Cauê de Castro Dobbin

Does collateral pricing matter for news-driven cycles?

DISSERTAÇÃO DE MESTRADO

DEPARTAMENTO DE ECONOMIA
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Thesis presented to the Programa de Pós-Graduação em Economia of the Departamento de Economia, PUC–Rio as partial fulfillment of the requirements for the degree of Mestre em Economia

Advisor : Prof. Eduardo Zilberman
Co–Advisor: Prof. Carlos Viana de Carvalho

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Abstract

Dobbin, Cauê de Castro; Zilberman, Eduardo (Advisor) ; Carvalho, Carlos Viana de (Co–Advisor). **Does collateral pricing matter for news-driven cycles?**. Rio de Janeiro, 2015. 43p. MSc. Thesis — Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Asset prices are strongly influenced by expectations. Therefore, in the presence of collateralized debt, credit availability will depend on those expectations. We develop a simple RBC model, with credit constraints, to formalize this intuition. We then build a more complex model, fit for quantitative analysis, in order to study the relevance of the mechanism. Our main finding is that the credit constraint does not significantly affect the economy if we allow firms to substitute between equity and debt. This result holds even if such substitution is subjected to severe frictions.

Keywords

Anticipated Shocks; Sources of Aggregate Fluctuations; Collateral Constraints.

Resumo

Dobbin, Cauê de Castro; Zilberman, Eduardo; Carvalho, Carlos Viana de. **O apreçamento de colaterais é relevante em ciclos econômicos gerados por expectativas?**. Rio de Janeiro, 2015. 43p. Dissertação de Mestrado — Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Os preços de ativos são fortemente influenciados pelas expectativas. Dessa forma, na presença de dívida colateralizada, a disponibilidade de crédito vai depender dessas expectativas. Nós desenvolvemos um modelo RBC simples, com restrição ao crédito, para formalizar essa intuição. Em seguida, nos construímos um modelo mais complexo, próprio para análise quantitativa, e estudados a relevância desse mecanismo. Nossa principal descoberta é que a restrição ao crédito não afeta a economia significativamente se permitirmos que as firmas substituam entre dívida e equity. Esse resultado se mantém mesmo que essa substituição esteja sujeita a fricções severas.

Palavras–chave

Choques Antecipados; Fontes de Flutuação Agregada; Restrições de Colateral.

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1
Introduction

Since the subprime crisis in the summer of 2007, there is a growing interest in the role played by the financial sector in business cycles fluctuations. Among other channels, the financial sector may affect the real economy by providing credit to production. There is a burgeoning literature trying to understand this mechanism.

Jermann e Quadrini (2012) have introduced a working capital friction in a RBC model and showed how financial shocks may be an important driver of economic cycles. Particularly, they provide an explanation for the 2008 economic downturn. In their model, fluctuations on financial conditions are driven by an exogenous shock on collateral requirements.

Other articles, such as Iacoviello e Neri (2010) and Liu et al. (2013) have followed a different approach. In their models, debt is collateralized by land. Hence credit availability fluctuates with real estate prices, even if collateral requirements remain fixed. Volatility in land price is generated through a housing preference shock. This shock captures in reduced form any shock not included in the model that affects land prices.

In this article, we take a step further and try to endogenize collateral prices fluctuations. We do so by introducing anticipated shocks, in line with Jaimovich e Rebelo (2009) and Schmitt-Grohe e Uribe (2012). Since prices reflect the discounted sum of expected future payoffs, they respond sharply to news. Hence both the financial shock in Jermann e Quadrini (2012) and the housing preference shock in Iacoviello e Neri (2010) and in Liu et al. (2013) may be capturing fluctuations in expectations.

In order to study this mechanism, we introduce news shocks, working capital and collateral requirements in a RBC model. Our results show that financial frictions strongly amplify anticipation. Furthermore, we found that small but permanent shocks are most amplified. The reason is that prices are calculated considering an infinity horizon. We also conclude that, in this environment, we need capital adjustment costs and a large intertemporal elasticity of substitution to generate comovement between the main macroeconomic aggregates.

We then incorporate those features in a more complex model. This allows us to verify if the mechanisms of the basic model are quantitatively relevant in a more realistic environment.

The full model contains several additional features. Most importantly, firms are allowed to use intertemporal debt to alleviate working capital requirements. Additionally, preferences take the form proposed by Jaimovich e Rebelo (2009) and Schmitt-Grohe e Uribe (2012). This turns the model's responses to anticipated shocks more accurate. Finally, we introduce government spending and mark-up shocks, which have been shown to be important drivers of business cycles by Smets e Wouters (2007) and others.

In the full model, the financial friction turns out to be quantitatively irrelevant. The main reason is that firms substitute debt for equity to deal with working capital need. The higher the collateral requirements, the more firms favor equity over debt.

Since there is a dividend smoothing friction in the model, it is costly to make sharp adjustments in equity payout. Therefore, we show there is a significant real effect if financial conditions abruptly change. This is what happens in the articles discussed above, through a financial or housing preference shock. Nevertheless, the news shocks we introduced do not produce a sufficiently strong effect.

We give some tentative explanations for these results. First, credit constraints actually do not strongly influence business cycles. Second, interactions between financial and real sectors are driven mainly by shocks originated in the former, as in Jermann e Quadrini (2012). Third, the financial frictions used in macroeconomic literature - such as collateral requirements, dividend smoothing and working capital - do not capture the most relevant aspects of the problem. And fourth, our model do not have reliable asset pricing properties.

This article joins a large literature that incorporates financial frictions into DSGE models. Some examples are Iacoviello e Neri (2010), Jermann e Quadrini (2012), Liu et al. (2013) and Pintus e Wen (2013). These articles build on the seminal contributions by Kiyotaki e Moore (1997) and Bernanke et al. (1999). We add to this literature by discussing whether fluctuations in expectations may drive the connection between the financial sector and the real economy.

We also contribute to the debate of what is the relevance of news shocks in business cycles, which goes back to Pigou (1927) and have been recently refreshed by Beaudry e Portier (2006) and others. Particularly, we dialog with articles that follow a structural approach, such as Jaimovich e Rebelo (2009), Fujiwara et al. (2011) and Schmitt-Grohe e Uribe (2012). Among the articles that have explored the importance of news shocks in a financially constrained economy we may cite Kobayashi et al. (2012) and Gunn e Johri (2013).

The rest of the article goes as follows. Section 2 describes the basic model, calibrates it and discusses the results. Section 3 does the same for the full model. Section 4 concludes.

2
The Basic Model

In this section we present a simple model that highlights the main mechanisms we want to discuss. Our basic model is a RBC, with a representative firm and a representative agent, enhanced with financial frictions, real frictions and non-standard technology shocks.

The financial frictions are modeled as follows. The firm is required to take a collateralized short-term loan to pay workers and inputs in advance. Hence the value of the firm's assets limits its production.

The real frictions are twofold: there is a fixed input in production (land) and capital accumulation is subjected to adjustment costs. Those features make asset prices responsive to real shocks.

Finally, the technology process allows for anticipated and unanticipated shocks, both temporary and permanent. We thus may study in which circumstances the financial frictions are most relevant.

2.1 Description

A. Firm Sector

The representative firm has the production function

$$Y_t = (K_t^y)^{\alpha_K} (A_t N_t)^{\alpha_N} (A_t L_t^y)^{\alpha_L} \ ,$$

where Y_t is output, K_t^y is capital input, N_t is labor input, L_t^y is land input, A_t is technology level and α_K, α_N and α_L are parameters. We impose constant returns to scale, ie, $\alpha^K + \alpha^L + \alpha^N = 1$. In our notation, variables subscripted by t are chosen (if endogenous) or known (if exogenous) in t.

The firm owns stocks of capital and land, denoted respectively by K_t and L_t.There are rental markets for both inputs, hence investment and production decisions are uncoupled. The aggregate stock of land is fixed at $\bar{L}$ and capital accumulation is subject to adjustment costs and is given by

$$K_t = K_{t-1} \left[1 - \delta - H \left(\frac{I_t}{K_{t-1}} \right) \right] + I_t \ ,$$

where I_t is investment, δ is the depreciation rate and

$$H\left(\frac{I_t}{K_{t-1}}\right)=\frac{I_t}{K_{t-1}}-\left[\frac{\kappa_1}{1-\frac{1}{\xi}}\left(\frac{I_t}{K_{t-1}}\right)^{1-\frac{1}{\xi}}-\kappa_0\right] .$$

The firm's budget constraint is given by

$$\frac{B_t}{R_t}=B_{t-1}+Y_t+Z_t^K\left(K_{t-1}-K_t^y\right)+Z_t^L\left(L_{t-1}-L_t^y\right)-Q_t^L\left(L_t-L_{t-1}\right)-I_t-D_t-N_tW_t ,$$

where B_t is the firm's intertemporal wealth, R_t is the risk-free rate, Z_t^K is the rental price of capital, Z_t^L is the rental price of land, Q_t^L is the price of land, D_t is equity payout and W_t is the wage rate.

