Introducing Capital Structure in a Production Economy: Implications for Investment, Debt and Dividends*

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Abstract

This model adds to the standard neoclassical model of business fluctuations by introducing a more realistic capital structure problem, where firms have to balance the tax benefits of debt with the costs of potential financial distress. Therefore, firms solve a dynamic problem with both an investment and a financing decision. This feature allows firms to finance investment through both retained earnings and debt. As a result, debt will increase after a positive shock and dividends will follow a smoother path. This implies that, as pointed by previous empirical evidence, short-term fluctuations in investment are mostly absorbed by debt and not dividends. The capital structure deteriorates first but then improves after a few quarters. In this model, investment is also inversely related to financial leverage.

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1 Introduction

The standard real business cycle (RBC) model, as presented originally by Kydland and Prescott [29] or Long and Plosser [31] and some of the most important extensions of it, such as Hansen [24], have been quite successful in replicating some of the main stylized facts of macroeconomic variables. It has consequently triggered a vast literature with authors trying to extend or amend the model to account for an increasing number of observed features. Nevertheless, one of the fields where the RBC model has not yet been able to produce a good performance is financial markets. For instance, Danthine and Donaldson [13] or Jermann [25] have shown that RBC models have a tough time in trying to replicate the equity premium that is observed in financial markets. Furthermore, the standard RBC gives very few, if any at all, indications on how variables such as dividends or debt levels vary over the cycle. One of the possible reason for this failure mentioned by some authors is the absence of an elaborated financial sector in the model. As a matter of fact, in the standard model, financial markets are perfect, firms can borrow any amount they want at a riskless rate and default never happens. On the side of the firm, this means that there is no capital structure issue since the Modigliani-Miller theorem always holds. Such a framework leaves very little room for any structured interaction to take place between the balance sheet structure of the firm and the real economy. Consequently, adding a more complex financial sector and a more elaborated decision process for the firm to the model may help to account for a variety of features on financial markets.

The determination of the capital structure of the firm has been at the origin of a long and famous debate in the corporate finance literature. It started in particular with a famous contribution from Modigliani and Miller [35], who argue that capital structure is irrelevant and does not affect any investment decision. Major contributions afterwards have tried to contradict this point by presenting more sophisticated models. These includes Scott [43], Kim [26] and Myers [36] or, more recently, Kim [27], DeAngelo and Masulis [14] and Ross [41]. These models are however developed in partial equilibrium settings and have limited ability to look at how the global economic environment impacts the financial decision process of the firm.

The objective of this paper is to try to extend the standard RBC model by incorporating a more realistic capital structure element as derived in the corporate finance literature. More particularly, one of the most popular theory that has been exposed on the capital structure issue is the so-called "trade-off" model. In this model, the optimal capital structure is chosen by balancing the tax advantages of debt with the costs linked to an additional unit of debt, e.g. bankruptcy costs. For the purpose of introducing this new element, our model will incorporate two main new features. First, in order to introduce default, we will use heterogeneity among firms which will be subject to both aggregate and idiosyncratic shocks. The latter will determine which firms find themselves in a position not to redeem their debts and will therefore go bankrupt. Second, firms will be allowed to borrow from banks and use debt as a tax shield. With these two new elements, firms will choose their optimal capital structure by balancing the tax benefit of debt with the costs linked to higher risks of default. Hence, in this model, firms make both an investment and a financing decision. These two decisions will interact through the probability of bankruptcy. In this case, capital structure becomes relevant and the Modigliani-Miller theorem does not hold.

Results show that, in this new framework, firms will use debt to smooth dividends over time. Investment will not be done at the expense of dividends but will rather be financed by debt. This allows firms to continue to pay dividends and simultaneously reap the benefits of new investment opportunities. This is in accordance with results found for instance by Fama and French [16] who observe that short-term fluctuations in investment are mostly absorbed by debt. Debt in this model is therefore procyclical. Dividends on the other hand follow a smoother path than the one implied by the basic model. Furthermore, financial leverage is negatively related to investment which also seems to correspond to evidence found in Fama and French.

The models closest to ours are the one dealing with the implications from credit market imperfections. The major contributions in this field include papers from Bernanke, Gertler and Gilchrist [4], Carlstrom and Fuerst [9] or Kiyotaki and Moore [28]. The general objective of these papers is to investigate how financial factors influence the amplitude and persistence of business fluctuations. To motivate a meaningful role of financial markets, these models assume that credit markets are imperfect, for instance because there is asymetric information between borrowers and lenders. The main feature we share with these models is the presence of a structured financial sector with, in particular, the presence of risky debt for companies. However, our model differs from these contributions in the sense that it does not rely on asymetric information to motivate the presence of a capital structure problem but rather on the trade off between a tax benefit and costs of financial distress. Moreover, these models do not incorporate the issue of the dividend policy and are therefore not suited for looking at implications in terms of dividend fluctuations.

After reviewing the existing literature in the next section, the paper is then structured in two main parts, the first one dealing with the problem of the firm and the extension of the setting in a general equilibrium model. In this part, we will expose in subsections first the basics of the model, then the bankruptcy process, the bank behavior and the optimization problem of the firm and of households. The following section simulates the model and derives some results, comparing them in particular with the benchmarck classical real business cycle model. Section 5 concludes the paper.

2 Literature

Two kinds of literature are close to the topic of this paper. On one hand, we have general equilibrium models, where some of them focus on replicating the equity premium and others emphasize the role played by imperfections on the credit market. In this category, we are mostly interested in papers introducing some modifications on the firm optimization problem rather than on the preference structure of households. On the other hand, the corporate finance literature has supplied a lot of studies about the firm decision process in presence of bankruptcy and in particular on the interdependence of financing and investment decisions. These models are however developed in a partial equilibrium setting and most of them do not deal with the implications on the whole economy.

2.1 General equilibrium models

2.1.1 Credit market imperfections

The models closest to ours are certainly to be found in the recent literature dealing with the effect of credit market imperfections. The original contributions in this field are Bernanke and Gertler [3], Greenwald and Stiglitz [23] or Gertler [20] and [21]. These models have shown in different frameworks that the presence of imperfections on credit markets, due for instance to asymmetric information between lender and borrower, may alter the reaction of the economy to various shocks. By focusing on the role played by the net worth of entrepreneurs, they show that an outside shock, beside the traditional effect on productivity, also affects the conditions at which firms are able to obtain finance. The financial structure therefore adds a channel through which shocks impact the economy. This feature has resulted in a vast literature, in particular the whole branch dealing with the credit channel of monetary policy.

Among the most recent contributions, the paper by Bernanke, Gertler and Gilchrist [4] is certainly one of the most comprehensive and representative of this literature. Their paper illustrates a general equilibrium model in which credit market imperfections have been endogeneized. The presence of imperfections propagates and amplifies the effects of both nominal and real shock, giving rise to a "financial accelerator" effect. In this setting, imperfections on the credit markets arise because the presence of asymmetric information between lenders and borrowers implies agency costs. Due to the presence of agency costs, intermediaries will require a premium to finance firms. This premium is inversely related to the net worth of entrepreneurs. In turn, changes in net worth happen mostly through changes in the price of capital, but also through changes in entrepreneurial income. Therefore net worth is procyclical. As a consequence, a positive shock to the economy is amplified because it also improves the net worth of the firm, thereby facilitating the possibility to obtain credit. In a final step, the authors integrate this mechanism in a sticky price model and show that monetary policy shocks are amplified by the presence of credit market imperfections.

Other relevant contributions of the same type are found in Kiyotaki and Moore [28] and Carlstrom and Fuerst [9]. Kiyotaki and Moore emphasize the role played by changes in asset prices in the determination of credit conditions. In a model where land is used as collateral, they show for instance that a negative shock to the economy lowers the value of land and therefore the value of collateral. This is equivalent to a tightening of credit conditions and impacts the reaction of firms. Carlstrom and Fuerst on the other hand uses the same type of model as Bernanke, Gertler and Gilchrist [4] and illustrate that it is able to generate hump-shaped responses of output to shocks. Finally, in a series of two papers, Cooley and Quadrini [11] and [12], highlight the distributional implications of the presence of financial factors. In a general equilibrium model with heterogeneous firms and the presence of financial factors, they point to the fact that small firms are responding more than big firms to shocks. In their model, monetary shocks have a persistent impact on output.

2.1.2 Asset pricing

Following the seminal contribution from Mehra and Prescott [33], which shows that the traditional consumption based asset pricing framework is unable to replicate the observed equity premium, several authors have tried to investigate this issue in a general equilibrium production economy. In particular, Danthine and Donaldson [13] have shown explicitely the reasons why the traditional model fails in replicating the equity premium. The source of the disappointing results have to be found in the equality between the return on physical capital and the return on the financial asset. They argue that a richer modelling of the real side of the economy, as well as a more elaborate financial sector have the potential to increase the equity premium. Drawing from this conclusion, they add to the standard real business cycle model features such as adjustment costs of capital, financial leverage and risk-sharing labour contracts. They find that all these characteristics, and most importantly labour contracts, lead to a higher equity premium. Another relevant contribution in this field is the one of Jermann [25]. He also starts from the basic real business cycle and adds several refinements in order to increase the equity premium. This paper especially integrates habit formation preferences, which have been shown for instance by Campbell and Cochrane [8] to impact equity prices. Jermann establishes that the combination of preferences displaying habit formation and adjustment costs of capital helps in explaining the equity premium. Other contributions in the same vein can be found in Lettau [30] or in Tinguely [38].

