rho_{\Delta} = 1 \) corresponding to a random walk process, \( \Delta \) denotes the steady-state level of the preference shifter, which is assumed to be a fraction \( \lambda \in (0, 1) \) of the steady-state level of consumption \( c_{ss} \), i.e., \( \lambda = \frac{\Delta}{c_{ss}} \). The impulse to consumption demand \( \chi_t \) has a unanticipated component \( (\varepsilon_t) \) and a four-period ahead anticipated one \( (v_{t-4}) \). Both components, \( \varepsilon_t \) and \( v_{t-4} \), are assumed to be normally distributed with mean zero and variance \( \sigma_{\varepsilon}^2 \) and \( \sigma_v^2 \) respectively. The two components have zero autocorrelation and there is no correlation between them.

The first order condition for the household’s optimization problem is given by

\[ A (c_t - \Delta_t) n_t^X = w_t, \] (3.5)

38
which equates the household’s marginal rate of substitution between consumption and leisure to the real wage.

### 3.2.2 Firms

There is a continuum of identical competitive firms, with the total number normalized to one. Each firm produces output $y_t$ using the following Cobb-Douglas production function

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

where $u_t$ represents the endogenous rate of capital utilization, $k_t$ represents the firm’s capital stock and $n_t$ represents hours worked. In addition, we assume that the economy as a whole is affected by organizational synergies that cause the output of an individual firm to be higher if all other firms in the economy are producing more. The term $x_t$ captures these productive externalities that are taken as given by the individual firm, and postulated to take the form

$$x_t = \left( (U_t K_t)^\alpha N_t^{1-\alpha} \right)^\eta, \quad \eta \geq 0,$$

where $U_t K_t$ and $N_t$ represent the economy-wide average levels of utilized capital and labor inputs. In a symmetric equilibrium, all firms make the same decisions such that $k_t = K_t$, $n_t = N_t$, and $u_t = U_t$ for all $t$. As a result, (3.7) can be substituted into (3.6) to obtain the social technology that displays increasing returns-to-scale

$$y_t = (u_t k_t)^{\alpha(1+\eta)} n_t^{(1-\alpha)(1+\eta)},$$

where $\eta$ represents the degree of increasing returns. The case $\eta = 0$ corresponds to constant returns-to-scale, while $\eta > 0$ implies the existence of increasing returns.
The capital stock accumulates according to

\[ k_{t+1} = (1 - \delta_t)k_t + i_t, \quad k_0 > 0 \text{ given,} \]  

(3.9)

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

\[ \delta_t = \frac{u_t^{1+\theta}}{1+\theta}, \theta > 0, \]  

(3.10)

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.

Under the assumption that the labor market is perfectly competitive, firms take the wage \( w_t \) as given, and choose \( u_t, k_t, \) and \( n_t \) in order to maximize the discounted stream of expected profits

\[ E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{(c_t - \Delta_t)} [y_t - w_t n_t - i_t] \]  

\( \pi_t \)

subject to (3.8), the evolution of capital (3.9), and the depreciation rate in (3.10).

Since the firms act in the best interest of households, the profits at time \( t \) are valued using the household’s marginal utility of consumption, \( \frac{1}{(c_t - \Delta_t)}. \)

The firm’s first order conditions are

\[ w_t = (1 - \alpha) \frac{y_t}{n_t}, \]  

(3.12)

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

(3.13)
\[
\frac{1}{c_t - \Delta_t} = \beta E_t \left[ \frac{1}{(c_{t+1} - \Delta_{t+1})} (1 - \delta_t + \alpha \frac{y_{t+1}}{k_{t+1}}) \right],
\]
(3.14)
along with the transversality condition
\[
\lim_{t \to \infty} \beta^t \frac{k_{t+1}}{(c_t - \Delta_t)} = 0,
\]
(3.15)
where (3.12) states that the firm hires labor up to the point where its marginal product equals the real wage, (3.13) 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 \(u_t\), and (3.14) is the standard Euler equation that governs the intertemporal consumption choices modified to account for variable capital utilization.

Rearranging (3.13), and using the definition for \(\delta_t\) we get
\[
u_t = \alpha^{\frac{1}{\theta - \alpha(1+\eta)}} k_t^{\frac{\alpha(1+\eta)}{\theta - \alpha(1+\eta)}} n_t^{\frac{(1-\alpha)(1+\eta)}{\theta - \alpha(1+\eta)}}
\]
(3.16)
Plugging (3.16) into (3.8), yields the social technology as a function of capital and labor
\[
y_t = \alpha^{\frac{\alpha}{\theta - \alpha(1+\eta)}} k_t^{\frac{\alpha(1+\eta)(\theta - 1)}{\theta - \alpha(1+\eta)}} n_t^{\frac{(1-\alpha)(1+\eta)}{\theta - \alpha(1+\eta)}}
\]
(3.17)
with \(\frac{\alpha(1+\eta)(\theta - 1)}{\theta - \alpha(1+\eta)} < 1\), i.e., diminishing marginal product of capital, in order to insure the existence of an interior steady-state.