Within a period, the timing is as follows. The inputs are paid in the begging of the period, but the firm realizes its revenue only at the end. Therefore, the firm needs an intratemporal loan l_t given by

$$l_t+Z_t^LL_{t-1}+Z_t^KK_{t-1}=W_tN_t+Z_t^LL_t^y+Z_t^KK_t^y$$

Furthermore, the firm is subject to credit constrains. Its debts are restricted by the amount of collateral it possesses:

$$l_t\leq\psi Q_t^LL_t+\phi Q_t^KK_t , \tag{1}$$

$$B_t\leq\Psi Q_t^LL_t+\Phi Q_t^KK_t , \tag{2}$$

where ψ, ϕ, Ψ and Φ are loan-to-value ratios and measure the efficiency of the financial system and Q_t^K is the shadow price of capital.

B. Household

The representative agent has no credit constraints. She chooses consumption, housing, labor supply and savings to maximize discounted utility, given by

$$E_0\sum_{t=0}^{\infty}\beta^tU(C_t,N_t,L_t^h) ,$$

subject to the budget constraint:

$$\frac{B_t^h}{R_t}=B_{t-1}^h+W_tN_t-Z_t^LL_t^h-C_t+D_t ,$$

where B_t^h is household net assets, C_t is consumption, N_t is labor supply, L_t^h is housing and

$$U(C,N,L^h) = \frac{1}{1-\gamma}\left[C(1-N)^{\eta}(L^h)^{\chi}\right]^{(1-\gamma)} \ .$$

Since there is a rental market for land, the household does not need to own land for housing purposes. However, it could hold both land and capital as an investment. Nevertheless, both assets are more valuable to the firm, because they alleviate the credit constraint, hence, in equilibrium, the firm will hold all capital and land.

D. Technology

We allow technology A_t to be driven by a rich exogenous process. Hence we may study how the relevance of the frictions we introduced depends on the type of shock the economy faces. Technology is given by

$$log(A_t) = log(F_t) + V_t + e_t^A \ ,$$

$$log(F_t) = log(F_{t-1}) + \mu + X_t + e_t^F \ ,$$

$$V_t = \rho_V V_{t-1} + e_t^V \ ,$$

$$X_t = \rho_X X_{t-1} + e_t^X \ ,$$

where μ is the stationary growth rate, ρ_V and ρ_X are persistence parameters and e_t^A, e_t^F, e_t^V and e_t^X are exogenous processes. These processes play distinct roles in the economy: e_t^A is non-persistent shock on technology level, e_t^V is persistent shock on technology level, e_t^F is non-persistent shock on technology growth rate, e_t^X is persistent shock on technology growth rate. To better understand the dynamic of the exogenous processes, figures 2.1, 2.2, 2.3 and 2.4 display the responses of the technology level (A_t) and of the technology growth rate ($log(\frac{A_t}{A_{t-1}})$) to each of these shocks.

News are introduced as follows. Each of the four exogenous processes are the sum os several independent stationary shocks, with different anticipation horizons. Formally, each of the four processes takes the form:

$$e_t = e_t^0 + e_{t-1}^1 + e_{t-2}^2 + e_{t-3}^3 + ... \ ,$$

where (e_t^0, e_t^1, e_t^2, ...) are independent stationary shocks. Consider for instance a shock in e_t^{X2}. It means that in period t the agents are informed that there will be a shock in e_{t+2}^X.

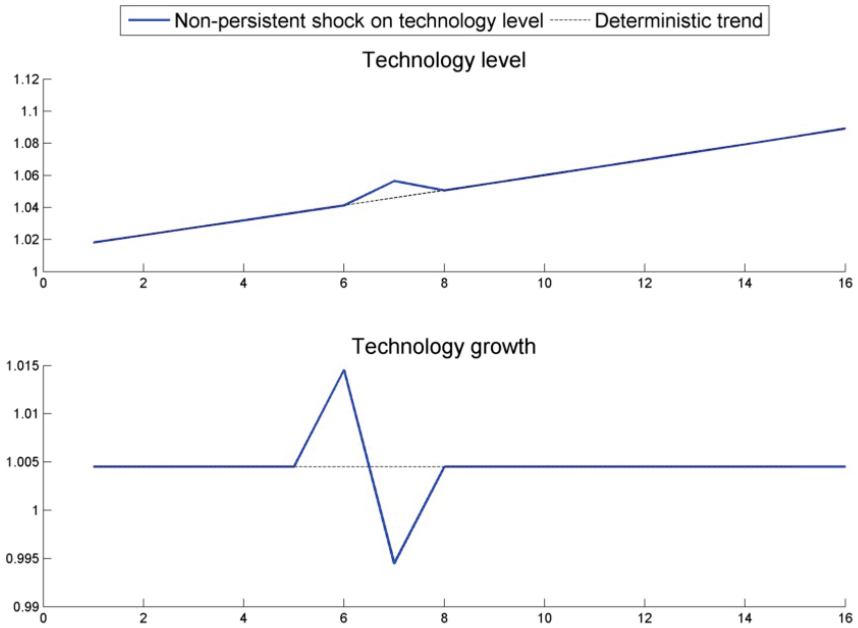

Figure 2.1: Responses to a non-persistent shock on the technology level.

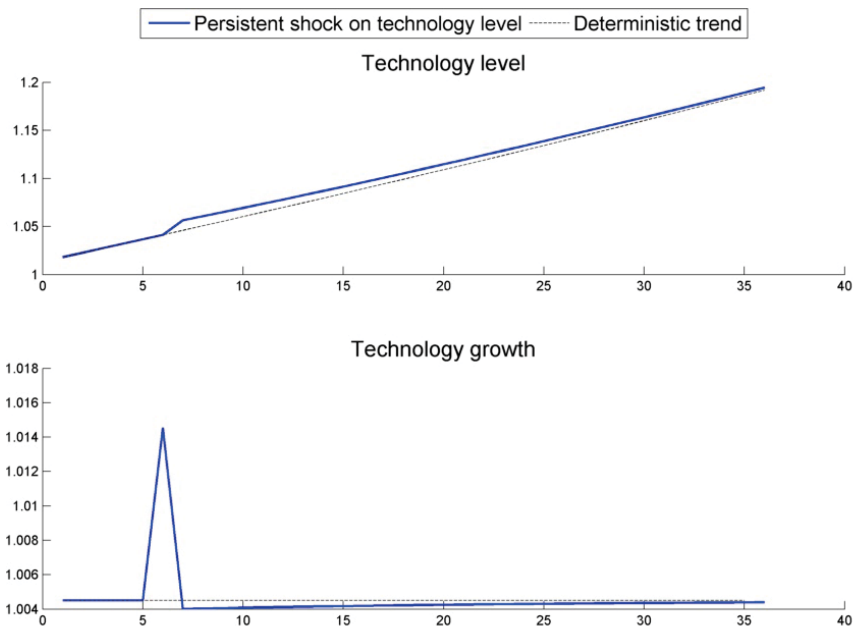

Figure 2.2: Responses to a persistent shock on the technology level.

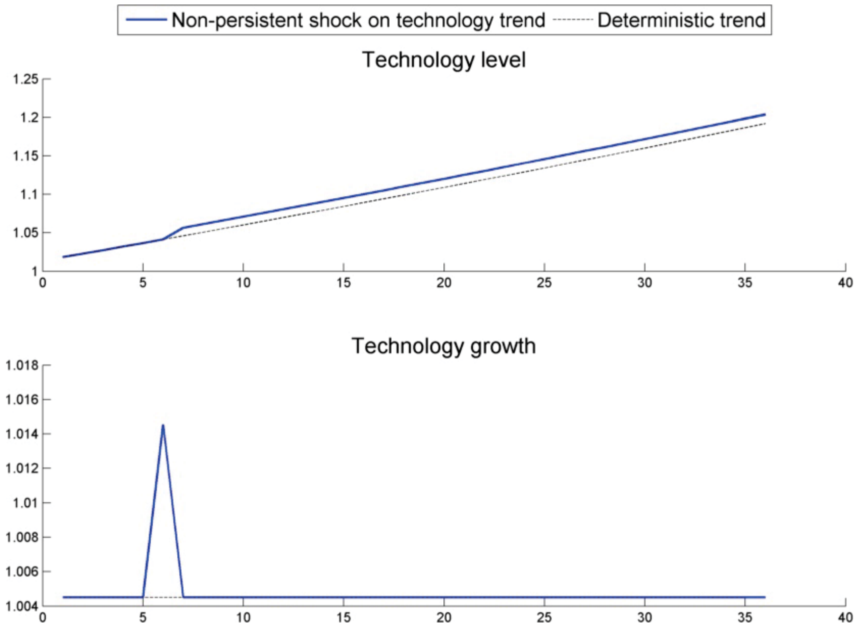

Figure 2.3: Responses to a non-persistent shock on the technology growth rate.