2.2 Corporate finance models

Our paper is also intimately linked to models of corporate finance dealing with the determination of the capital structure of the firm. There is a long tradition in the corporate finance literature of papers investigating the problem of the optimal amount of debt. The first and most obvious contribution was the one of Modigliani and Miller [35], which states the famous theorem according to which the capital structure is irrelevant in the invesment decision of the firm. Following this seminal paper, authors have focused on the incentives for firms to take debt. The general academic view for the determination of the optimal level of debt relies on a decision which tries to balance the tax benefits of debt with the costs related to leverage. Leverage costs have included all sorts of costs, in particular costs linked to financial distress. Major contribution in this area where brought by Scott [43], Kim [26] or Myers [36]. However, another famous contribution by Miller [34] showed that an important factor had been omitted, i.e. the tax disadvantage for households to hold corporate bonds relative to equities. Thereafter, authors have been busy with restoring the balancing theory through the introduction of new features. Examples can be found in Kim [27], DeAngelo and Masulis [14] or Ross [41].

More recently, papers in the same line of research, and closer to the model we develop below, have tried to draw conclusions on the interaction between the financing and the investment decision. In particular, Dotan and Ravid [15] illustrate that investment and optimal financing decisions have to be simultaneously determined. In this case, a negative relationship exists between operating and financial leverage, supporting empirical evidence on this topic. They also show that an increase in the tax rate leads to lower investment and higher optimal leverage. The sensitivity of investment to the financing decision was also emphasized by empirical papers such as Whited [47], Bond and Meghir [5] or Wald [46]. These papers have estimated Euler equations for investment, however augmenting them with variables linked to the capital structure of the firm. They find that those augmented Euler equations are better able to account for the behavior of investment than the traditional neoclassical one.

3 The model

The behavior of the firm is the central feature differentiating this model from the classical real business cycle model. There are two main departures from the standard model. The first is that firms are allowed to default whenever they are not able to meet their payment obligations. In the case of bankruptcy, profit and capital, net of bankruptcy costs, will be seized by creditors. Of course, creditors, as well as shareholders, might require a premium to finance firms which have a positive probability of bankruptcy. Recall that in the standard model, firms are assumed to never default so that they are always able to meet their liabilities. To introduce bankruptcy, we will need some heterogeneity among firms so that only a fraction of them default on each period. Therefore, in this economy firms will be hit by two kinds of shocks. The first one is a standard economy-wide technology shock. The second one is a shock specific to each firm, which will determine the firms that will default.

If the model should introduce default for firms, then it must be the case that firms have outside liabilities and that conditions exist under which the firm is not in a position to meet its payment obligations. Therefore, and this is the second departure from the standard model, we assume that the firm finances its capital expenditures by both internal and external finance. On one hand, the firm can use retained earnings.

On the other hand, it might also look for outside finance and therefore ask for loans to banks. However, banks will require a premium to compensate for the possibility of bankruptcy. In turn, this will impact the amount of dividends the firm will be able to pay to shareholders.

3.1 The basics

The economy is populated by a continuum of firms of measure one. Firm j produces according to the following technology

$$Y_t^j = f\left(K_t^j, L_t^{j,d}\right)\lambda_t \tag{1}$$

where K_t^j is the amount of capital owned by the firm, $L_t^{j,d}$ is the quantity of labour hired by the firm and λ_t is an aggregate productivity shock.

Earnings of the firm, before interest and taxes (EBIT) is defined as the output less the wage bill

$$EBIT_t^j = Y_t^j - W_t L_t^{j,d} = f\left(K_t^j, L_t^{j,d}\right)\lambda_t - W_t L_t^{j,d} \tag{2}$$

where W_t is the wage rate. These earnings are then subject to corporate taxes, which shaves a fraction τ of earnings. However, firms are allowed to use debt as a tax shield by substracting the payments linked to their debt from taxable earnings. Therefore, profit will be determined as follows

$$\pi_t^j = (1-\tau)\left(f\left(K_t^j, L_t^{j,d}\right)\lambda_t - W_t L_t^{j,d} - R_{t-1}^j B_{t-1}^j\right) \tag{3}$$

where B_{t-1} stands for the amount of debt contracted by the firm and R_{t-1} for the gross interest rate on debt contracted in period $t-1$ but paid in period t. The period subscript for debt and interest rate refers to the period in which debt was contracted. Payment of debt plus interest rate occurs in the period following the period of contracting.

The profit is then used by the firm to pay dividends or kept as retained earning so that the following identity holds

$$\pi_t^j = RE_t^j + D_t^j \tag{4}$$

where RE_t represents retained earnings and D_t dividends.

Moreover, the firm has to determine how to finance its investment. Contrary to the standard model, where the firm finances investment only through retained earnings, the firm now has the possibility to borrow from a bank. Therefore, the firm has to make a financing decision, i.e. how much retained earnings and debt to use.

For simplification, we assume that the firm does not issue new shares[1]. The financing decision implies the following condition:

$$I_t^j = RE_t^j + B_t^j \tag{5}$$

where I_t is investment in period t. Moreover, capital accumulates over time and is subject to a depreciation rate , so that

$$K_{t+1}^j = K_t^j \left(1 - \quad\right) + I_t^j \tag{6}$$

Dividends will follow after the financing decision has been made and are defined as

$$D_t^j = \pi_t^j - I_t^j + B_t^j = (1-\tau)\left(f\left(K_t^j, L_t^{j,d}\right)\lambda_t - W_t L_t^{j,d} - R_{t-1}^j B_{t-1}^j\right) - I_t^j + B_t^j \tag{7}$$

3.2 The bankruptcy process

In our setup, firms can default. Bankruptcy happens when operational profit (EBIT) is not sufficient to pay back the debt contracted in the previous period even after liquidating firm's assets. The final determinant of default will be the specific shock hitting the firm. We assume that the specific shock affects the gross return on capital, which means that default occurs when

$$\delta_t^j \left(EBIT_t^j + K_t^j \left(1 - \quad\right)\right) < B_{t-1}^j R_{t-1}^j \tag{8}$$

where δ_t^j is a specific shock which is i.i.d. across time and firms, follows a cumulative distribution function $G(\delta)$, a density function $g(\delta)$. This type of specification for the bankruptcy process is similar to the one used by several papers on the credit channel of monetary policy, such as Bernanke, Gertler and Gilchrist [4] or Carlstrom and Fuerst [9], which assume that the specific shock determines the gross return on capital. Several remarks apply nevertheless. First, the reason why the shock enters at the EBIT level is that it allows firms to pay wages even in the case of bankruptcy. This assumption consents to keep consumer out of the bankruptcy issue, i.e. they will not be affected by the default of firms. Given that the focus of this paper is more on the implications of default for the behaviour of the firm, we believe that this assumption, even if simplistic, should be less relevant to the overall results[2]. Second, there are several reasons to apply the shock to capital as well as to the current period profit. The first one is more technical. As capital accumulates over time, it is

[1] This can be justified by the observation that firms finance most of their investment projects using outside finance. Taggart (1985) indeed reports that the share of assets financed by new equity issues has not exceeded 5% in the after world war II period. Moreover, as it will become clear later, the firms which would issue new shares are likely to be the one hit by bad shocks and therefore have a rather unhealthy situation. Thus, this condition simply assumes that firms with bad shocks are prevented to access the stock market to obtain new financing.

[2] Moreover, bankruptcy laws very often give priority in the case of default to the payment of wages, which means that workers are able to get back their salary.

likely to be larger than the amount of debt contracted for a single period. Would the shock affect only current period operational result, then the firm would almost always be able to sell part of the capital to reimburse debt. The risk of default would thus almost disappear and most likely not be able to influence the decision process of the firm. This leads to the second reason, which relates to the difference between illiquidity and insolvency. Assume a negative specific shock hits only current period profits, leaving capital unaffected. Even if profit is not sufficient to pay back debt, an arrangement could always be found to let the firm sell part of its capital. This case is therefore more related to the problem of illiquidity. Insolvency would arise if, even by selling the capital, the firm is not able to pay back debt and would thus be forced to default. This means that the shock should also affect the capital used by the company. Finally, one could intuitively think that, when a shock hits the goods produced by a firm, then the value of the equipments used to produce it could also lose some value. You would only assume that equipments are to some extent specific to the production of this particular good. If, for instance, a given good becomes suddenly out of fashion, then the equipment would also be less useful and therefore lose some value as it could not be reallocated easily to the production of another good.

The bankruptcy threshold for the specific shock is the value of δ_t^j below which the firm's output and residual capital are too small to pay back the wage bill and the loan. Hence, the threshold value $\bar{\delta}_t^j$ is such that

$$\bar{\delta}_t^j \left[f\left(K_t^j, L_t^{j,d}\right) \lambda_t - W_t L_t^{j,d} + K_t^j \left(1 - \quad\right) \right] = B_{t-1}^j R_{t-1}^j \tag{9}$$

and therefore

$$\bar{\delta}_t^j = \frac{B_{t-1}^j R_{t-1}^j}{f\left(K_t^j, L_t^{j,d}\right) \lambda_t - W_t L_t^{j,d} + K_t^j \left(1 - \quad\right)} \tag{10}$$

The bankruptcy threshold is increasing in the amount of debt and decreasing in the amount of capital. The latter dependence arises from the fact that by adding capital, the firms extends its production possibilities and is therefore more likely to meet its payment obligations in the following period. The probability of default will thus be a positive function of the amount of debt and a negative function of the stock of capital of the firm. Thereafter, we will use the following notation for the probability that the firm does not default:

$$\Pr\left(no\_default\right) = P_t^j\left(B_{t-1}^j, K_t^j\right) \tag{11}$$

with

$$\frac{\partial P_t^j}{\partial B_{t-1}^j}\left(B_{t-1}^j, K_t^j\right) < 0 \tag{12}$$

and

$$\frac{\partial P_t^j}{\partial K_t^j}\left(B_{t-1}^j, K_t^j\right) > 0 \tag{13}$$

The probability of default is equal to the complementary $1 - P_t^j\left(B_{t-1}^j, K_t^j\right)$.