### 3.3 Expectations-Driven Business Cycles

In this section we investigate whether the above one-sector RBC model is able to generate both qualitatively and quantitatively realistic cyclical fluctuations driven by
news shocks to future consumption demand. We start by deriving a necessary condition under which the model exhibits positive co-movement between consumption and investment. Further, assuming that this condition holds, we examine the response of the economy to the news regarding a permanent one percent increase in the preference shifter. Then, we evaluate the model in simulations, by comparing the business cycle statistics for the model generated series to their empirical counterparts.

### 3.3.1 The Co-movement Problem

In order to have the macroeconomic aggregates co-moving, as supported by the data, it is enough to have consumption $c_t$ and investment $i_t$ moving in the same direction. In this case, output $y_t$ automatically co-moves with them and since capital is predetermined and no other changes in fundamentals have happened in the current period, the changes in output must be entirely explained by the changes in hours worked. Therefore, the condition(s) under which consumption $c_t$ and investment $i_t$ co-move, insure condition(s) that all macro-aggregates move in the same direction. For proving this result, we use Beaudry and Portier’s (2004, Appendix A; 2007) temporary equilibrium approach. Equations (3.12) and (3.2) characterize the temporary equilibria. By totally differentiating these two equations and using (3.17) and the definition of profits and knowing that $k_t$ is predetermined and exogenous variables are constant, we get

$$\frac{dc_t}{di_t} = \left\{ \frac{\frac{\theta(1-\alpha)(1+\eta)}{\theta-\alpha(1+\eta)}}{\frac{\theta(1-\alpha)(1+\eta)}{\theta-\alpha(1+\eta)} - 1 - \gamma \left( \frac{y_t}{c_t - \Delta t} - 1 \right)} \right\}^{-1}, \tag{3.18}$$
which governs the sign of co-movement between consumption and investment. In our model, \(\frac{1}{\alpha} - \Sigma_t > 0\) since it represents the marginal utility of consumption. Then, if the first ratio in the expression above is negative, it follows that \(\frac{dc_t}{dt} < 0\) and there is no chance to get expectations-driven business cycles. Therefore, for \(\frac{dc_t}{dt} > 0\), this ratio must be positive.

Moreover, \(\theta > 1, 0 < \alpha < 1, \eta \geq 0, \theta - \alpha(1+\eta) > 0\) \(^3\) and one can see that this ratio cannot be positive unless

\[
\frac{\theta(1-\alpha)(1+\eta)}{\theta - \alpha(1+\eta)} - 1 > \gamma. \tag{3.19}
\]

We notice that if (3.19) holds, then the first ratio in (3.18) is higher than one and we have the following two cases:

Case 1: If \(\Delta_t > 0\) (a positive preference shock), then \(0 < c_t - \Delta_t < c_t < y_t\) and

\[
\frac{\theta(1-\alpha)(1+\eta)}{\theta - \alpha(1+\eta)} - 1 - \gamma > \frac{c_t - \Delta_t}{y_t} > 0. \tag{3.20}
\]

Case 2: If \(\Delta_t < 0\) (a negative preference shock), we may have that \(c_t - \Delta_t > y_t\) and (3.20) may not hold

Hence, consumption and investment will move in the same direction only if (3.19) holds.

Under the assumption of perfect competition in the labor market the marginal product of labor equals the real wage rate \(w_t\) and (3.5) governs agents’ intratemporal employment decision is governed by

\[
(1 - \alpha) \frac{y_t}{h_t} \text{ demand} = w_t \text{ supply} = A(c_t - \Delta_t) h_t^\gamma, \tag{3.21}
\]

\(^3\)Since \(0 < \alpha < 1, \eta \geq 0\) and \(\theta > 1\), and \(0 < \frac{\alpha(1+\eta)(\theta-1)}{\theta - \alpha(1+\eta)} < 1\) in order to guarantee the existence of an interior steady-state, it follows that \(\theta - \alpha(1+\eta) > 0\).
The equilibrium wage-hours locus can be obtained by taking logarithms on both sides of the first equality of (3.21) and its slope equals \( \frac{\theta(1-\alpha)(1+\eta)}{\theta-\alpha(1+\eta)} - 1 \), while the labor supply curve can be obtained by taking logarithms on both sides of the second equality in (3.21).  \(^4\) The slope of the labor supply curve is equal to \( \gamma \geq 0 \) and its intercept depends on the level of “net consumption” \( (c_t - \Delta_t) \).