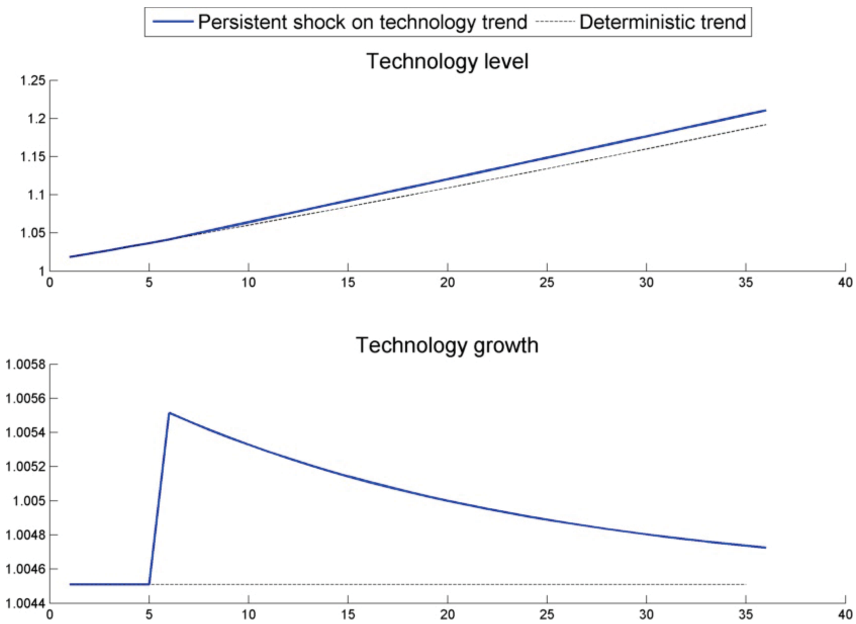

Figure 2.4: Responses to a persistent shock on the technology growth rate.

2.2 Solution

The equilibrium conditions of our economy are

$$Q_t^L = E_t\left[M_{t+1}\frac{Z_t^L(1+\varphi_{t+1})+Q_{t+1}^L}{1-\psi\varphi_t}\right] ,$$

$$Z_t^L = \alpha_L\frac{1}{1+\varphi_t}\frac{Y_t}{L_t^Y} , \tag{3}$$

$$Z_t^L = \chi\frac{C_t}{L_t^H} ,$$

$$L_t = \bar{L} ,$$

$$Q_t^K = E_t\left[M_{t+1}\frac{Z_t^K(1+\varphi_{t+1})+Q_{t+1}^K(1-\delta-H_t+\frac{I_t}{K_{t-1}}H_t')}{1-\phi\varphi_t}\right] ,$$

$$Z_t^K = \alpha_L\frac{1}{1+\varphi_t}\frac{Y_t}{K_t^Y} , \tag{4}$$

$$Q_t^K = \frac{1}{1-H_t'} ,$$

$$W_t = \eta\frac{C_t}{1-N_t} ,$$

$$W_t = \alpha_N\frac{1}{1+\varphi_t}\frac{Y_t}{N_t} , \tag{5}$$

where M_t is the stochastic discount factor and φ_t is the Lagrange multiplier associated with restriction (1). Since there are no frictions in the substitution between intertemporal debt and equity, restriction (2) will not bind in equilibrium.

Analyzing the equilibrium conditions, we may understand the role played by the credit constraint. As we see in equations 3, 4 and 5, when the restriction is biding ($\varphi_t > 0$), the multiplier drives an wedge between input prices and their marginal productivity. Therefore, the allocation of resources will be inefficient.

2.3 Calibration

Our calibration is summarized in table 2.1. The parameters β, δ, ρ_V, ρ_X, η and ξ are calibrated as it is standard in the literature. The intertemporal elasticity os substitution (γ) is usually higher than 1 in the RBC literature, however articles studying long-run risk (LRR) have argued in fa-

Table 2.1: Calibrated parameters of the basic model

Parameter	Value	Explanation
β	0.995	Annualized risk free rate: 3%
γ	0.5 / 1.5	IES ¿ 1 (LRR) / IES ¡ 1 (RBC)
η	2.1	N = 0.3 in steady state
χ	0.016	Housing wealth/GDP = 1.1 in steady state
α_N	0.7	Wage share
α_L	0.05	Literature
δ	0.0125	RBC Literature
ξ	5	Literature
ψ	2%	Constraint Biding
ϕ	2%	Constraint Biding
ρ_X	0.95	Long Run Risk literature
ρ_V	0.95	RBC literature

vor of $\gamma > 1$, such as Massimiliano Croce (2014). We will consider both cases, $\gamma > 1$ being our benchmark. The land share of income (α_L) is set to be among the values used in the collateralized debt literature, such as Iacoviello (2005) and Liu et al. (2013), and in the news-shocks literature, such as Jaimovich e Rebelo (2009) and Schmitt-Grohe e Uribe (2012). We set both loan-to-value ratios (ψ and ϕ) to 2% in order to assure that the credit constraint is always biding in our simulations, keeping the model simple. In the full model we will relax this assumption. Finally, κ_0 and κ_1 are chosen to make $H(\cdot) = H'(\cdot) = 0$ in the steady state.

2.4 Results

In order to better understand the mechanisms of our model, in this section we will analyze several impulse response functions. All the shocks in e_A, e_V and e_F will be of 1% of the steady state and shocks in e_X will be of 0.1%. This is in line with evidence from Massimiliano Croce (2014). He shows that long-run risk shocks have approximately a tenth of the magnitude of the temporary ones.

To begin with, figure 2.5 displays the responses to an expected persistent positive shock on the technology growth rate (e^X). The shock takes place at $t = 5$, but the agents are informed about it at $t = 2$. The blue line represents the responses of the benchmark model, described above. The red line shows the same responses for a model without credit constraints and otherwise equal to the benchmark.

We see that anticipation is much greater with credit constraints. Asset prices depend on their infinity discounted sum of payoffs. Therefore, prices will

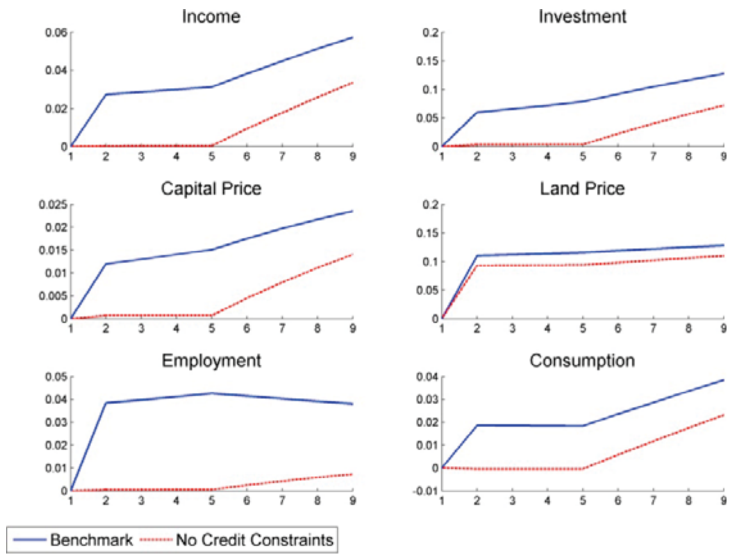

Figure 2.5: Responses to an expected persistent shock on the technology growth rate, in log-deviations of the steady-state. The shock takes place at $t = 5$, but the agents are informed about it at $t = 2$.

rise in response to good news about the future, because of the expectation of greater payoffs. Since debt is collateralized, higher prices alleviate the credit constraint. Therefore, employment, consumption, investment and income rise in response to the news. This result provides evidence that the role of anticipated shocks may turn out to be much greater if we take credit constraints into consideration.