3.3 The bank

The bank borrows from households and use the funds to lend to firms. Since it has the opportunity to make loans to a lot of different firms, it is able to perfectly diversify away idiosyncratic risks. Therefore it serves the risk-free rate to agents holding bonds[3]. In its lending activity, it sets the interest rate so that it expects to earn at least its opportunity cost, which in this case is the risk-free rate. The bank will set a premium over the risk-free interest rate in order to compensate for the risk of default of the borrower. If the firm does not go bankrupt, the bank will receive back in the following period the amount it has lent plus the interest rate set at the beginning of the deal. In case of default however, the firm will not be able to pay back the loan. Consequently, the bank will seize what is remaining of profit as well as the assets of the firm. But the bank will also have to incur some bankruptcy costs, which means that it will be able to obtain only a fraction θ of the total value of profit and assets. Bankruptcy costs are considered here as a deadweight loss. The bank will then go on the market with the goods seized and sell them. This amount will thus be part of total supply, together with the goods offered by companies which have not defaulted[4].

All in all, the following condition must hold for the bank to participate to the deal[5]:

$$P_{t+1}^{j}\left(B_{t}^{j},K_{t+1}^{j}\right)B_{t}^{j}R_{t}^{j}+\int_{0}^{\bar{\delta}^{j}}\left(\theta\delta_{t}^{j}\left(EBIT_{t+1}^{j}+K_{t+1}^{j}\left(1-\quad\right)\right)\right)dG\left(\delta^{j}\right)=B_{t}^{j}R_{t}^{f} \quad (14)$$

where R_t^f is the risk-free interest rate. The first term on the left-hand side is what the bank gets in the case there is no default whereas the second term is the residual value of the firm in case of default, i.e. gross profit and residual capital, net of bankruptcy costs. θ is the fraction of capital the bank receives after default, so that $(1-\theta)\,\delta_t^j\left(EBIT_{t+1}^j+K_{t+1}^j(1-\quad)\right)$ represents the bankruptcy costs. The right-hand side is the opportunity cost of the bank.

Reformulating the expression yields the following expression for the premium banks will require over the risk-free rate to be compensated for the possibility of bankruptcy:

$$\frac{R_t^j}{R_t^f}=\frac{B_t^jR_t^f-\int_0^{\bar{\delta}^j}\left(\theta\delta_t^j\left(EBIT_{t+1}^j+K_{t+1}^j\left(1-\quad\right)\right)\right)dG\left(\delta^j\right)}{P_{t+1}^j\left(B_t^j,K_{t+1}^j\right)B_t^jR_t^f} \quad (15)$$

In this expression it appears that the premium is increasing in the probability of bankruptcy. Moreover, the spread decreases with an improvement in the recovery

[3] This is a classical assumption made in particular in the literature dealing with credit market imperfections (see e.g. Bernanke, Gertler and Gilchrist [4]).

[4] A full description of the equilibrium conditions will be provided at a later stage.

[5] We assume in this model that there is no asymetric information, i.e. the bank is perfectly able to observe the production process and its outcome.

ratio. Observe that if the default probability is zero, the interest rate charged to firms is identical to the risk-free rate. For future use, we can express the interest charged to the firm in the following way:

$$R_t^j = R_t^j\left(B_t^j, K_{t+1}^j\right) \tag{16}$$

with

$$\frac{\partial R_t^j}{\partial B_t^j}\left(B_t^j, K_{t+1}^j\right) > 0 \tag{17}$$

and

$$\frac{\partial R_t^j}{\partial K_{t+1}^j}\left(B_t^j, K_{t+1}^j\right) < 0 \tag{18}$$

3.4 The firm's optimization problem

The firm will maximise shareholder value, i.e. the present value of future cash flows. The variables over which maximisation will take place are the amount of labor and capital and the amount of debt. Therefore, the firm faces an investment and a financing decision. In making both decisions, the firm is however aware that it might default at any time in the future. Should that happen, shareholders would not be able to receive dividends anymore. Therefore, future cash flows are weighted by the probability for the firm to stay alive. Of course, in both its investment and financing decisions, the firm will take into account that the amount of capital and debt it chooses will impact the probability of default. Consequently, and contrary to the standard model, real and financial decisions will interact, so that the irrelevance of capital structure of Modigliani-Miller will not hold in this setup.

As it will become clear in a while, in this framework, both the investment and the financing decisions are based on variables which are not dependent on the specific shock. Therefore all firms make the same decision and we can from now on drop the superscript j. The timing of events in this economy is detailed in appendix I.

The problem is the following:

$$\max_{L_t, K_{t+1}, B_t} D_t + E_t\left[\sum_{h=1}^{\infty} M_{t,h} P_{t+h}\left(B_{t+h-1}, K_{t+h}\right) D_{t+h}\right] \tag{19}$$

subject to

$$\pi_t = (1-\tau)\left[f\left(K_t, L_t^d\right)\lambda_t - W_t L_t^d - R_{t-1}B_{t-1}\right]$$

$$D_t = \pi_t - I_t + B_t = (1-\tau)\left[f\left(K_t, L_t^d\right)\lambda_t - W_t L_t^d - R_{t-1}B_{t-1}\right] - I_t + B_t$$

$$\bar{\delta}_t = \frac{B_{t-1}R_{t-1}}{f\left(K_t, L_t^d\right)\lambda_t - W_t L_t^d + K_t(1- \quad)}$$

$$K_{t+1} = K_t \left(1 - \quad\right) + I_t$$

$$R_t = R_t \left(B_t, K_{t+1}\right)$$

M_t is the appropriate discount factor and will be defined later.

To solve the problem, we can formulate the following Lagrangian

$$\begin{aligned} \Lambda_t &= D_t + E_t[\sum_{h=1}^{\infty} M_{t,h} P_{t+h} D_{t+h} + \\ &+ \sum_{i=0}^{\infty} M_{t,i} \left(q_{t+i} \left(K_{t+i} \left(1 - \quad\right) + I_{t+i} - K_{t+i+1}\right)\right)] \end{aligned} \tag{20}$$

which has been obtained by adding the constraint on capital accumulation through the Lagrange multiplier q_t. Moreover, by substituting for the definition of dividends into the maximand, this yields the following formulation:

$$\begin{aligned} \Lambda_t &= (1-\tau)\left[f\left(K_t, L_t^d\right)\lambda_t - W_t L_t^d - R_{t-1} B_{t-1}\right] - I_t + B_t + \\ &+ E_t[\sum_{h=1}^{\infty} M_{t,h}[P_{t+h}((1-\tau)\left(f\left(K_{t+h}, L_{t+h}^d\right)\lambda_{t+h} - W_{t+h} L_{t+h}^d - R_{t+h-1} B_{t+h-1}\right) - \\ &- I_{t+h} + B_{t+h})] + \\ &+ \sum_{i=0}^{\infty} M_{t,i} \left(q_{t+i} \left(K_{t+i} \left(1 - \quad\right) + I_{t+i} - K_{t+i+1}\right)\right)] \end{aligned} \tag{21}$$

The first order conditions of this problem are as follows:

$$\begin{aligned} 0 &= E_t\{ -1 + M_{t,1}[P_{t+1}\left((1-\tau)\frac{\partial f_{t+1}}{\partial K_{t+1}} + (1 - \quad)\right) + \\ &+ \frac{\partial P_{t+1}}{\partial K_{t+1}} D_{t+1} - P_{t+1}\left(B_t (1-\tau)\frac{\partial R_t}{\partial K_{t+1}}\right)]\}\} \end{aligned} \tag{22}$$

for K_{t+1},

$$0 = E_t\left\{1 + M_{t,1}\left[\frac{\partial P_{t+1}}{\partial B_t} D_{t+1} - P_{t+1} R_t + \tau P_{t+1} R_t - P_{t+1}\left(B_t (1-\tau)\frac{\partial R_t}{\partial B_t}\right)\right]\right\} \tag{23}$$

for B_t and

$$\frac{\partial f_t}{\partial L_t^d}\lambda_t = W_t \tag{24}$$

for L_t.

3.5 Implications for investment and capital structure

3.5.1 The financing decision

Equation (23) drives the debt policy of the firm. For this variable, there is no comparison with the standard model, since in the latter firms finance themselves only through retained earnings and are not allowed to take risky debt. In our setting, the firm chooses its optimum level of debt by balancing the tax advantages with the costs of an additional unit of debt. The costs in this model are of two kinds. On one hand, an additional unit of debt increases the probability of default, and therefore the costs of financial distress. On the other hand, increasing financial leverage makes debt more costly by increasing the interest rate charged by banks.