Therefore, the necessary condition in (3.19) states that co-movement in our model arises only if the equilibrium wage-hours locus is positively sloped and slopes steeper than the household’s labor supply curve. This condition is identical to the necessary condition for our model to exhibit equilibrium indeterminacy, as pointed out by Wen (1998, p. 16). Therefore, as noticed by Eusepi (2009), in a one-sector RBC model there is a tight connection between the condition governing the positive co-movement of the macroeconomic aggregates and the condition for the model to exhibit equilibrium indeterminacy.

### 3.3.2 Dynamic Responses

This section examines agents’ response to optimistic expectations regarding the preference shock, while maintaining saddle-path stability and equilibrium uniqueness. As in Beaudry and Portier (2004), the stochastic process for the exogenous preference shock fed into our numerical experiments is postulated as follows: the economy starts at its steady...
state in period zero. In period 1, households receive a signal that there will be a one-percent permanent increase in the preference shifter from period 4 onwards. In period 4, the news materializes and therefore the preference shifter permanently increases by one percent.

In addition, we adopt the following quarterly parameterization that is commonly used in the real business cycle literature: 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 percent return to capital, as in King, Plosser, and Rebelo (1988), the steady-state capital depreciation rate is set to $\delta = 0.025$, the labor supply is infinitely elastic, i.e., $\gamma = 0$, as in Hansen (1985). Given the calibrated values for $\beta$ and $\delta$, $\theta = 1.6091$. The preference parameter $A = 4.3392$, so that labor hours equal one third in the steady-state. Given $\alpha, \beta, \delta$, and $\theta$, the threshold level of productive externalities that satisfies the necessary condition for positive co-movement between consumption and investment, as in (3.19), is $\eta_{\min} = 0.1578$. There is one parameter for which we do not have empirical estimates. This is the parameter $\lambda = \frac{\Delta}{c_{\Delta}}$, which is set to 0.1 arbitrarily by Benhabib and Wen (2004). We use a Simulated Method of Moments to pin down this parameter. Details about the estimation are provided in the section on Simulation Results. This method recommends a value of $\lambda = 0.43$. In addition, the process described in the previous paragraph corresponds to setting $\rho_{\Delta} = 1$ in (3.3).

Figure 3.1 depicts impulse response functions for the case of returns-to-scale equal to 1.16 (which corresponds to $\eta = 0.16$), for the purpose of clear illustration. This value is very close to the 1.09–1.11 range, with an upper bound of no more than 1.20 recent estimates in Laitner and Stolyarov (2004). One can clearly notice that there is a simultaneous increase in the four macroeconomic aggregates upon the arrival of positive news regarding the future
preference shock. In order to understand the economic mechanism that creates our results, it is crucial to understand what agents standing today anticipate that will happen at the time when the news materilizes. Figure 3.2 depicts the anticipated time $t = 4$ labor market associated to this case. As long as condition (3.19) holds, the equilibrium wage-hours locus is positively sloped and steeper than the household’s labor supply curve. The arrival of positive news about future preference shocks allows agents to anticipate an increase in future consumption $c_4$, which due to increasing returns is sufficiently strong and exceeds $\Delta_4$ and therefore $(c_4 - \Delta_4)$ increases, determining a leftwards shift of the the labor supply curve. The equilibrium moves from $E$ to $E'$. The new equilibrium is characterized by a higher wage $w_4$ and higher hours worked $n_4$ and consequently a higher marginal product of capital $MPK_4$. In the current period, $t = 1$, the expected higher lifetime labor income makes agents increase current consumption via a positive wealth effect, while the expected higher $MPK_4$ determines the agents to be willing to decrease consumption and increase investment today via a substitution effect. However, income effect dominates and we observe an increase in current consumption $c_1$. Since in the current period there is no other change in fundamentals, the increased consumption shifts the labor supply curve leftwards. This results in an increase in hours worked and consequently in current output. The increase in output is sufficiently strong to support an increase in both current consumption and investment. Therefore, in the current period we observe an economic expansion of all macroeconomic aggregates in response to good news regarding preferences.
3.3.3 Simulation Results

So far we have seen that our model is able to generate qualitatively realistic cyclical fluctuations. In this subsection we want to evaluate the performance of the model by comparing the statistical properties of the macroeconomic aggregates generated in the model with their empirical counterparts\(^5\). Empirical moments as well as model generated ones are obtained from the H-P filtered cyclical components of the time series in logarithm\(^6\). Empirical moments were computed for the period 1954Q1 – 2009Q2, at quarterly frequency. We solve the model by log-linearizing the equations characterizing the equilibrium by taking a first order Taylor series approximation around the unique steady-state. The parametrization for \(\alpha, \beta, \gamma, \delta, \theta, \) and \(A\) is the one specified in the previous subsection.