Figure 2.6 displays the response of income to each of the four shocks. Comparing figure 2.6 with figures 2.1 - 2.4, it is clear that, the greater the effect of a shock in the long-run, the bigger the anticipation. The reason is that prices respond more to persistent shocks, because they generate higher payoffs for a longer span of time. Figure 2.7 displays the responses of several variables to an expected non-persistent shock on technology level. Since this is the shock with weaker effect in the long-run, anticipation is mild.

We will now perform some robustness checks. Firstly, figure 2.8 displays the responses to an expected persistent shock on the technology growth rate (e^X), in a model with a low intertemporal elasticity of substitution ($\gamma = 1.5$) and otherwise equal to the benchmark. With this calibration, the news shocks does not generate business cycles, ie, comovement between the main macroeconomics aggregates. With this calibration, the wealth effect predominates over the substitution effect, and consumption rises whereas income falls in response to the news. Therefore, a high intertemporal elasticity of substitution seems to be more appropriate, which is in line with other articles studying long-run risk, such as Massimiliano Croce (2014) and Bansal e Yaron (2004).

Another relevant issue is the relative importance of land and capital

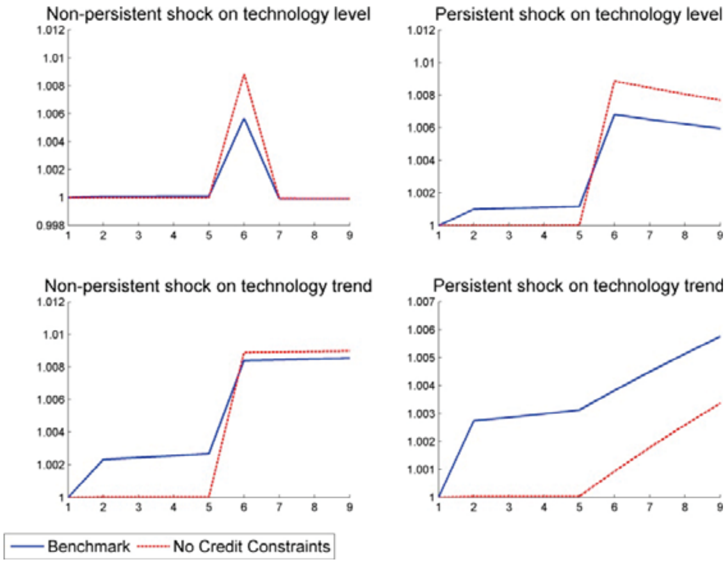

Figure 2.6: Income responses to various technology shocks, in log-deviations of the steady-state. The shocks take place at $t = 5$, but the agents are informed about it at $t = 2$.

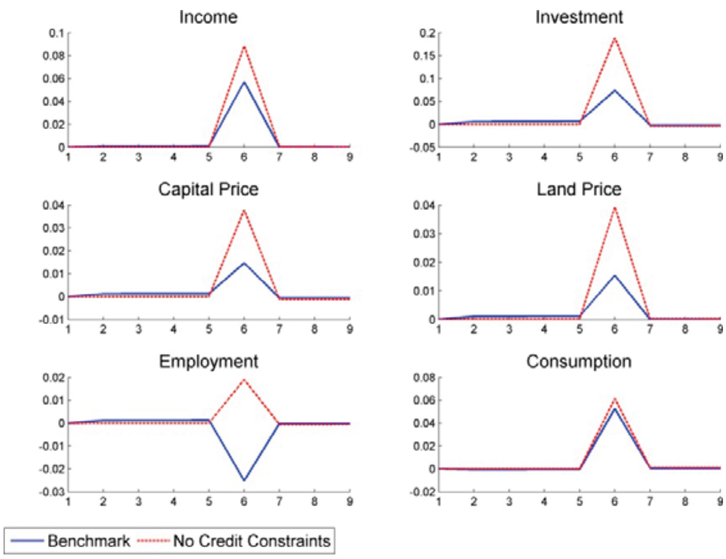

Figure 2.7: Expected non-persistent shock on technology level, in log-deviations of the steady-state. The shock takes place at $t = 5$, but the agents are informed about it at $t = 2$.

Figure 2.8: Responses to an expected persistent shock on the technology growth rate, in log-deviations of the steady-state. In his calibration, $\gamma = 1.5$. The shocks take place at $t = 5$, but the agents are informed about it at $t = 2$.

in credit markets volatility. Figure 2.9 displays in red the responses to an expected persistent shock on the technology growth rate, for a model in which capital may not be used as collateral ($\phi = 0$) and figure 2.10 displays the same for a model in which land may not be used as collateral ($\psi = 0$). When land is the only collateralizable asset, the responses are quite similar to the benchmark model. On the other hand, when capital is the only collateralizable asset, the economy behaves quite differently. It is noteworthy that, in response to the good news, the credit constraint becomes more severe, as the rise in the multiplier (φ) signalizes. This happens because capital price is much less volatile than land price, since the later has a fixed stock. Hence, the rise in capital price is not enough to make the credit constraint less tight. Therefore, the results of the benchmark model seem to be driven mainly by fluctuations in land price.

Let us discuss what drives such fluctuations. Besides being used as an input, land is also used for housing. Figure 2.11 displays the responses of our model when land is not used as housing ($\chi = 0$). The economy behaves almost exactly equally the benchmark, particularly regarding asset pricing. We thus conclude that land price is driven by its use as an input.

Finally, figure 2.12 displays in red the responses to an expected persistent shock on the technology growth rate, for a model with no capital adjustment costs ($\xi = 0$). The most remarkable change is that investment falls in response to the good news, because of the wealth effect, which drives a sharp rise in consumption. With adjustment costs, investment rises in response to good news because it would be too costly to make a large increase in capital stock when

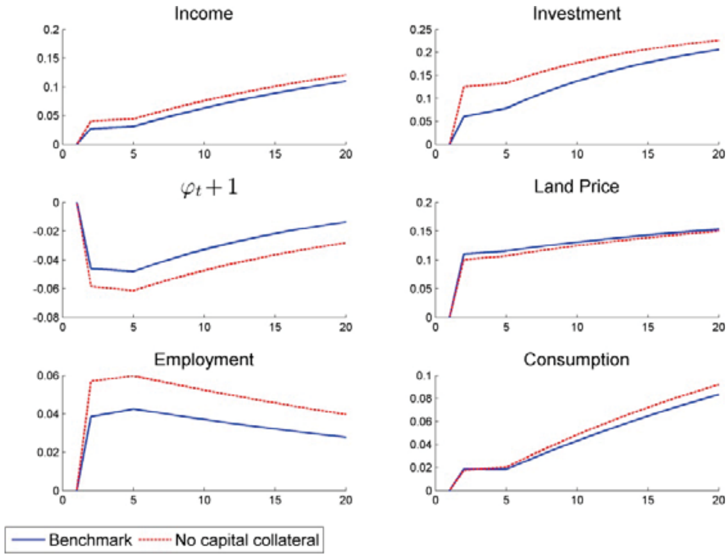

Figure 2.9: Responses to an expected persistent shock on the technology growth rate, in log-deviations of the steady-state. In this model, capital may not be used as collateral. The shocks take place at $t = 5$, but the agents are informed about it at $t = 2$.

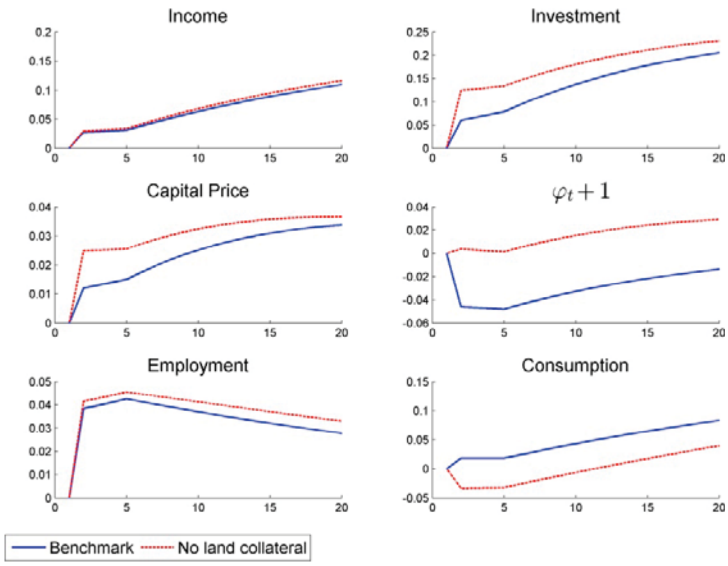

Figure 2.10: Responses to an expected persistent shock on the technology growth rate, in log-deviations of the steady-state. In this model, land may not be used as collateral. The shocks take place at $t = 5$, but the agents are informed about it at $t = 2$.