The advantages and costs of the financing decision can be seen in equation (23). The first term in this equation corresponds to the proceeds of one additional unit of debt. The second term takes into account that borrowing more increases the next period default probability and therefore decreases the chance to receive dividend. The third term catches the cost of borrowing, i.e. interest and principal payments, conditional on the firm not going bankrupt. The fourth term corresponds to the tax advantage of taking a unit of debt. The final term stands for the impact of more debt on next period contractual conditions for debt. Indeed, borrowing more today increases tomorrow's probability not to be able to pay back debt, lose the stock of capital and therefore being charged a higher interest rate by creditors. This equation thus formalizes the fact that in making its debt decision, the firm balances the tax advantage with the costs of financial distress.

The choice of the optimal level of debt can be best seen by looking at figure 1. This figure shows how the value of the firm, i.e. in our framework the present value of future dividends, is evolving with changes in the amount of debt. One can see that the tax benefits of debt are increasing with the level of debt. At very low levels of debt, the costs are very small and thus it is profitable for the firm to take more debt. However, the costs of debt are becoming increasingly important at higher levels of debt. After a given level of debt, costs are becoming more important than the tax advantages and the firm has no further incentive to increase the level of debt. The optimal level of debt is therefore achieved when the costs linked to financial distress and to increasing interest rates increase quicker than the tax advantages, inducing a decline in the value of the firm. The optimal level of debt in the figure is reached at the point B^*, since from there on, the value of the firm is decreasing in debt. Obviously, a rise in the tax rate increases the tax benefits and thus is associated with a higher optimal level of debt.

Indeed, this implication very much follows the literature in corporate finance. In order to explain the presence of a positive amount of debt, authors have emphasized the role played by taxes on one side and by various costs linked to financial distress on the other side. Well known contributions in this field include Scott (1976), Kim (1978, 1982), DeAngelo and Masulis (1980) or Ross (1985).

Furthermore, in our framework, the optimum level of debt is impacted by the investment decision as well. Indeed, in this framework, the level of capital only affects the costs side of the debt decision. More capital makes the firm's balance sheet more healthy and therefore decreases the costs linked to an additional unit of debt. Therefore, an increase in capital is associated with a rise in the optimal level of debt. In figure 1, an increase of capital from K to K' decreases the costs of leverage for an equal level of debt. As the benefits remain unaffected, the optimal amount of debt rises from B^* to B^{**}.

3.5.2 The investment decision

To study the investment decision, let's first recall how the Euler equation for investment looks like in the neoclassical model:

$$0 = E_t \left\{ -1 + M_{t,1} \left[\frac{\partial f_{t+1}}{\partial K_{t+1}} + (1 - \quad) \right] \right\} \tag{25}$$

In equation (22), we can observe that the introduction of bankruptcy has several implications for the invesment decision of the firm. The first term corresponds to the cost of investment and is of course identical to the classical model. The second term is the effect of one additional unit of capital on next period production. However, in our case, the term incorporates two different features. The first one is about taxes and indicates simply that a fraction of the marginal output goes to the government in the form of corporate taxes. The second new element reflects the fact that the firm is worried about its possible default next period and consequently not to be able to receive the marginal product. Therefore, the marginal product is multiplied by the probability for the firm to be still active next period. Overall, these two effects reduce the present value of an additional unit of capital. The third term is similar to the classical model and can be interpreted as the proceeds of liquidating the remaining investment goods.

The following terms take into account the fact that the firm is aware that any change in capital will alter its financial position next period in two ways. The first one is that adding capital today improves the production capacities of the firm and therefore increases the probability of receiving dividend in the next period. The second reflects the fact that a change in the financial structure of the firm will affect its position with respect to the bank. Adding capital makes the firm more likely to meet its future payment obligations, which in turn will allow the bank to charge a lower interest rate.

Finally, we can also see that the level of debt matters in the investment decision. An increasing level of debt makes the firm more likely to default and therefore increases the power of the default effect. This shows that the separability of investment and financing decisions do not apply in this setup because any change in the debt level would change the perception of the default possibility by the firm and therefore affect its investment behaviour. As seen in the previous section, a rise in capital results in a higher optimal debt level. However, more debt makes financing more costly for the firm and will therefore affect negatively investment.

3.6 The government

The goverment raises taxes from firms in a way which was explicited in the previous section. The total amount of taxes raised is

$$T_t = \int_{\bar{\delta}_t}^{\infty} \left[\tau \left(f \left(K_t^j, L_t^{j,d} \right) \lambda_t \delta_t^j - W_t L_t^{j,d} - R_{t-1}^j B_{t-1}^j \right) \right] dG\left(\delta_t\right)$$

, where τ is the tax rate on firms which do not default.

Since the objective of this model is not to focus on the role of the government, we assume that taxes are then rebated to households in the form of a lump-sum transfer tr_t.

3.7 Households

Households in our model maximise their lifetime stream of discounted utilities. They derive revenues from supplying labor, from investment on financial markets and from government's transfers. The proceeds are then used to consume and save. To transfer consumption through time, households have two kind of financial instruments at their disposal. On one hand, they might buy risk-free bonds. Bonds are issued by banks in order to collect the funds for loans to entrepreneurs. The bank is assumed to lend money to a lot of different firms so that the idiosyncratic risk is diversified away. As households do not incur any specific risk by purchasing bonds, they get the risk-free interest rate. On the other hand, consumer might go on the equity market and buy shares. Those shares entitle him to receive dividends from firms. Consequently, the optimization problem looks as follows:

$$\max_{C_t, L_t^s, Z_{t+1}, B_{t+1}^H} E_t \left[\sum_{h=0}^{\infty} \beta^{t+h} u \left(C_{t+h}, 1 - L_{t+h}^s \right) \right] \tag{26}$$

subject to

$$C_t + Q_t Z_{t+1} + B_{t+1}^H \leq W_t L_t^s + \left(Q_t + D_t\right) Z_t + R_t^f B_t^H + tr_t \tag{27}$$

where L_t^s is the amount of labour supplied by the household, W_t is the wage rate, B_t^H is the amount of risk-free bonds, Z_t the quantity of equities, Q_t the price of the equity, D_t the dividend distributed by firms and tr_t transfers from the government. Here we have assumed that households hold a portfolio of shares which entitle them to the aggregate flow of dividends. This could have also been done by introducing mutual funds and assuming that households own shares of these funds, which in turn hold a diversified portfolio of all existing firms.

The first order conditions of this problem are

$$\frac{\partial u\left(C_t, 1-L_t^s\right)}{\partial L_t^s}=\frac{\partial u\left(C_t, 1-L_t^s\right)}{\partial C_t} W_t \tag{28}$$

for labor supply and the usual Euler equations

$$1=\beta E_t\left\{\frac{\frac{\partial u\left(C_{t+1}, 1-L_{t+1}^s\right)}{\partial C_{t+1}}}{\frac{\partial u\left(C_t, 1-L_t^s\right)}{\partial C_t}} R_{t+1}^f\right\} \tag{29}$$

for risk-free bonds and

$$Q_t=\beta E_t\left\{\frac{\frac{\partial u\left(C_{t+1}, 1-L_{t+1}^s\right)}{\partial C_{t+1}}\left(Q_{t+1}+D_{t+1}\right)}{\frac{\partial u\left(C_t, 1-L_t^s\right)}{\partial C_t}}\right\} \tag{30}$$

for equity holdings. Solving recursively, this latter equation has a unique non-explosive solution:

$$Q_t=E_t\left\{\sum_{i=1}^{\infty} \beta^i \frac{\frac{\partial u\left(C_{t+i}, 1-L_{t+i}^s\right)}{\partial C_{t+i}}}{\frac{\partial u\left(C_t, 1-L_t^s\right)}{\partial C_t}} D_{t+i}\right\} \tag{31}$$

We are now able to define the appropriate discount factor which has been used in the firm's problem. M_t reflects the intertemporal marginal rate of substitution in consumption and is defined as

$$M_{t,h}=\beta^h \frac{\frac{\partial u\left(C_{t+h}, 1-L_{t+h}^s\right)}{\partial C_{t+h}}}{\frac{\partial u\left(C_t, 1-L_t^s\right)}{\partial C_t}} \tag{32}$$

3.8 Equilibrium

To define what the equilibrium of this economy will be, we first have to determine what aggregate values are. This should take into account that a proportion of firms will default in each period and will therefore not pay dividend. The law of large numbers implies that the proportion of firms defaulting in each period t is $G\left(\bar{\delta}_t\right)$. For dividends and investment, aggregate value correspond to dividends paid and investment made by firms which do not default.

$$D_t^A=\int_{\bar{\delta}_t}^{\infty} D_t dG(\delta)=\int_{\bar{\delta}_t}^{\infty}\left[\pi_t-I_t+B_t-B_{t-1} R_{t-1}\right] dG(\delta) \tag{33}$$

$$I_t^A=\int_{\bar{\delta}_t}^{\infty} I_t dG(\delta) \tag{34}$$

where the superscript A stands for aggregate values. As far as aggregate output is concerned, one must take into account that a fraction of production is lost as a bankruptcy costs. The output of firms which default is seized by banks which have to incur a bankruptcy cost which is a fraction $1-\theta$ of the output seized. As these costs are considered as a deadweight loss, they must be deducted from total production.

$$Y_t^A = Y_t - (1-\theta)\int_0^{\bar{\delta}_t} (Y_t - W_t L_t)\, dG(\delta) \tag{35}$$

In terms of capital accumulated, the aggregate stock of capital is the depreciated stock of capital of firms which will continue to run their business, plus the aggregate investment.

$$K_{t+1}^A = I_t^A + \int_{\bar{\delta}_t}^{\infty} (K_t(1-\quad))\, dG(\delta) \tag{36}$$

Moreover, we need equilibrium conditions on the goods market as well as on the bond and equity markets. Concerning the goods market, total supply includes aggregate output, i.e. total production excluded the fraction of output lost in bankruptcy costs. However, banks seizes the assets of defaulted firms and sell them on the goods market. Therefore total aggregate supply also includes a fraction θ of the assets of firms which have gone bankrupt. Demand includes aggregate investment and consumption. Therefore, equilibrium conditions look as follow:

$$Y_t^A + \int_0^{\bar{\delta}_t} \theta\,(K_t(1-\quad))\, dG(\delta) = I_t^A + C_t \tag{37}$$

$$Z_t = 1 \tag{38}$$

$$B_t^H = B_t \tag{39}$$

$$L_t^D = L_t^S = L_t \tag{40}$$

Equilibrium can finally be defined as a series of wages and share prices such that firm's first order conditions (22), (23), (24) and consumer first order conditions (28), (29) and (30) are satisfied, together with market clearing conditions (37) to (40).