To calibrate the preference shift process, we follow Baxter and King (1991). To identify the preference shocks, we use the log-linearized version of (3.5)

\[
\frac{\Delta_t}{c_{as}} = \log c_t - \log w_t
\]  

(3.22)

In order to construct the process in (3.22), we need data about consumption and the real wage\(^7\). We find that the process for the preference shocks in logarithms is well approximated by an autoregressive of order one process, with constant and time trend. Based on our estimation, we set the persistence parameter \(\rho_\Delta = 0.98\) and \(\sigma_\chi = 0.0089\). Details regarding this estimation are given in Appendix A.2.

Until now, all parameters have been set, except the ratio \(\lambda \in (0, 1) \ (\lambda = \frac{\Delta}{c_{as}})\) and the volatilities of the anticipated \((\sigma_v)\) and unanticipated \((\sigma_e)\) components of the

---

\(^5\)Details regarding the data used to compute the U.S. business cycle statistics can be found in Appendix A1
\(^6\)We use a smoothing parameter \(\lambda = 1600\)
\(^7\)See Appendix A.1 for details
preference shock, for which there are no \textit{a priori} estimates. Note that once we have $\sigma_\varepsilon$, the volatility of the news component of the preference shock, $\sigma_v$, is uniquely determined as $\sigma_v = \sqrt{0.0089^2 - \sigma_\varepsilon^2}$. In order to pin down $\lambda$ and $\sigma_\varepsilon$, we follow Beaudry and Portier (2004) and Karnizova (2010) and use a Simulated Method of Moments (SMM, henceforth).

We define a vector $\Gamma = (\sigma_\varepsilon, \lambda)$ 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 volatility of output $\sigma_y$ and the contemporaneous correlation between consumption and output $\rho_{cy}$. The output volatility is very relevant for the (relative) importance of the news component of the preference shock, while the consumption-output correlation $\rho_{cy}$ is informative for the choice of the $\lambda-$ ratio. Let us define $M^D = (\sigma_y, \rho_{cy})$ to be the vector of targets, i.e., actual moments computed from the data.

For a given set of parameters $\Gamma$, we simulate the model $N = 1000$ times for $T = 222$ periods (the length of the interval in each simulation is 300 periods, but from each simulation we drop the first 78 periods in order to minimize the effects of the initial conditions) each simulation. The estimate of $\Gamma$ is

$$\hat{\Gamma} = \arg \min \left( M^D_T - M^{Model}_{TN}(\Gamma) \right)^T \Omega \left( M^D_T - M^{Model}_{TN}(\Gamma) \right)$$

(3.23)

where $M^D_T$ represents the vector of targets, calculated from actual data and $M^{Model}_{TN}(\Gamma)$ denotes vector of model generated output volatility and consumption-output correlation, constructed as averages over the $N$ simulations for a particular parameter vector $\Gamma$. Matrix $\Omega$ represents a weight matrix$^8$.

$^8$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.
This procedure yields $\Gamma = (0.0067 \ 0.43)$ and we can compute $\sigma_v = 0.0058$ and the relative importance of the news component, $\frac{\sigma^2_x}{\sigma^2_x} = 0.43$. Therefore, the criterion in (3.23) strongly supports the importance of the anticipation effects, indicating that the anticipated component accounts for almost half of the variance of the preference shock. As already mentioned, there are no empirical estimates for the $\lambda-$ ratio in the literature. Atkeson and Ogaki (1996, Table 7) use U.S. aggregate consumption expenditure time series data for the 1968 – 1988 interval and find an estimate of 0.4 for the intertemporal elasticity of substitution in consumption. In our case, for the logarithmic in consumption preferences, this corresponds to $\lambda = 0.6$, as the intertemporal elasticity of substitution is $\frac{c_{a+1} - \Delta c_{a+1}}{c_{a+1}}$, which equals $(1 - \lambda)$. Also, Álvarez-Peláez and Díaz (2005) impose an upper bound of 0.4 on the $\lambda-$ ratio. In view of these studies, our estimated $\lambda = 0.43$ seems reasonable.