Figure 2.11: Responses to an expected persistent shock on the technology growth rate, in log-deviations of the steady-state. In this model, land is not used for housing ($\chi = 0$). The shocks take place at $t = 5$, but the agents are informed about it at $t = 2$.

the shock materializes. This shows that capital adjustment costs are necessary to generate business cycles in our model.

Figure 2.12: Responses to an expected persistent shock on the technology growth rate, in log-deviations of the steady-state. In this model, there are no capital adjustment costs ($\xi = 0$). The shocks take place at $t = 5$, but the agents are informed about it at $t = 2$.

3
The Full Model

In this section we describe a more complex model, which incorporates the mechanisms discussed in the previous section. It allows us to verify if the results we found are quantitatively relevant in a more realistic environment.

The full model possesses several additional attributes. Most importantly, firms are allowed to use intertemporal debt to alleviate working capital requirements. Additionally, preferences take the form proposed by Jaimovich e Rebelo (2009) and Schmitt-Grohe e Uribe (2012). This turns the model's responses to anticipated shocks more accurate. Finally, we introduce government spending and mark-up shocks, which have been shown to be important drivers of business cycles by Smets e Wouters (2007) and others.

3.1 Description

A. Firm Sector

The representative firm has the production function

$$Y_t = Z_t^Y (U_t K_{t-1})^{\alpha_K} (X_t^Y N_t)^{\alpha_N} (X_t^Y L_{t-1})^{\alpha_L} \ ,$$

where Y_t is output, K_t capital, N_t labor input, L_t land, X_t^Y an exogenous technology trend, Z_t^Y an exogenous transitory technology shock, U_t the capital utilization rate and α_K, α_N and α_L are parameters. We impose constant return to scale, ie, $\alpha^K + \alpha^L + \alpha^N = 1$. In our notation, variables subscripted by t are chosen (if endogenous) or known (if exogenous) in t.

The total stock of land is fixed at $\bar{L}$. Capital accumulation is subject to adjustment costs and is given by

$$K_t = (1 - \delta(U_t))K_{t-1} + Z_t^I I_t \left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) \ ,$$

where Z_t^I is an investment specific transitory shock, $\delta(U_t)$ is the depreciation rate, given by

$$\delta(U_t) = \delta^0 + \delta^1(U_t - 1) + \frac{\delta^2}{2}(U_t - 1)^2 \ ,$$

where δ^0, δ^1 and δ^2 are parameters. We choose δ^1 to make $U_t = 1$ in steady state. Investment adjustment costs take the form:

$$S\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - \bar{g}^I\right)^2 \ ,$$

where $\bar{g}^I$ is the steady state growth of investment and κ is a parameter.

The firm may issue debt and equity. We follow Hennessy e Whited (2005) and Jermann e Quadrini (2012) and assume that debt is preferred to equity (pecking order) because of tax advantage. Formally, the firm pays an interest rate R_t^F given by

$$R_t^F = (R_t - 1)(1 - \tau) \ ,$$

where R_t is the risk free market rate and τ is a parameter that measures the tax advantage. Therefore, the firm's budget constraint is

$$\frac{B_t}{R_t^F} = B_{t-1} + Y_t - Q_t^L\left(L_t - L_{t-1}\right) - \frac{I_t}{X_t^I} - D_t\left(1 + \varphi\left(\frac{D_t}{D_{t-1}}\right)\right) - N_t W_t Z_t^W \ ,$$

where Q_t^L is the price of land, D_t is equity payout, X_t^I is an investment specific technology trend and Z_t^W is a mark-up shock. The firm pays a markup over the wage workers receive because a labor union intermediates the labor market. There is a dividend smoothing friction given by

$$\varphi\left(\frac{D_t}{D_{t-1}}\right) = \frac{\eta}{2}\left(\frac{D_t}{D_{t-1}} - \bar{g}^D\right)^2 \ ,$$

where η is a parameter and $\bar{g}^D$ is the steady state growth rate of dividends payout.

Within a period, the timing is as follows. Payments to workers, investment goods, shareholders and bondholders are made before the realization of revenues. Hence the firm needs to contract an intraperiod loan l_t given by

$$l_t = \frac{B_t}{R_t} - B_{t-1} + Q_t^L\left(L_t - L_{t-1}\right) + \frac{I_t}{X_t^I} + D_t\left(1 + \varphi\left(\frac{D_t}{D_{t-1}}\right)\right) + N_t W_t Z_t^W \ ,$$

Since this loan is repaid within the same period, in equilibrium it pays no interest. Nevertheless, the credit market is imperfect and debt must be collateralized. Total debt can not be greater than a fraction ζ of the firm's worth. Formally:

$$l_t - \frac{B_t}{R_t} \leq \zeta \left(\phi^L Q_t^L L_t + \phi^K Q_t^K K_t \right) \ , \tag{1}$$

where Q_t^K is the shadow price of capital and ϕ^L and ϕ^K are parameters. Notice that, in this formulation, fluctuations in interperiod debt (B_t) may alleviate or worsen the constraint on the intraperiod loan.

B. Household

The representative agent has no credit constraints. She chooses consumption, housing, labor supply and savings to maximize discounted utility, given by

$$E_0 \sum_{t=0}^{\infty} \beta^t Z_t^\beta \frac{\left(C_t - \nu C_{t-1} - \psi N_t^\theta H_t \right)^{1-\sigma} - 1}{1-\sigma} \ ,$$

subject to the budget constraint:

$$\frac{B_t^H}{R_t} = B_{t-1}^H + W_t N_t + D_t + D_t^{LU} - C_t - T_t \ ,$$

where B_t^H is the household net assets, C_t is consumption, N_t is labor supply, W_t is the wage received from the firm, D_t^{LU} are dividends received from the labor union and D_t from the firm, T_t is a lump-sum tax and Z_t^β is an exogenous preference shock. The parameters β, ν, ψ and σ specify the preference and H_t is a geometric average of current and past habit-adjusted consumption levels and its law of motion is

$$H_t = (C_t - \nu C_{t-1})^\gamma H_{t-1}^{1-\gamma} \ .$$

This preference is based on Jaimovich e Rebelo (2009) and on Schmitt-Grohe e Uribe (2012) and introduces the parameter $\gamma \in (0, 1]$, which controls magnitude of the wealth elasticity of labor supply. As shown in these papers, this preference helps to generate comovement between employment and the other macroeconomic aggregates in response to news shocks.

C. Government

The public sector is mechanic. Government collects taxes from the agent, finances the tax benefit for the firm's debt and consumes. Government consumption is exogenous and given by

$$G_t = Z_t^G X_t^G \ ,$$

where Z_t^G is a transitory spending shock and X_t^G is a stochastic trend. Government's budget constraint is

$$T_t = G_t + B_t\left(\frac{1}{R_t^F} - \frac{1}{R_t}\right) .$$

D. Labor Union

The labor union is also mechanic. It receives a payment $Z_t^W W_t N_t$ from the firm and pays $W_t N_t$ to the agent. Consequently, it pays dividends:

$$D_t^{LU} = (Z_t^W - 1)W_t N_t .$$

E. Market Clear

Equilibrium in the final good market is given by

$$Y_t = C_t + G_t + \frac{I_t}{X_t^I} + \varphi\left(\frac{D_t}{D_{t-1}}\right) D_t .$$

Equilibrium in bonds market is given by

$$B_t = -B_t^H .$$

F. Shocks and Trends

The trends mentioned above evolve according to

$$X_t^Y = g_t^Y X_{t-1}^Y ,$$

$$X_t^I = g_t^I X_{t-1}^I ,$$

$$X_t^G = \left(X_{t-1}^G\right)^{\rho_{XG}} \left(X_{t-1}^Y \left(X_{t-1}^I\right)^{\frac{\alpha_k}{1-\alpha_k}}\right)^{1-\rho_{XG}} ,$$

where g_t^Y and g_t^I and exogenous shocks and ρ_{XG} is a parameter. All the exogenous processes evolve according to

$$log\left(\frac{x_t}{x}\right) = \rho_x log\left(\frac{x_{t-1}}{x}\right) + \epsilon_t^x ,$$

where $x_t \in \{Z_t^Y, Z_t^I, Z_t^G, Z_t^W, Z_t^\beta, g_t^Y, g_t^I\}$, x is the steady state of x_t, $\{\rho_x\}_x$ are persistence parameters and $\{\epsilon_t^x\}_x$ are shocks given by

$$\epsilon_t^x = \sigma_x^0 \epsilon_t^{x0} + \sigma_x^4 \epsilon_{t-4}^{x4} + \sigma_x^8 \epsilon_{t-8}^{x8} ,$$

where ϵ_t^{x0}, ϵ_{t-4}^{x4} and ϵ_{t-8}^{x8} are exogenous, stationary, independent and standard normally distributed random variables and $\{\sigma_x^i\}_{x,i}$ are parameters.