4 Calibration

4.1 Functional forms

Functional forms chosen for the evaluation of the model largely follow the benchmark RBC model of Hansen [24]. The production function in this economy is of the standard Cobb-Douglas style

$$Y_t = K_t^{\alpha} L_t^{1-\alpha} \lambda_t \tag{41}$$

where α is the share of capital and λ_t is the aggregate productivity shock.

Preferences are represented by the utility function of the form

$$u(C_t, 1 - L_t) = \log C_t - AL_t \tag{42}$$

where the linearity in the labor variable is derived from indivisibilities in the labor choice used in Hansen's model.

Finally, the aggregate productivity shock λ_t is assumed to follow a first order autoregressive process in logs

$$\log \lambda_t = \psi \log \lambda_{t-1} + \epsilon_t \tag{43}$$

where ϵ_t is a random variable distributed according to an i.i.d. normal distribution with mean zero and variance σ_ϵ^2.

4.2 Parameters

We select very standard values for the preference and technology parameters, mostly following observed business cycle characteristics referenced in Cooley and Prescott [10]. In our model, a period corresponds to a quarter. In particular, we choose standard parameters so as to match a capital over output ratio of 3.32 and an investment over capital ratio of 0.076. This results in a quarterly discount rate β of 0.99 (corresponding ot real interest rate of one percent per quarter). The capital share α is set to 0.35 and the household labor share is thus the complementary 0.65. The quarterly depreciation rate of capital is assigned the usual value of 0.019.

Remaining are the parameters which are non standard, i.e. those linked with the financing decision of the firm. Here, we mostly follow much of the literature on credit market imperfections, such as Bernanke, Gertler and Gilchrist [4], Fisher [17] or Carlstrom and Fuerst [9]. The parameters are set so as to match the following steady-state outcomes: (1) a spread between risk-free interest rate and the interest rate charged by the bank of 200 basis points, approximately consistent with the historical average spread between the prime lending rate and the six-month Treasury bill rate; (2) an annualized default rate of 3 percent; (3) a debt over capital ratio of 0.5. Concerning this last variable, Taggart [37] has reported values about the fraction of assets financed through debt in the after war period varying between 30% and 47%. Therefore, in order to make results as robust as possible, we implement the simulations for a leverage ratio of 0.3 as well. For a leverage ratio of 50%, the tax rate will be close to 20%, which is approximately consistent with estimates given by Taggart [37]. The recovery ratio is 78% for a debt over capital ratio of 0.5 and 92% for a ratio of 0.3, which is roughly in line with the values mentioned by Carlstrom and Fuerst [9] and the studies quoted in their paper. Finally, the specific shock is distributed uniformly on an interval determined by ε. This parameter takes a value of 0.75 for a debt over capital ratio of 0.3 and a value of 0.53 for a ratio of 0.5. The parameters of the model are summarized in table 1.

4.3 Approximation method

To solve the model, we use the method of undetermined coefficients explicited in Campbell [6] and Uhlig [44]. This method implies a log-linear approximation of the system around the steady state.

5 Results

The model will be evaluated by computing both the moments of the main variables and impulse response functions to an aggregate productivity shock. As a benchmark model, we use the model of indivisible labor put forth by Hansen [24]. The model is however slightly modified to incorporate the payment of dividends from firms. We define dividends in the basic model as the residual profit after the investment decision

$$D_t = \pi_t - I_t = f\left(K_t, L_t^d\right)\lambda_t - W_t L_t^d - I_t \tag{44}$$

In this sense, we follow authors such as Danthine and Donaldson [13], Jermann [25] or Rouwenhorst [42]. Therefore, and when possible, results will be compared to the moments derived from the benchmark model and to the observed moments of the US economy. The later are taken mostly from Hansen [24] where they have been computed using quarterly data detrended with a Hodrick-Prescott filter. Statistics for dividends and debt have been computed by ourselves using quarterly data available from US NIPA statistics for dividends and from the US Flow of Funds statistics for debt[6]. The statistics computed from the various versions of the models are also detrended using a Hodrick-Prescott filter. To evaluate the impulse response functions of the model, we also estimate from the data a VAR framework with the main variables of the model and derive the empirical impulse response to a 1% technology shock. The VAR used is a very basic one including real GDP, inflation, commodities inflation and real fed funds rate. The variable for which we want to investigate the reaction is always added at the first place in the ordering. This results in a 5 variables VAR estimated with quarterly observations on the period 1955-2001. The empirical impulse responses are reported in figure 8.

The first thing we are interested in is the behavior of debt in the model and, by the same token, of the leverage ratio. Figure 2 shows the response of debt to a one percent positive productivity shock. There we can see that, as expected, debt is increasing after a positive shock. This happens because a positive shock leads to more investment and therefore more capital. But, as mentioned previously, a rise in capital leads to an increase in the optimal level of debt, through a decrease of financial and default costs linked to debt. The reaction of debt in our model is very similar to the one identified by the empirical VAR. One can see on figure 8 how close

[6] For debt, we have selected the L. 101 category on the level of total non-financial business loans from the US Flow of Funds statistics.

the reaction of the artificial and the empirical measure of debt are. The procyclical nature of debt is also observable through the simulated moments of the economy, i.e. variance and correlation with output. These figures are reported in table 2, together with the observed moments of the US economy and those of the benchmark model. There we see that the correlation of debt with output is positive and highly significant and that the variance of debt is around 20% that of output. In the US economy, debt is indeed positively correlated with output, but the coefficient is not that important. Moreover, the variance of debt is rather high, roughly three times that of output, i.e. in between that of investment and the one of consumption. Consequently, our model is doing a good job in replicating qualitative aspect of the behavior of debt but still needs improvement as far as the quantitative side is concerned.

An increase in debt also means that the firm is using external funds to finance its investment plans. In the standard RBC model, the firm have no access to outside finance and is forced to fund investment through retained earnings. As a result, dividends are strongly countercyclical in the standard model because they absorb all the short-term fluctuations of investment. Indeed, when looking at the impulse responses in figure 3, one can note that the reaction of dividends in the standard model is almost the mirror image of that of investment. In our model, the firm is allowed to use both retained earnings and debt to finance investment. A rise in debt implies that the firm does not need to lower dividends as much as in the standard model in order to obtain funds for investment. The impact of the addition of debt in the model on the behavior of dividends can be observed in figure 3. There we note that dividends are now much less countercyclical than they are in the standard model. In other terms, the use of debt allows firms to smooth dividends over time. In the standard model, firms would have to forego very profitable investment opportunities in order to be able to achieve a smoother dividend path. This seems to bode well with evidence described by Fama and French [16], who show empirically that short-term fluctuations in investment are absorbed mainly by debt, whereas dividends remain relatively sticky. These changes in the shape of the reaction of dividends are also striking from the simulated moments in table 2. Whereas in the standard model the variance of dividends is four times higher than the one of output, in the model with a leverage ratio of 50%, the variance of dividends becomes lower than the one of output. Furthermore, the correlation with output moves from -0.98 to -0.74. On this later front however, the model is not yet achieving a satisfactory result. It has been shown by Campbell [7], Fama and French [16] or Gertler and Hubbard [22] that dividends are positively correlated with economic activity. In table 2, we have computed that the correlation of dividends with output is 0.34. One can also observe in figure 8 that dividends react positively to a technology shock. Consequently, whereas our model is able to reproduce a smoother path for dividends, it is still not able to reproduce the positive correlation with economic activity.

The corollary of this evolution is that investment in this model still has a positive reaction to a favorable productivity shock, but the amplitude of the reaction is decreased. This happens because investment is now financed partly by outside finance. But this type of funds is more costly than internal funds, both in terms of increase in the probability of default and in terms of interest rates. In table 2, we see that the reaction of investment is not as strong anymore as in the standard model. Moreover, figure 4 shows that the reaction is dampened when the leverage ratio is increased. The higher the leverage ratio, the higher the cost of obtaining outside finance and therefore the lower the reaction of investment. This result is consistent with observations and implications from the corporate finance literature. In particular, Dotan and Ravid [15] emphasize that in a same type of model, however in partial equilibrium, operating and financial leverage are inversely related. They claim that this results is consistent with empirical observations. Moreover, Fama and French [16] have also reported that leverage was negatively related to investment opporturtinities. As a further consequence, output in our framework is slightly less volatile than in the benchmark model (figure 5).