In Table 3.1 we compare the business cycle second moments for the U.S. economy (in column one) with the model generated ones (in column 2), computed for $\sigma_v = 0.0058$ and $\lambda = 0.43$. The numbers in parentheses represent the relative to output volatilities. We notice that the model does a very good job in matching the business cycle moments. The output volatility and the hours worked volatility are almost identical to those in the data. While a good match for the output volatility was expectable since this is one of the targets, we notice here that we do not have any target related to hours worked volatility or its correlation with output. Consumption is slightly slower than in the data and investment slightly more volatile. The model predicts that all variables are strongly pro-cyclical, as supported by the data. It does a particularly good job in matching the consumption-output correlation.
Table 3.1: Business Cycle Statistics

<table>
<thead>
<tr>
<th>Moments Data (54Q1-09Q2)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volatilities</strong>$^*$ ($\sigma_x$)**</td>
<td></td>
</tr>
<tr>
<td>$\sigma_y$  &amp; 1.603(1.00) &amp; 1.603(1.00)</td>
<td></td>
</tr>
<tr>
<td>$\sigma_c$  &amp; 0.872(0.54) &amp; 0.522(0.33)</td>
<td></td>
</tr>
<tr>
<td>$\sigma_i$  &amp; 7.506(4.68) &amp; 6.121(3.82)</td>
<td></td>
</tr>
<tr>
<td>$\sigma_n$  &amp; 1.588(0.99) &amp; 1.590(0.99)</td>
<td></td>
</tr>
<tr>
<td><strong>Contemporaneous Correlations with output</strong> ($\rho_{xy}$)**</td>
<td></td>
</tr>
<tr>
<td>$\rho_{cy}$ &amp; 0.801 &amp; 0.782</td>
<td></td>
</tr>
<tr>
<td>$\rho_{iy}$ &amp; 0.913 &amp; 0.981</td>
<td></td>
</tr>
<tr>
<td>$\rho_{ny}$ &amp; 0.893 &amp; 0.999</td>
<td></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 $y$

Overall, our model performs well in mimicking the business cycle statistics and we consider that this supports the importance of news regarding the future preference shock.

### 3.4 Conclusion

The standard real business cycle model fails to generate expectations-driven business cycles. This is due to its inability to produce positive co-movement between output, consumption, investment and labor hours in response to news about future fundamentals. In this paper, we show that a standard real business cycle model, enriched with variable capital utilization and mild increasing returns-to-scale in production, and driven solely by news shocks to preferences, can support both qualitatively and quantitatively realistic cyclical fluctuations. It is worth noticing that our result does not rely on non-separable preferences or investment adjustment costs, which are *sine quibus non* ingredients in previous one-sector
real business cycle model successful in delivering expectations-driven business cycles.
Figure 3.1: Impulse Response Functions
Figure 3.2: Anticipated (at $t = 1$) time $t = 4$ labor market
Chapter 4

News About Taxes and Expectations - Driven Business Cycles

4.1 Introduction

In this chapter we analyze 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.

Similar to the business cycles literature that developed beginning early 1980’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 income taxation 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\footnote{Yang (2007) documents 27 major tax events in the U.S. for the period 1948-2005.} 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\footnote{Yang (2007) reports 66.4\% in 1950 and 58.1\% in 2006, based on Joint Committee on Taxation documents.}.

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 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 rate change.

Given these pieces of evidence, our objective in this chapter 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.

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 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 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 chapter adds to the previous literature on the effects of tax 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 chapter 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.

4.2 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. Output is the numeraire. 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.

4.2.1 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

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

(4.1)

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

$$c_t = (1 - \tau_t)w_t n_t + d_t + T_t. \quad (4.2)$$

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

$$Ac_t n_t^\gamma = (1 - \tau_t)w_t. \quad (4.3)$$

The intratemporal condition in (4.3) equates the household’s marginal rate of substitution between consumption and leisure to the net-of-tax real wage.

### 4.2.2 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

$$y_t = (u_t k_t)\alpha n_t^{1-\alpha}, 0 < \alpha < 1, \quad (4.4)$$

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

$$k_{t+1} = (1 - \delta_t)k_t + i_t \left(1 - \varphi \left(\frac{i_t}{i_{t-1}}\right)\right), \quad k_0, i_{-1} > 0 \text{ given}, \quad (4.5)$$
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

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

(4.6)

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 $\delta_t$ 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 (4.5) 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 $\varphi''(1) = \phi > 0^3$. We postulate the following functional form for $\varphi(\cdot)$

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

(4.7)