3.2 Solution

The first order conditions of the problems of the agent and of the firm give the following equilibrium equations:

$$\lambda_t^F \left(1 + \varphi_t + \frac{D_t}{D_{t-1}}\varphi_t'\right) = 1 + E_t M_{t+1} \left(\frac{D_{t+1}}{D_t}\right)^2 \varphi_{t+1}' \lambda_{t+1}^F \ ,$$

$$E_t \left[M_{t+1} \frac{\varphi_{t+1}'}{\varphi_t'} R_t^F\right] = 1 - \lambda_t^S \frac{R_t^F}{R_t} \varphi_t' \ , \tag{2}$$

$$Q_t^K = \left(1 - \varphi_t' \lambda_t^S\right) \frac{\alpha_k \frac{Y_t}{K_{t-1}U_t}}{\delta_t'} \ , \tag{3}$$

$$W_t = (1 - \varphi_t' \lambda_t^S) \frac{\alpha_N \frac{Y_t}{N_t}}{Z_t^W} \ , \tag{4}$$

$$Q_t^K Z_t^I \left(1 - S_t - \frac{I_t}{I_{t-1}} S_t'\right) = \frac{1}{X_t^I} - E_t \left[M_{t+1} \frac{\varphi_t'}{\varphi_{t+1}'} Z_{t+1}^I \left(\frac{I_{t+1}}{I_t}\right)^2 S_{t+1}' Q_{t+1}^K\right] \ ,$$

$$Q_t^L \left(1 - \zeta \phi^L \varphi_t' \lambda_t^S\right) = E_t M_{t+1} \frac{\varphi_t'}{\varphi_{t+1}'} \left[\left(1 - \varphi_{t+1}' \lambda_{t+1}^S\right) \alpha_L \frac{Y_{t+1}}{L_t} + Q_{t+1}^L\right] \ ,$$

$$Q_t^K \left(1 - \zeta \phi^K \varphi_t' \lambda_t^S\right) = E_t M_{t+1} \frac{\varphi_t'}{\varphi_{t+1}'} \left[\left(1 - \varphi_{t+1}' \lambda_{t+1}^S\right) \alpha_K \frac{Y_{t+1}}{K_t} + (1 - \delta_{t+1}) Q_{t+1}^K\right] \ ,$$

$$\begin{aligned} \lambda_t^{RO} = & \frac{1}{\left(C_t - \nu C_{t-1} - \psi N_t^\theta H_t\right)^\sigma} - \gamma \lambda_t^H \frac{H_t}{C_t - \nu C_{t-1}} \\ & - \nu E_t \beta \frac{Z_{t+1}^\beta}{Z_t^\beta} \left[\frac{1}{\left(C_{t+1} - \nu C_t - \psi N_{t+1}^\theta H_{t+1}\right)^\sigma} - \gamma \lambda_{t+1}^H \frac{H_{t+1}}{C_{t+1} - \nu C_t}\right] \ , \end{aligned}$$

$$W_t = \frac{\psi \theta N_t^{\theta - 1} H_t}{\lambda_t^{RO}} \frac{1}{\left(C_t - \nu C_{t-1} - \psi N_t^\theta H_t\right)^\sigma} \ ,$$

$$M_t = \beta \frac{Z_t^\beta}{Z_{t-1}^\beta} \frac{\lambda_t^{RO}}{\lambda_{t-1}^{RO}} \ ,$$

$$E_t \left[M_{t+1} R_t\right] = 1 \ , \tag{5}$$

$$\lambda_t^H = \frac{\psi N_t^\theta}{\left(C_t - \nu C_{t-1} - \psi N_t^\theta H_t\right)^\sigma} + E_t \beta \frac{Z_{t+1}^\beta}{Z_t^\beta}(1-\gamma)\frac{H_{t+1}}{H_t}\lambda_{t+1}^H \ ,$$

where λ_t^{RO}, λ_t^H, λ_t^F and λ_t^S are, respectively, the Lagrange multipliers associated with the agent's budget constraint, habit formation, the firm's budget constraint and the credit constraint.

The mechanism through which the credit constraint acts is, intuitively, the same of the basic model. When the constraint is biding - ie, $\lambda_t^S > 0$ - there is a wedge between input prices and their marginal productivity, as we see in equations (3) and (4).

Furthermore, since we are allowing for interactions between intraperiod and interperiod debt, equations (2) and (5) also bring an import intuition. In the absence of dividend smoothing frictions ($\eta = 0$) and subsided debt ($\tau = 0$), these equations imply that $\lambda_t^S = 0$, ie, the credit constraint is loose. In other words, the firm is able to completely overcome working capital restrictions substituting debt for equity. This is why those frictions are essential for our model.

3.3 Calibration

Since our model is very similar to the one in Schmitt-Grohe e Uribe (2012), our benchmark calibration is taken from their estimation. This includes the parameters of the exogenous processes, particularly the variance of the news shocks. The values are summarized in table 3.2. The period is a quarter.

Nevertheless, there is no financial sector in their model. Therefore, we choose (ζ, τ, η) jointly to match moments of American business sector debt and equity payout. The numbers are in table 3.1. The data is from the Flow of Funds Accounts of the Federal Reserve Board and covers the 1984:I–2010:II period. We begin our sample in 1984 because there have been a sharp decline in economic volatility after the Great Moderation. Equity payout is measured by dividends and share repurchases minus equity issues of nonfinancial corporate businesses, minus net proprietor's investment in noncorporate businesses. Debt is measured by "Credit Market Instruments". Finally, ϕ and ψ are set to one so capital and land have equal importance in credit markets.

3.4 Results

A. Main Result

Table 3.1: Financial parameters of the full model

Parameter	Value	Quantity	Data	Model
ζ	0.085	$mean\left(\frac{Debt}{GDP}\right)$	3.36	3.46
τ	0.10	$std\left(\frac{Debt}{GDP}\right)$	1.46	1.58
η	0.000042	$std\left(\frac{Equity\ payout}{GDP}\right)$	1.13	1.03

Notes: 'std' stands for standard deviation. The model moments are calculated from simulated paths.

Table 3.2: Parameters taken from Schmitt-Grohe e Uribe (2012)

Parameter	Value	Parameter	Value
β	0.99	$\sigma^0_{g^Y}$	11.72
σ	1	$\sigma^4_{g^Y}$	1.93
α^K	0.225	$\sigma^8_{g^Y}$	5.50
α^N	0.675	$\sigma^8_{Z^Y}$	0.09
δ_0	0.025	ρ_{g^I}	0.48
g^Y	1.0045	$\sigma^0_{g^I}$	0.21
g^I	1/0.9957	$\sigma^4_{g^I}$	0.16
z^G	0.2	$\sigma^8_{g^I}$	0.16
z^W	1.15	ρ_{z^G}	0.96
N	0.2	$\sigma^0_{z^G}$	0.62
θ	4.74	$\sigma^4_{z^G}$	0.57
γ	0.00	$\sigma^8_{z^G}$	0.37
κ	9.11	ρ_{g^Y}	0.38
δ_2/δ_1	0.34	$\sigma^0_{g^Y}$	0.38
ν	0.91	$\sigma^4_{g^Y}$	0.08
ρ_{XG}	0.72	$\sigma^8_{g^Y}$	0.10
ρ_{Z^Y}	0.92	ρ_{z^W}	0.98
$\sigma^0_{Z^Y}$	0.65	$\sigma^0_{z^W}$	0.50
$\sigma^4_{Z^Y}$	0.11	$\sigma^4_{z^W}$	4.79
$\sigma^4_{z^\beta}$	1.89	$\sigma^8_{z^W}$	0.51
$\sigma^8_{z^\beta}$	2.21	ρ_{z^β}	0.17
ρ_{g^Y}	0.47	$\sigma^0_{z^\beta}$	4.03

Notes: The reported parameters are the medians of the posterior distributions from Schmitt-Grohe e Uribe (2012).