This implication is partly surprising when looking at some of the literature on credit market imperfections. For instance, Bernanke, Gertler and Gilchrist [4] find that the introduction of imperfections on the credit market amplifies output fluctuations. This implication is indeed at the heart of the theory of the financial accelerator. However, firms in their model do not solve for an optimal level of debt and do not distribute dividends. Indeed, the amount borrowed depends on the evolution of net worth of entrepreneurs. Profits increase net worth and are entirely kept to finance future investment plans. Since net worth is improved during expansions, firms are able to obtain finance at more favorable conditions and therefore expand investment. However, what we show is that, as soon as we allow firms to pay dividends, entrepreneurs will prefer to rely more on external finance and pay positive dividends. Since this kind of finance is more costly, investment is lowered. Therefore, the two models highlight two different mechanisms, which are likely to be complementary.

The next question is what happens to the structure of capital. Figures 6 and 7 give us some hints by illustrating the reaction of both debt and capital to a positive productivity shock. In the short term, the firm relies heavily on external finance to fund investment and therefore the increase in debt is stronger than the rise of capital. Thus, the debt over capital ratio worsens in the immediate quarters following the shock. Nevertheless, after a while, investment becomes productive and generates profits. In turn, this allows firms to finance part of investment through retained earnings and thus debt is decreasing faster than capital. Some time after the shock, the capital structure starts to improve definitely. Since when the leverage ratio is higher the reaction of debt is smaller, the capital structure improves quicker with a leverage ratio of 50% than with one of 30%. With a leverage ratio of 50%, the structure of capital deteriorates in the first year only and then starts to improve from the second year onward.

6 Conclusion

The objective of this paper is to look at the implications of the introduction in a standard RBC model of a more sophisticated decision process on the side of the firm. Our model nests a traditional real business cycle model with a classical contribution from the corporate finance field. The later argues that in order to determine the optimal capital structure, firms balance the tax benefit of debt with the costs linked to financial distress. In our model, firms can go bankrupt because they might suffer from a sufficiently negative shock so that they will be unable to meet their payment obligations. In order to allow for default, we have introduced the possibility for the firm to borrow funds from banks. Moreover, the model also introduces taxes as a major determinant of the capital structure decision. Therefore, in this setup, firms have to solve simultaneously for an investment and a financing decision. In the later decision, the firm will have to determine how much retained earnings and how much external funds it will use in order to finance the desired investment plans. In making both decisions, firms are aware that they might default at any point in time in the future and lose their future dividend stream. As a result, both decisions will interact and the Modigliani-Miller theorem does not apply in this framework.

Among the main contributions of this paper, we have shown that the introduction of a more elaborated capital structure problem allows for a positive correlation of debt with output and a much smoother path for dividends than it is the case in the standard RBC model. Indeed, firms will use in part debt to finance new investment plans in order to be able to keep a certain level of dividends. In the standard RBC model, since only internal funds are used, dividends tend to vary in a mirror image with investment. Therefore, and consistent with empirical evidence, fluctuations in investment are mostly absorbed by debt and not by dividends. Moreover, since outside finance is more costly than internal finance, investment tend to react less in our model than in a standard model. As a matter of fact, the higher the leverage ratio, the more muted the reaction of investment, and therefore capital and output, is. This confirms that an economy in which the balance sheet conditions are more vulnerable, firms will be less able to reap the full benefits of new investment opportunities. Furthermore, this is in accordance with results where it has been shown that leverage is negatively related to investment opportunities.

In further research, the model might be used to study a variety of problems. One possible extension would be to look at the impact of a smoother path of dividends on asset prices. Indeed, a less countercyclical path of dividends would make equities less valuable for households. In this sense, it might add to the equity premium. Another direction that might be investigated is the effect of monetary policy and more particularly the hypothesis of the presence of a financial accelerator effect. Overall, we believe that the model shows that adding a more sophisticated firm problem to the standard RBC model might allow to investigate a variety of issues on the interaction between corporate finance decisions and general economic conditions.

7 Appendix

Timing issues : this is the sequence of events in a given period t

B_{t-1}, K_t, R_{t-1} are inherited from previous period

1. Aggregate shock is realized : λ_t
2. Firms decide on labor input : L_t^D
3. Households supply labor : L_t^S
4. Bankruptcy threshold $\bar{\delta}_t$ is determined
5. Specific shock is realized : δ_t. Production takes place
   (a) Firms for which $\delta_t \leq \bar{\delta}_t$ default : $W_t L_t$ of goods are kept by the firm to pay wages. The rest of the production and assets K_t are seized by the bank. Firms stop activity
   (b) Firms for which $\delta_t \geq \bar{\delta}_t$ continue.
6. Labor and good markets clear. Supply of goods is the production of non default firms plus goods of default firms seized by the bank less bankruptcy costs :

$$Y_t - (1-\theta) \int_0^{\bar{\delta}_t} \left[Y_t - W_t L_t + K_t (1 - \quad) \right] dG(\delta)$$

7. Firms pay back debt plus interest contracted in the previous period $B_{t-1}R_{t-1}$. Profit is determined.
8. Investment and financing decisions are made simultaneously, firms decide on next period capital and amount of debt: I_t, K_{t+1}, B_t
9. The bank defines the interest rate charged on the basis of the amount of debt contracted and the next period quantity of capital : R_t. Firms get money for new contracted loan B_t
10. Dividends are paid : D_t

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	B/K=0.3	**B/K=0.5**
β	0.99	
α	0.35	
	0.019	
ψ	0.95	
σ_ϵ	0.00712	
θ	0.78	0.92
τ	0.19	0.06
ε	0.75	0.53

Table 1: Value of the parameters of the model

	US data			Basic RBC			With debt B/K=0.3			With debt B/K=0.5		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
capital	0.63	0.36	0.04	0.45	0.24	0.32	0.37	0.22	0.35	0.32	0.20	0.36
debt	4.82	2.78	0.29				0.43	0.25	0.94	0.28	0.18	0.81
consumption	1.29	0.73	0.85	0.48	0.26	0.87	0.58	0.34	0.91	0.63	0.40	0.93
output	1.76	1.00	1.00	1.88	1.00	1.00	1.69	1.00	1.00	1.59	1.00	1.00
labor	1.66	0.94	0.76	1.48	0.79	0.99	1.20	0.71	0.98	1.03	0.65	0.97
investment	8.60	4.89	0.92	6.85	3.64	0.99	5.71	3.38	0.99	5.04	3.17	0.99
dividends	3.73	2.14	0.34	7.62	4.05	-0.98	2.06	1.22	-0.73	1.20	0.75	-0.74

Table 2: Summary statistics for US economy, benchmark model and present model. Data for the US economy are taken from Hansen (1985) for standard variables and computed by the author for debt and dividends. The benchmark model is the one of Hansen (1985) slightly modified to incorporate dividends. Column (a) is the variance of the variable, column (b) is the variance of the variable relative to the variance of output and column (c) is the correlation with output

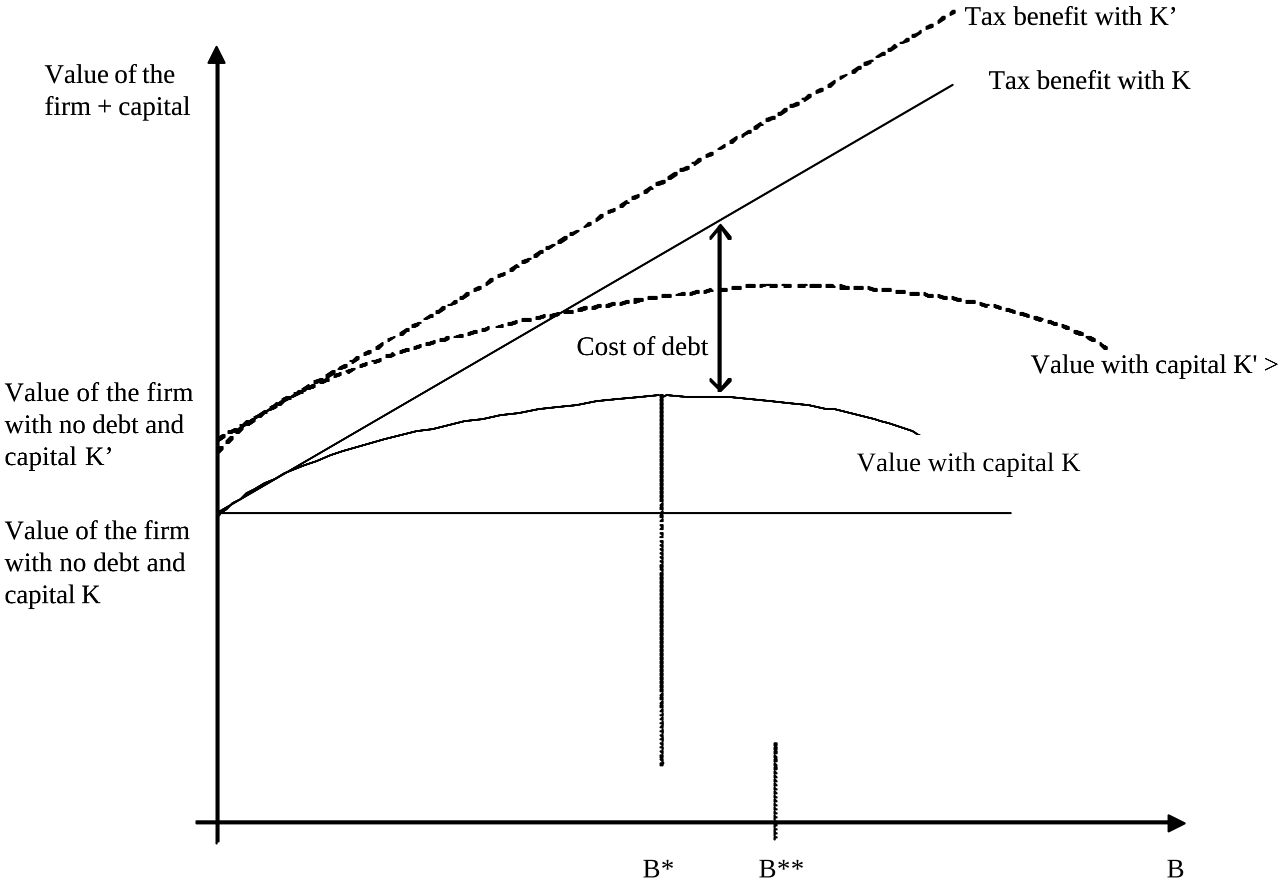

Figure 1: The value of the firm and the optimal level of debt.