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

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3See Christiano, Eichenbaum, and Evans (2005) for more on the investment adjustment costs function.
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 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 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 $1/c_t$

$$\max_{n_t,k_{t+1},u_t} E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{c_t} \left[ (1 - \tau_{kt})(y_t - w_t n_t) - i_t + \tau_{kt}\delta k_t \right],$$  \hspace{1cm} (4.8)

subject to the production function in (4.4), the capital accumulation equation (4.5) and the depreciation rate in (4.6). The government taxes only 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

$$w_t = (1 - \alpha) \frac{y_t}{n_t},$$ \hspace{1cm} (4.9)
\[
\mu_t u_t^{\psi-1} k_t = (1 - \tau_{kt}) \alpha \frac{y_t}{u_t c_t}, \quad (4.10)
\]

\[
\mu_t = \beta E_t \left[ (1 - \delta_{t+1}) \mu_{t+1} + \frac{1}{c_{t+1}} \left( (1 - \tau_{kt+1}) \alpha \frac{y_{t+1}}{k_{t+1}} + \delta \tau_{kt+1} \right) \right], \quad (4.11)
\]

\[
\frac{1}{c_t} = \mu_t \left[ 1 - \varphi \left( \frac{i_t}{i_{t-1}} \right) - \varphi' \left( \frac{i_t}{i_{t-1}} \right) \frac{i_t}{i_{t-1}} \right] + \beta E_t \left[ \mu_{t+1} \varphi' \left( \frac{i_{t+1}}{i_t} \right) \left( \frac{i_{t+1}}{i_t} \right)^2 \right], \quad (4.12)
\]

along with the transversality conditions, where \( \mu_t \) represents the Lagrange multiplier associated with (4.5), 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 (4.9) states that the firm hires labor up to the point where its marginal product is equal to the real wage. Equation (4.10) 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 \( \mu_t \), (4.10) also becomes an intertemporal condition. Equations (4.11) and (4.12) represent the Euler equations that govern the household’s intertemporal consumption and investment choices.

From the first order conditions in (4.3) and (4.11) 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.

### 4.2.3 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
\[ T_t = \tau_{nt} w_t n_t + \tau_{kt} (y_t - w_t n_t) - \tau_{kt} \delta k_t, \]  

(4.13)

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 (4.13) represents the capital depreciation allowance.

By combining equations (4.2), (4.13), and using the definition of dividends we obtain the aggregate resource constraint as

\[ c_t + i_t = y_t \]  

(4.14)

4.2.4 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 (4.1), subject to (4.2).

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 (4.8), subject to (4.4), (4.5) and (4.6).

3. The government budget constraint (4.13) holds.

4. all markets (goods and labor) clear (i.e., (4.14) holds and \( n_{t}^d = n_{t}^s \) (labor demand equals labor supply)).
4.2.5 Labor Market

In this section we derive the labor demand and supply\footnote{For more on the labor market approach, see Wang (2010).} 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, 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.

The labor supply curve can be obtained by log-linearizing (4.3) around the deterministic steady-state. The labor supply curve writes

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

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).

The labor demand curve can be derived by log-linearizing (4.9) around the deterministic steady-state, and using (4.4), (4.10), (4.12), and (4.14) in log-linearized form. The
labor demand curve is given by

\[ \tilde{w}_t = B + \alpha \phi (c_{ss}/i_{ss}) \widetilde{c}_t + \alpha \phi \beta \widetilde{i}_{t+1} - \alpha \frac{\tau_{t, t+1}}{1-t_{t}} \frac{\widetilde{r}_{kt}}{1} + \left[ \frac{(1 - \alpha)(1 + \theta)}{(1 + \theta) - \alpha + \alpha \phi (1 + \beta)(y_{ss}/i_{ss})} - 1 \right] \tilde{n}_t, \]

(4.16)

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 \( B = ((1 + \theta) - \alpha) \tilde{k}_t + \alpha \phi \tilde{n}_{t-1} \).

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 (4.10) 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.

4.3 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.

4.3.1 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 steady-state \(^5\), 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\(^6\) 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 A.1. Table 4.1 summarizes the parameters used.

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

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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).
Table 4.1: 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. ( \bar{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{n} = 1/3 )</td>
</tr>
<tr>
<td>( \theta )</td>
<td>mg. depreciation elasticity</td>
<td>0.796</td>
<td>computed based on ( \beta, \delta )</td>
</tr>
<tr>
<td>( \tau_n )</td>
<td>avg. labor income tax rate</td>
<td>21%</td>
<td>computed (Jones (2002))</td>
</tr>
<tr>
<td>( \tau_k )</td>
<td>avg. 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>0.96</td>
<td>match the actual ( \sigma_i/\sigma_y )</td>
</tr>
</tbody>
</table>

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 \( \phi = 0.96 \).

4.3.2 Dynamic Responses

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 4.1 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 4.2. This being understood, what happens in the time $t = 1$ labor market unravels in a very natural way. From (4.15), 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 4.2. 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 4.3 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 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.