Figure 3.1: Simulated paths for the models with (benchmark) and without financial constraints. All variables are in percentage growth rates.

Table 3.3: The relationship between ζ and intertemporal debt

ζ	0.80	0.60	0.40	0.20	0.10	0.05	0.01
$mean\left(\frac{Debt}{GDP}\right)$	15.44	14.62	13.40	10.51	5.27	-4.96	-86.19

Notes: The model moments are calculated from simulated paths.

Figure 3.1 displays simulated paths for the main aggregates of our model, with and without credit constrains. They are almost indistinguishable. It shows that the financial friction does not seem to be relevant in this model. This is in sharp contrast with the results of the basic model, in which news shocks are strongly amplified by the credit restriction. We will devote the rest of this section to understand why.

B. The importance of intertemporal debt

One of the differences between the basic and the complete models is that in the later the credit constraint is applied simultaneously to inter and intratemporal debt. Therefore, the firm is allowed to adjust its intertemporal debt level in order to alleviate the constraint. Indeed, table 3.3 shows that a tighter credit constraint (low ζ) implies a smaller intertemporal debt. Actually, for an extreme parametrization, the firm becomes net creditor.

To verify if this mechanism is relevant, we construct a model in which intertemporal debt is not considered in the credit constraint. Formally, restriction (1) becomes

$$l_t \leq \zeta\left(\phi^L Q_t^L L_t + \phi^K Q_t^K K_t\right) \ .$$

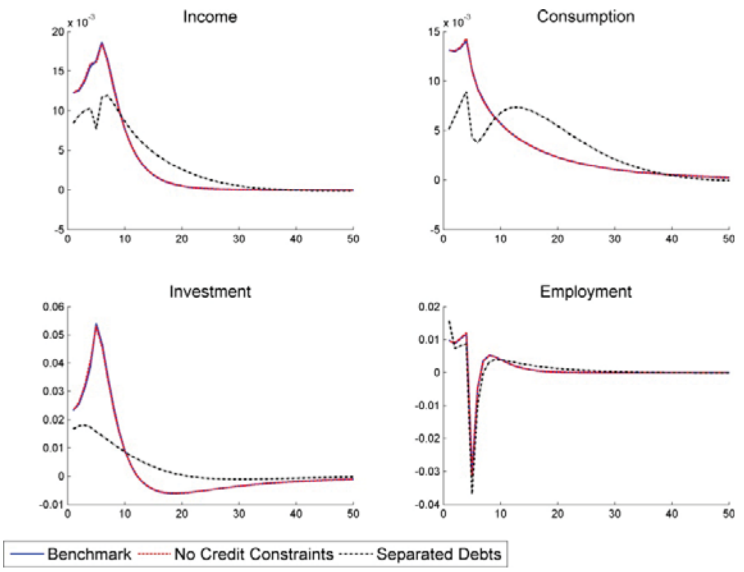

Figure 3.2: Impulse responses to a shock in e_t^{gY4} for the models with (benchmark) and without financial constraints. In the 'Separated Debts' model, only intratemporal debt is constrained. All variables are in percentage growth rates.

Since intertemporal debt is no longer restricted, we must make $\tau = 0$ to prevent the firm from acquiring infinity debt. The model is otherwise identical to the benchmark and we will name it 'Separated Debts'. Figure 3.2 displays impulse responses to an one standard deviation anticipated shock in technology growth rate (gY). As expected, the benchmark model responses are almost identical to the 'No Credit Constraints' ones. Nevertheless, the 'Separated Debts' responses are remarkably different.

C. Comparison with Jermann e Quadrini (2012)

It is interesting to compare our results with Jermann e Quadrini (2012). In their paper, intra and intertemporal debt are considered jointly and the credit constraint is still relevant. This happens because they have a financial shock which impacts the loan-to-value ratio (ζ, in our model). Table 3.3 shows that to deal with high collateral requirements, the firm lowers its steady state intertemporal debt. However, if those requirements suddenly rise, the firm may not immediately adjust its intertemporal debt because there is a dividend smoothing friction.

To exemplify this mechanism, let us introduce a shock in the loan-to-value ratio. Formally, the borrowing constraint takes the form

$$l_t - \frac{B_t}{R_t} \le \zeta_t \left(\phi^L Q_t^L L_t + \phi^K Q_t^K K_t\right) \ ,$$

where

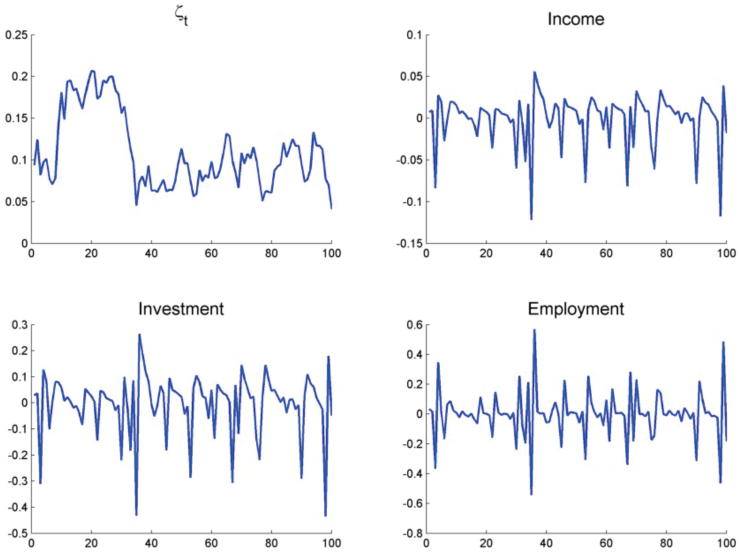

Figure 3.3: Simulated responses from shocks in the loan-to-value rate. ζ_t is displayed in level and the remaining panels in percentage growth rates.

$$\zeta_t = \bar{\zeta} * Z_t^{\zeta} \ ,$$

where $\bar{\zeta} = 0.085$ and $Z_t^{\zeta} \sim \mathcal{N}(1, 0.1)$. We turn off the other shocks and simulate an economy driven only by fluctuations in ζ_t. As discussed above, the firm may substitute debt for equity in order to alleviate the credit constraint. Therefore, dividend payout becomes too volatile with the inclusion of this financial shock. We thus raise the dividend smoothing friction to $\eta = 0.0003$, lowering $std\left(\frac{Equity\ payout}{GDP}\right)$ to 1.87. The model remains otherwise equal to the benchmark.

The results are in figure 3.3. It shows that shocks on the loan-to-value ratio have a significant impact on the economy. Particularly, the volatility of employment is 15% of the generated by the model with all exogenous drivers. Therefore, although the static financial friction resulted irrelevant in our model, financial shocks are still effective, in line with Jermann e Quadrini (2012).

D. Robustness

As a first robustness check, we will take each of the financial parameters of our model to an extreme value. The loan-to-value ratio (ζ) is reduced to 1%. The dividend smoothing friction (η) is raised to 0.0003 and the debt subside (τ) to 35%. These numbers can not be higher, otherwise we get too close to the Blanchard-Khan conditions and the simulations become imprecise.

Figure 3.4 displays the responses of income to an expected shock on technology growth with those alternative calibrations. We see that even with an extreme parametrization, the responses with and without financial frictions are almost identical.

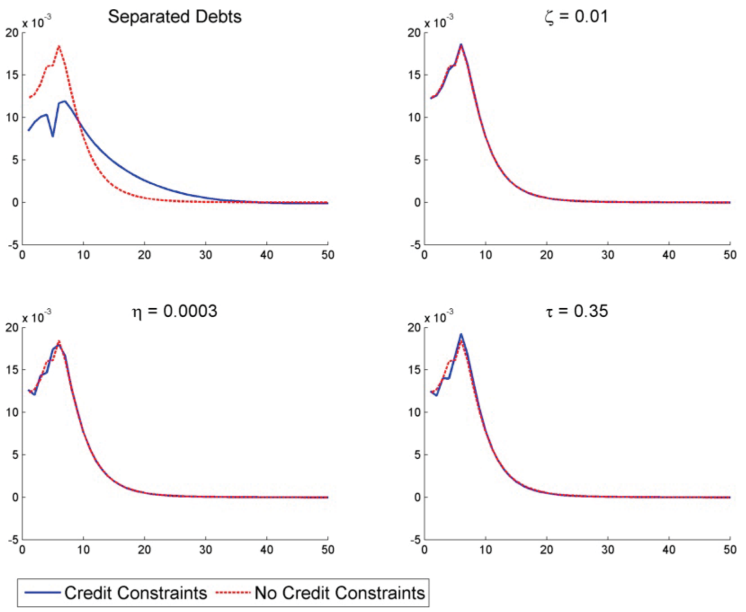

Figure 3.4: Income responses to a shock in e_t^{gY4} for models with and without financial constraints. In the 'Separated Debts' model, only intratemporal debt is constrained. In each of the other three graphs, the indicated parameter is different from the benchmark. Income is in percentage deviation of steady state growth rate.