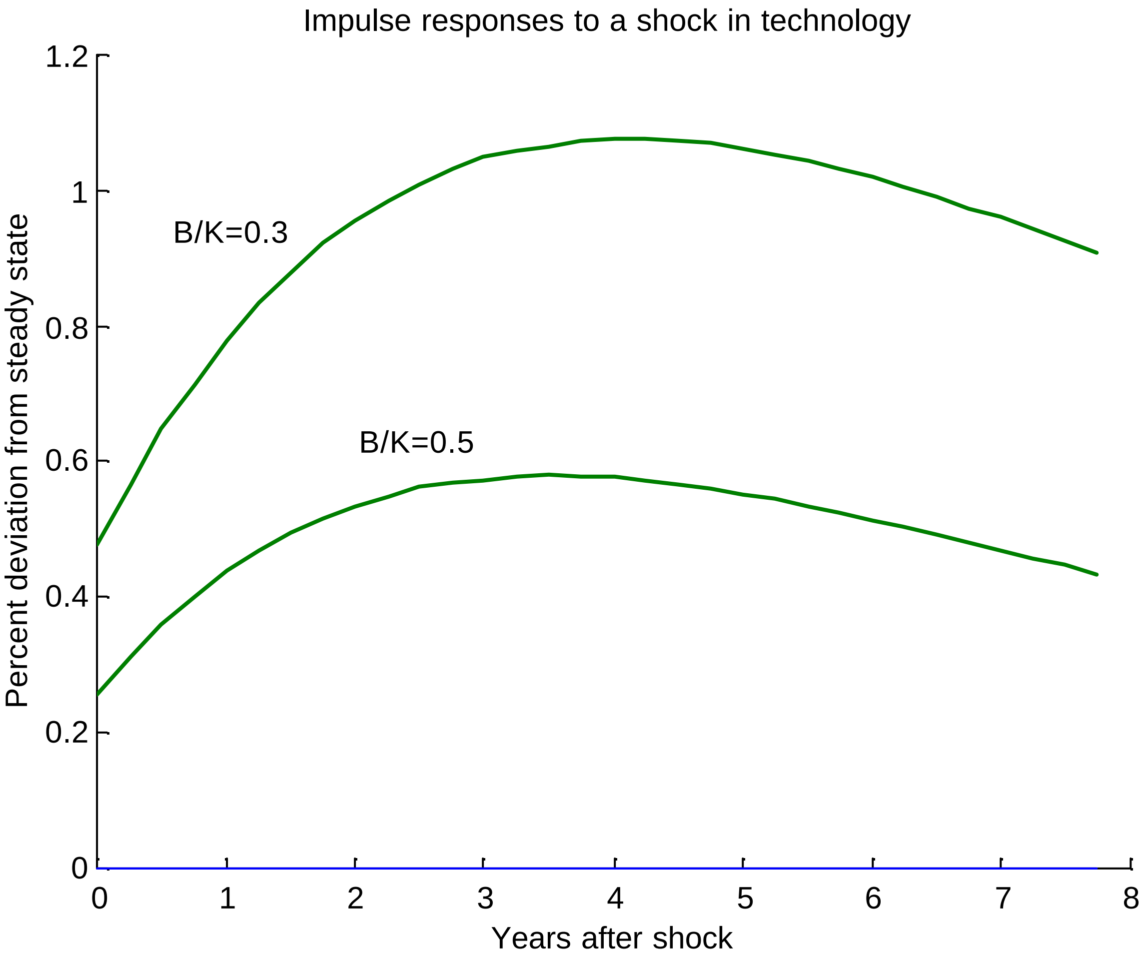

Figure 2: Response of debt to a one percent positive technology shock.

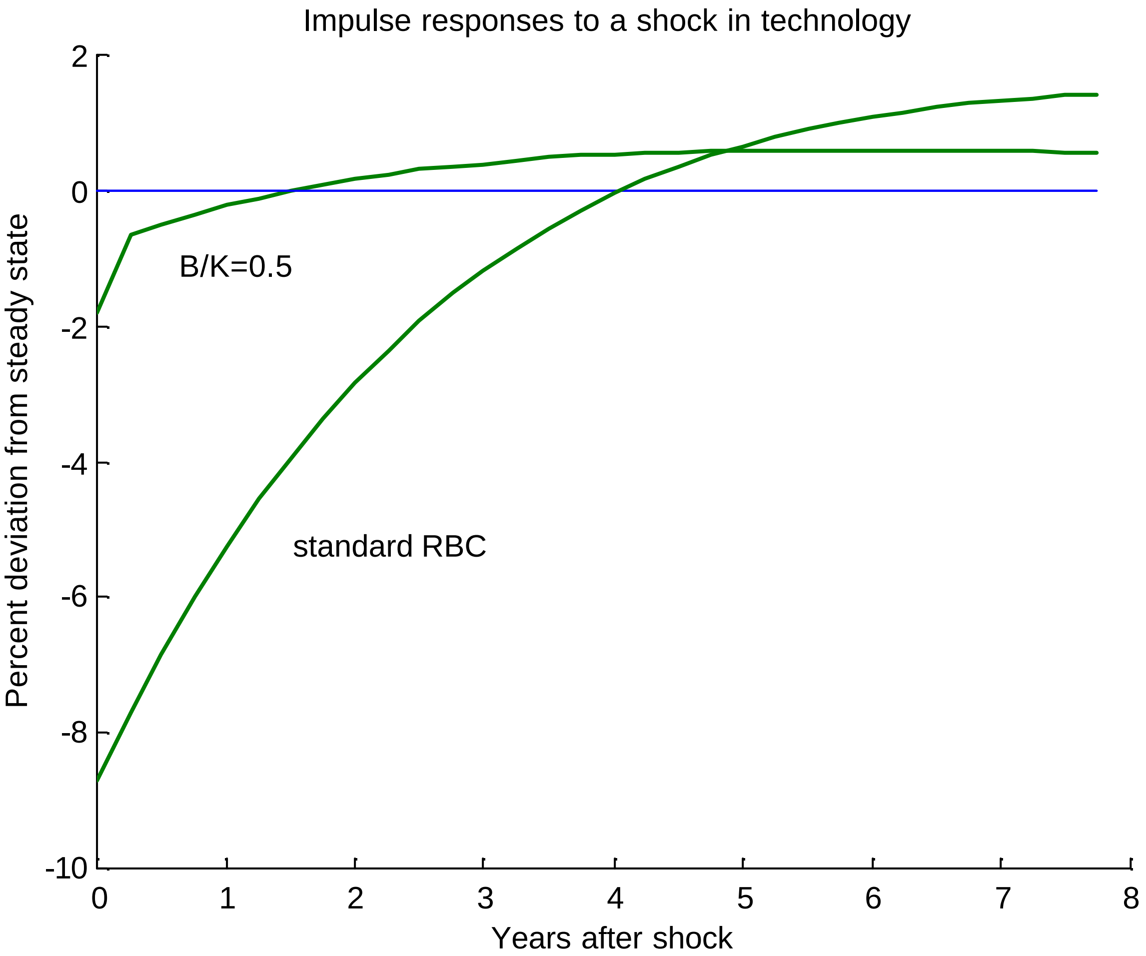

Figure 3: Response of dividends to a one percent positive technology shock.