**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 4.4 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 4.5 depicts what agents anticipate that will happen in the time $t = 4$ labor market once they get the news at time $t = 1$. From (4.16), 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 $\tau_k$ will shift the labor demand curve at $t = 4$ rightwards, which results in the equilibrium shifting from $E$ to $E'$ in Figure 4.5. 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 $MPK$ 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 4.6 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 4.6. 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.

**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 4.7 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 4.8 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 macroeconomic aggregates. Without adjustment costs, the first order condition with respect to the capital utilization rate in (4.10) becomes

$$u_t^\theta k_t = (1 - \tau_{kt}) \alpha \frac{y_t}{u_t}, \quad (4.17)$$

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 via a positive wealth effect, while the higher expected MPK 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.

4.4 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

$$\tau_{kt+1} = 0.95\tau_{kt} + \chi_{kt}$$  \hspace{1cm} (4.18)

where $\chi_{kt}$ 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 (4.18) by a two-point Markov chain with support

$$\{\tau^L_k, \tau^H_k\} = \{35.5\%, 39.5\%\}$$  \hspace{1cm} (4.19)
where the $L$ superscript stands for low tax and a $H$ superscript stands for high tax, and transition matrix

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

(4.20)

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, 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

$$
\Pr\left( T_t = i \mid \tau_{kt+4} = \tau_k^H \right) = a_1,
\Pr\left( T_t = i \mid \tau_{kt+4} = \tau_k^L \right) = a_2,
$$

(4.21)

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

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

(4.22)

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 \textit{a priori} estimates. In order to pin down these parameters, we use a Simulated Method of Moments (SMM, henceforth).

We define a vector $\Gamma = (\phi \ a_1 \ a_2)$ 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 $T = 206$ 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 $\Gamma$ is

$$\hat{\Gamma} = \arg \min \left( M_T^{Data} - M_T^{Model}(\Gamma) \right) \Omega \left( M_T^{Data} - M_T^{Model} \right) \quad (4.23)$$

where $M_T^{Data}$ represents the vector of targets, calculated from actual data and $M_T^{Model}(\Gamma) = \left( \frac{\sigma_i(\Gamma)}{\sigma_y(\Gamma)} \ \frac{\sigma_c(\Gamma)}{\sigma_y(\Gamma)} \ \rho_{ny}(\Gamma) \right)$ 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 (4.23) 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$^9$. In Table 2.2 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 statistics 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$^{10}$. 

Regarding the volatilities, since we cannot expect that 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 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.

---

$^7$Matrix $\Omega$ was computed as the inverse of the variance-covariance matrix of these estimators from $N$ simulations. 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)

$^9$Details regarding the data can be found in the Appendix A.1. Data on tax receipts go back only to 1958Q1

$^{10}$We use a smoothing parameter $\lambda = 1600$. 

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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 4.2: Business Cycle Statistics

<table>
<thead>
<tr>
<th></th>
<th>Data (58Q1-09Q2)</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volatilities</strong>*(σ_x)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>σ_y</td>
<td>1.57(1.00)</td>
<td>0.77(1.00)</td>
</tr>
<tr>
<td>σ_c</td>
<td>0.89(0.57)</td>
<td>0.41(0.53)</td>
</tr>
<tr>
<td>σ_i</td>
<td>7.31(4.66)</td>
<td>3.87(5.02)</td>
</tr>
<tr>
<td>σ_n</td>
<td>1.53(0.98)</td>
<td>0.45(0.59)</td>
</tr>
<tr>
<td><strong>Contemporaneous Correlations with output</strong>*(ρ_xy)** ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ρ_cy</td>
<td>0.82</td>
<td>0.88</td>
</tr>
<tr>
<td>ρ_iy</td>
<td>0.91</td>
<td>0.93</td>
</tr>
<tr>
<td>ρ_ny</td>
<td>0.89</td>
<td>0.90</td>
</tr>
</tbody>
</table>

*numbers in parentheses are relative to output standard deviations

** σ_x represents the volatility of variable x

*** ρ(x, y) represents the contemporaneous correlation of variable x with output y

Therefore, our model does generate plausible business cycle fluctuations.

4.5 Conclusions

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 able 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 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.
Figure 4.1: 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 4.2: 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 4.3: 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 4.4: 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 4.5: 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 4.6: 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 4.7: 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 4.8: Impulse response functions for an announcement made at time $t = 1$ regarding a permanent decrease in the capital income tax rate by 1 percentage point starting $t = 4$, model with variable capital utilization and no adjustment costs.