The shadow price of the credit constraint, measured by its multiplier divided by the firm's flow of funds multiplier, confirms this result. In the benchmark model, the steady-state shadow price is 0.0014 units of the final good. In the 'Separated Debts' model, it is 0.1620, more than a hundred times higher. Whereas ζ and η do not alter the steady-state multiplier, rising τ takes it only to 0.0051.

In the basic model, we learned that persistent shocks are more strongly amplified by the financial constraint. Figure 3.5 displays income responses to persistent shocks on production technology growth (g^Y) and on investment technology growth (g^I). Both persistences are raised to 0.99. In both cases, the credit constraint is still irrelevant.

Now we will construct a large grid of parameters and check, for each of them, if the credit constraint is relevant. The grid will be constructed sampling from the posterior distribution reported in Schmitt-Grohe e Uribe (2012). Since we do not have the exact distribution, we will assume each parameter has a normal posterior distribution, with the percentiles reported in the paper.

The parameter measuring the wealth elasticity of labor supply (γ) has an almost degenerate posterior distribution, close to the edge of the parametric space. We will thus fix γ at the posterior median. For robustness, we repeat the procedure with a different value for γ. For each of those values, 2000 sets of parameters are drawn from the posterior distribution.

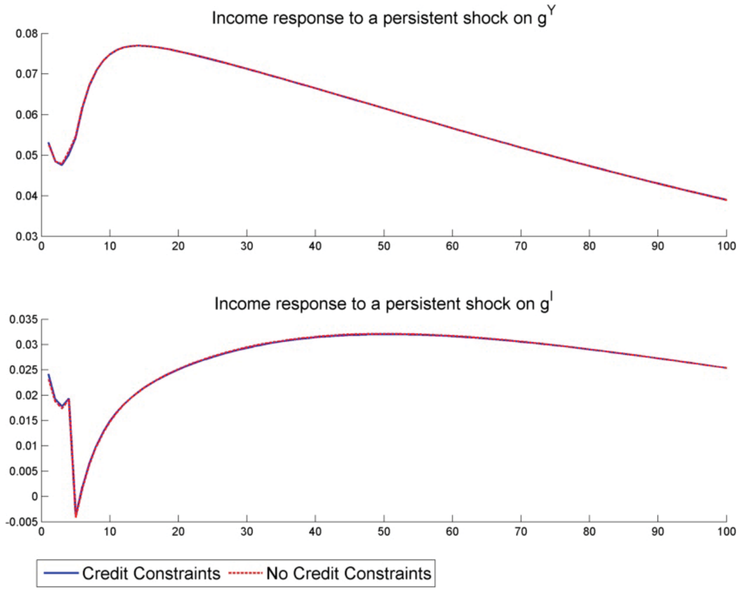

Figure 3.5: Income responses to persistent shocks for models with and without financial constraints. All variables are in percentage growth rates. In the first graph $\rho_{g^Y} = 0.99$ and in the second $\rho_{g^I} = 0.99$.

Table 3.4: Maximum distances between the benchmark and the 'No Credit Constraints' models

Variable	Maximum Distance (%)	
	$\gamma = 0.0019$	$\gamma = 0.9$
Income	0.41	0.32
Consumption	0.43	0.42
Investment	0.28	0.37
Employment	1.67	2.25

For each set of parameters, we calculate the standard deviation of the growth rate of income, consumption, investment and employment, in the benchmark model and in the one without credit constraints. Then we define the following measure of distance:

$$dist(var) = 100 \cdot \left| \frac{std^{CreditConstraints} - std^{NoCreditConstraints}}{std^{CreditConstraints}} \right| ,$$

where var is one of the growth rates. The greatest distances found are reported in table 3.4. Notice that we take the maximum distances separately for each variable. The highest distance in our sample was 2.25%, for investment. In other words, we have not found any calibration in which the financial frictions seemed relevant, which confirms our previous results.

D. Asset Pricing

The behavior of asset prices is very important for our model, since it determines credit availability. However, it is known that production based models have a hard time in explaining some stylized facts of asset returns. See Mehra e Prescott (2003) for a review.

It is out of the scope of this article to discuss in detail the asset pricing properties of macroeconomic models. Therefore, we will just highlight a feature which exemplifies the problems of the environment we are in. Namely, we will compare the excess returns of our model with the data.

Let us begin with some definitions. The value of the representative firm is given by:

$$V_t^M = Q_t^K K_t + Q_t^L L_t + \frac{B_t}{R_t} \ .$$

Therefore, unlevered returns on equity are given by:

$$R_t^M = \frac{V_t^M + D_t}{V_{t-1}^M} \ .$$

In the data, returns are levered. Therefore, we will look at the following excess returns:

$$R_t^{Lev} = \Gamma \left(R_t^M - R_t \right) \ ,$$

where $\Gamma = 2$. Our calibration of Γ is in line with the financial leverage measured by Rauh e Sufi (2011) and conservative with respect to Garcia-Feijio e Jorgensen (2010).

Empirical excess returns are taken from the Fama-French data set, available in K. French's webpage[1]. We consider the 1984.I-2010.II period, the same used to calibrate the financial parameters of the model.

We perform the following exercise. The model is calibrated with the benchmark parameters to generate 6000 samples of 106 periods, as in the data. For each sample, we calculate the mean and the standard deviation of excess returns. The results are in figure 3.6.

We see that the behavior of returns in the model is quite different from the data. The empirical mean of excess returns is above the 93^{th} percentile of the artificial samples. The empirical standard deviation is above the 99^{th} percentile.

Those results raise the question whether the irrelevance of the credit constraint in our model is due to bad asset pricing properties. To solve this

[1] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html, accessed in February 19, 2015.

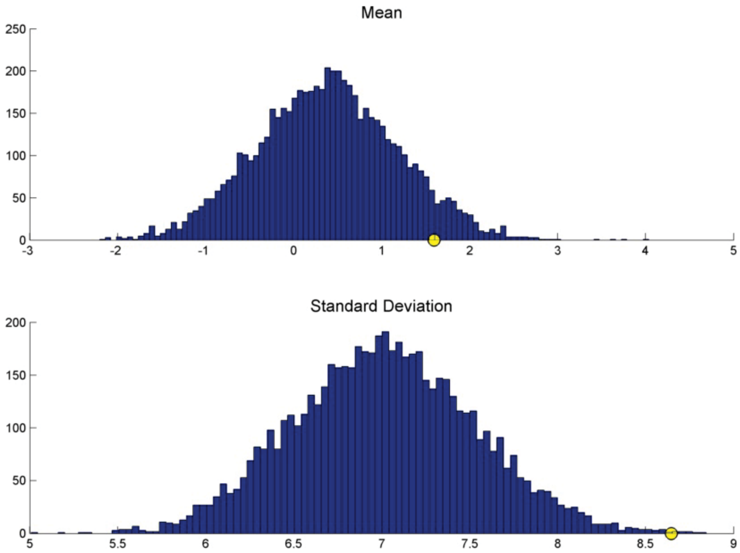

Figure 3.6: The histograms display the mean and the standard deviation of levered excess returns, for each of 6000 artificial samples generated with the benchmark calibration. The yellow circles mark the correspondent values in data.

issue, it would be interesting to include the financial frictions we studied here in a model with reliable asset pricing. We leave this for future research.

4
Conclusion

Prices are strongly influenced by expectations. Therefore, financial conditions will depend on those expectations if firms rely upon collateralized debt to finance production. In this article, we formalize this intuition in a dynamic general equilibrium model.

Our results show that this mechanism seems to be quantitatively irrelevant. The main reason is that firms substitute debt for equity to deal with working capital need. The higher the collateral requirements, the more firms favor equity over debt.

We give some tentative explanations for these results. First, credit constraints actually do not strongly influence business cycles. Second, interactions between financial and real sectors are driven mainly by shocks originated in the former, as in Jermann e Quadrini (2012). Third, the financial frictions used in macroeconomic literature - such as collateral requirements, dividend smoothing and working capital - do not capture the most relevant aspects of the problem. And fourth, our model do not have reliable asset pricing properties.

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