* consumption reaches the new steady-state after about 20 quarters
Chapter 5

Conclusions

Starting with the work of Beaudry and Portier (2004, 2007) it has been known that the standard one-sector real business cycle model with a constant returns-to-scale technology and perfectly competitive markets and driven solely by news shocks about productivity cannot generate expectations-driven business cycles, understood as a simultaneous expansion of output, consumption, investment, and hours worked in response to good news about the future. Subsequent literature that concentrated mainly on news regarding productivity recommends features such as a multiple production sectors, knowledge capital, imperfect competition, sticky prices, non-separable preferences and investment adjustment costs among others as possible solutions to this problem\(^1\).

In this dissertation, we extend the analysis from news about the supply side (such as a productivity shock) to news about other fundamentals such as income tax rates or about aggregate demand. On the other hand, we are interested in finding the most parsimonious departure from the standard one-sector RBC model able to generate qualitatively

\(^1\)See Chapter 1 (Introduction) for references.
and quantitatively realistic business cycle fluctuations driven solely by news shocks.

In Chapter 2 we analyze news shocks about the supply side, such as productivity. We start from Beaudry and Portier (2004) finding that in a standard one-sector RBC model consumption increases, and investment, hours worked and output decrease in response to news about an upcoming improvement in productivity. First of all, we can identify two puzzles: on the one hand, there is a co-movement puzzle, since current consumption and current investment move in opposite direction. On the other hand, there is a pro-cyclicity puzzle, since good news about the future sets off an output recession today. Secondly, we address Eusepi’s (2009) analytical finding that a one-sector RBC model may exhibit positive co-movement between consumption and investment when the equilibrium wage-hours locus is positively-sloped and steeper than the household’s labor supply curve. We show (numerically) that this condition does not imply expectations-driven business cycles will emerge in Eusepi’s model, as a positive news shock about future productivity improvement leads to an aggregate recession in which all macroeconomic aggregates fall. We conclude that Eusepi’s condition only solves the co-movement puzzle. Further, we question what element(s) our model is missing in order to deliver realistic fluctuations. We find that by adding investment adjustment costs to an otherwise standard one-sector RBC model with increasing returns-to-scale at the level determined by Eusepi’s analytical condition, solve the pro-cyclicity puzzle as well and consequently deliver expectations-driven business cycles. We notice that similar to the previous models, this model also preserves the assumption of separable preferences.

In chapter 3 we focus on news about aggregate demand, such as preference shocks.
Our model departs from the standard one-sector RBC model by assuming mild increasing returns-to-scale in production and variable capital utilization. The model is very simple and compared to existing literature non-separable preferences or investment adjustment costs are not assumed. Under this specification, our model delivers both quantitatively and qualitatively realistic cyclical fluctuations.

In Chapter 4, we analyze news about income tax rates. Our model departs from the standard model by incorporating variable capital utilization and investment adjustment costs. To notice here that our result does not rely on non-separable preferences. Compared to existing literature analyzing the effects of tax policy changes, mainly empirical so far, this framework allows us to distinguish between the effects of news about labor and capital income tax rates. We find that good news about the labor income tax rates cannot generate expectations-driven business cycles, while good news about capital income tax rates can. Quantitative simulations show that news shocks about capital income tax rates can account for a significant share of the business cycle volatility.
Bibliography


[38] Tsai, Yi-Chan (2009), “News Shocks and Costly Technology Adoption,” unpublished manuscript.


Appendix A

Appendix

A.1 Data Appendix

This appendix supplies detailed information about the US data used in this paper. The data cover the interval 1954(1958)Q1-2009Q2.

**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 Sta-
Statistics, CNP16OV

**Hours Worked** = Nonfarm private sector total hours, from BLS (1964Q1-2009Q2) and for the interval before 1964, from Valerie Ramey’s website.

**Hourly Wage** = Wage and Salary Disbursements by Industry (NIPA tables 2.2A&B) / Hours Worked

Per capita variables are 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 \( \tau_p \)

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

\[ CI = PRI/2 + RI + CP + NI \]

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)
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)

A.2 Preferene Shock Stochastic Process

Details about the data used in obtaining the time series for the shock process can be found in Appendix A.1. Using data regarding the wage and consumption expenditures, we follow Baxter and King (1991) and obtain the preference shock process by log-linearizing equation (3.22) in the text around the deterministic steady-state.
We find that the preference shock in logarithms is well approximated by an autoregressive process of order one, with constant and time trend. Below are the results of the estimations, with standard errors reported in parentheses:

\[
\log \Delta_t = 0.0966 + (3.35 \times 10^{-5})t + 0.9777 \log \Delta_{t-1} + d_t
\]

\[\begin{array}{ccc}
(0.0693) & (2.89E-05) & (0.0163) \\
\end{array}\]  

(A.1)

R-squared: 0.9939

Durbin-Watson statistic: 2.3210

Standard error of regression: 0.0089