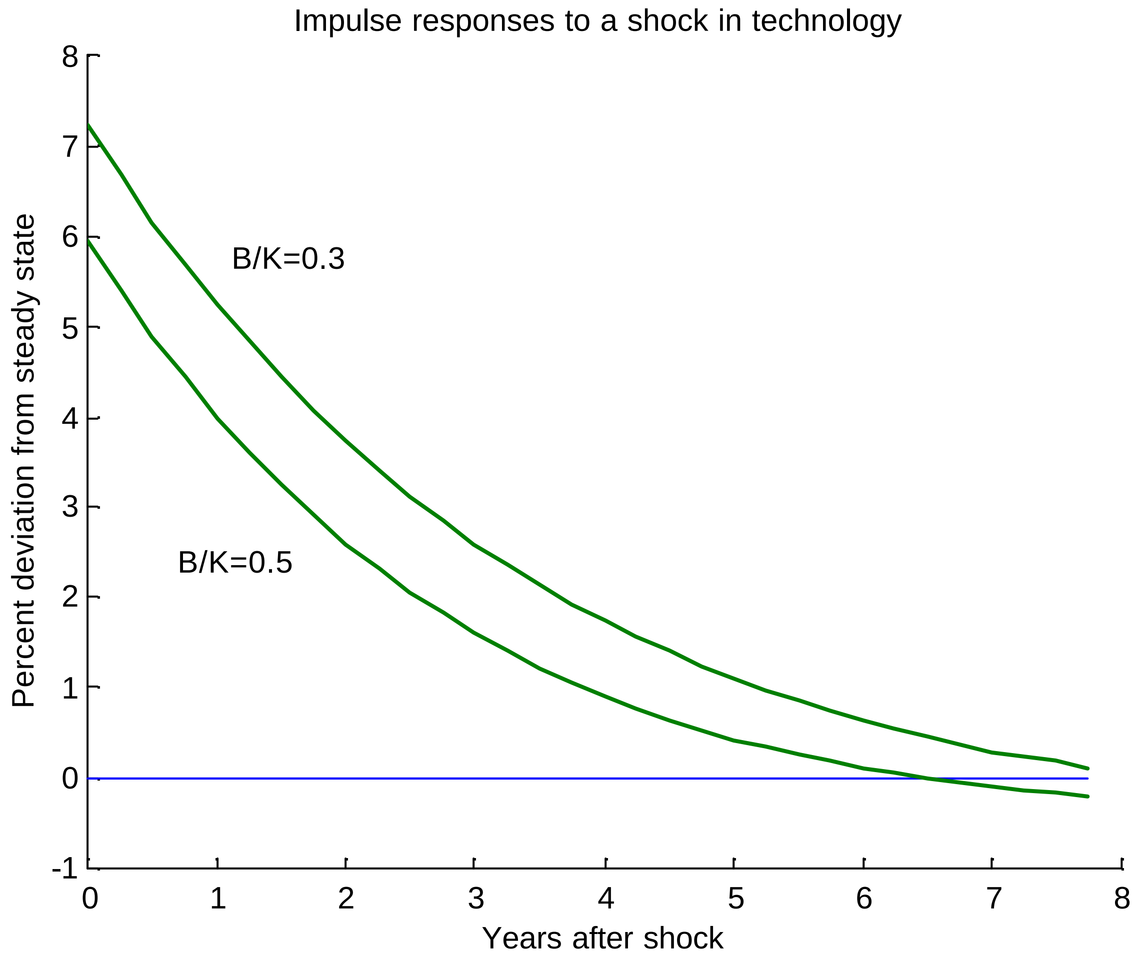

Figure 4: Response of investment to a one percent positive technology shock.

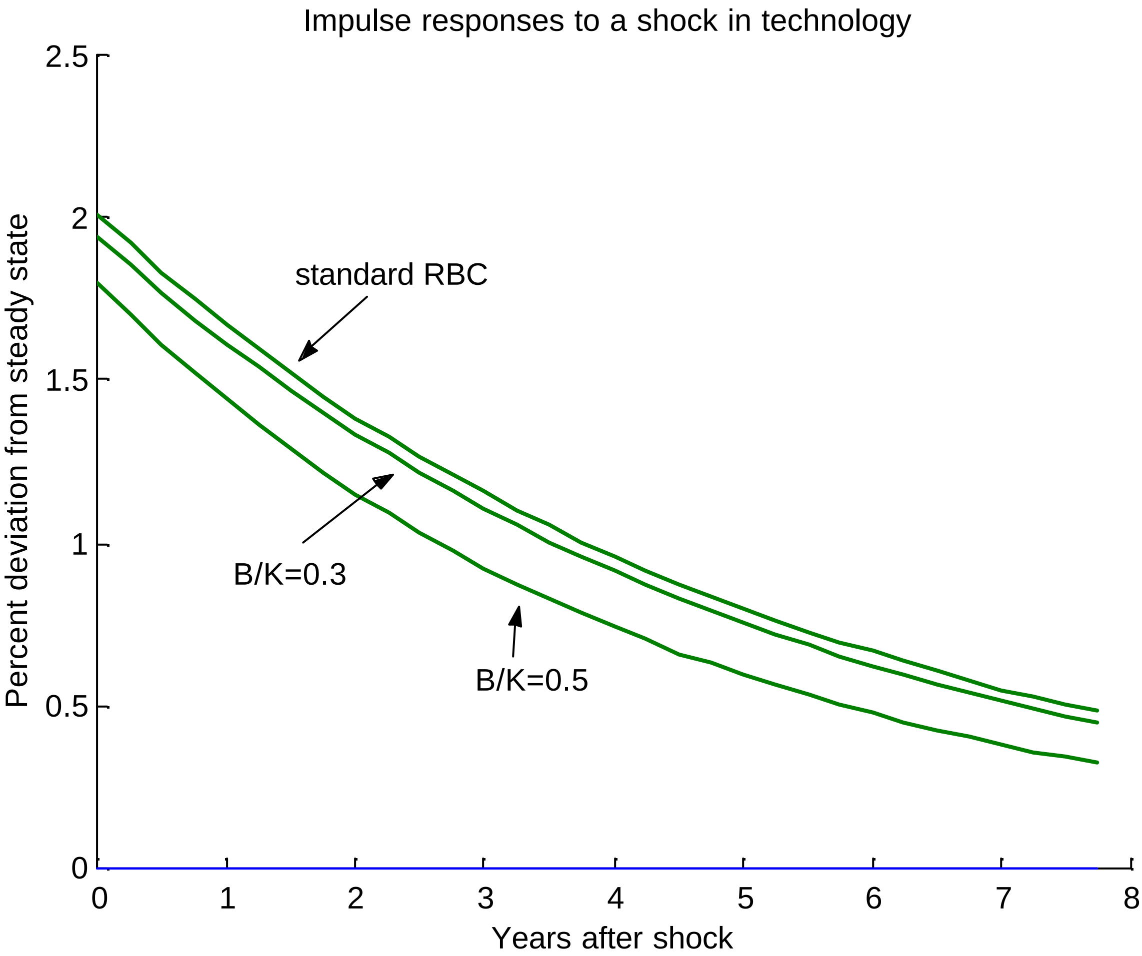

Figure 5: Response of output to a one percent positive technology shock.

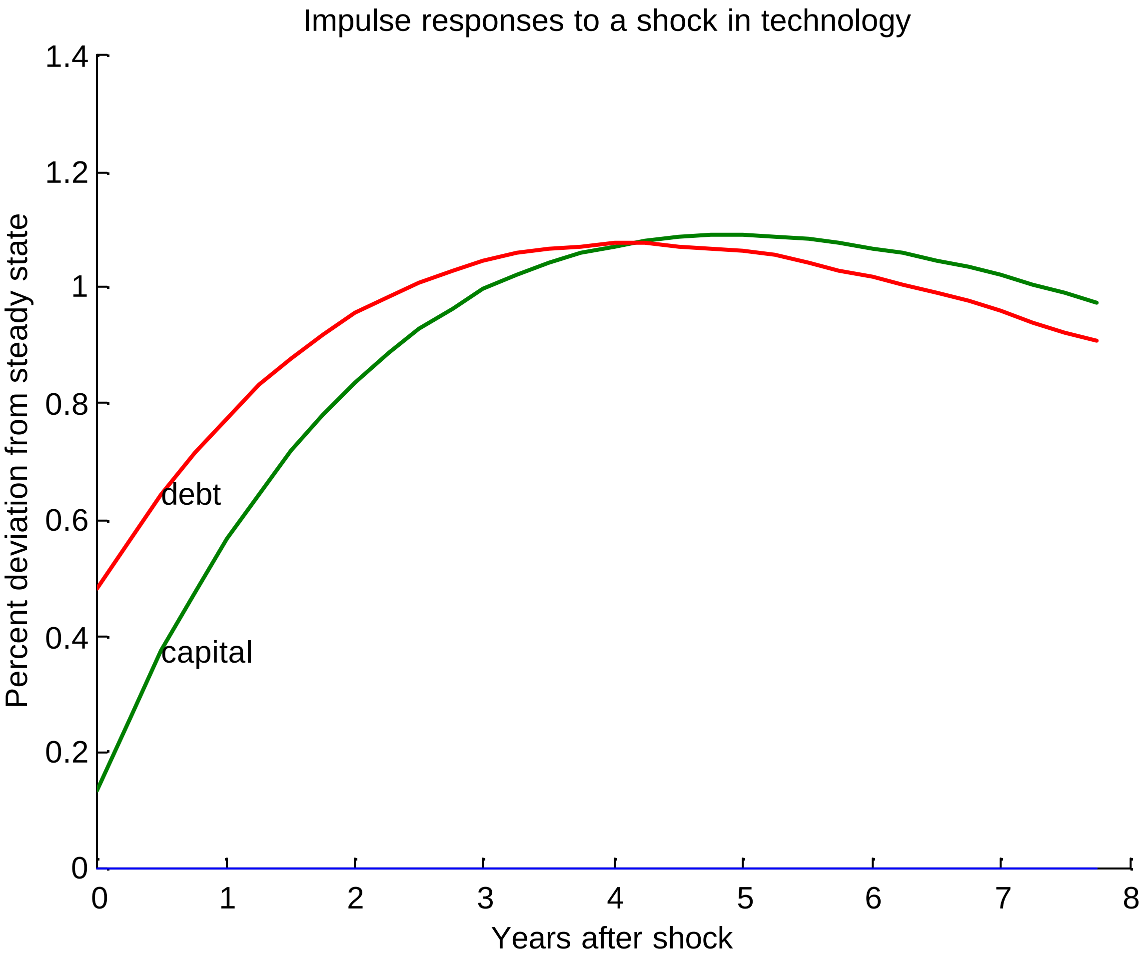

Figure 6: Response of debt and capital to a one percent positive technology shock with a leverage ratio of 30%.

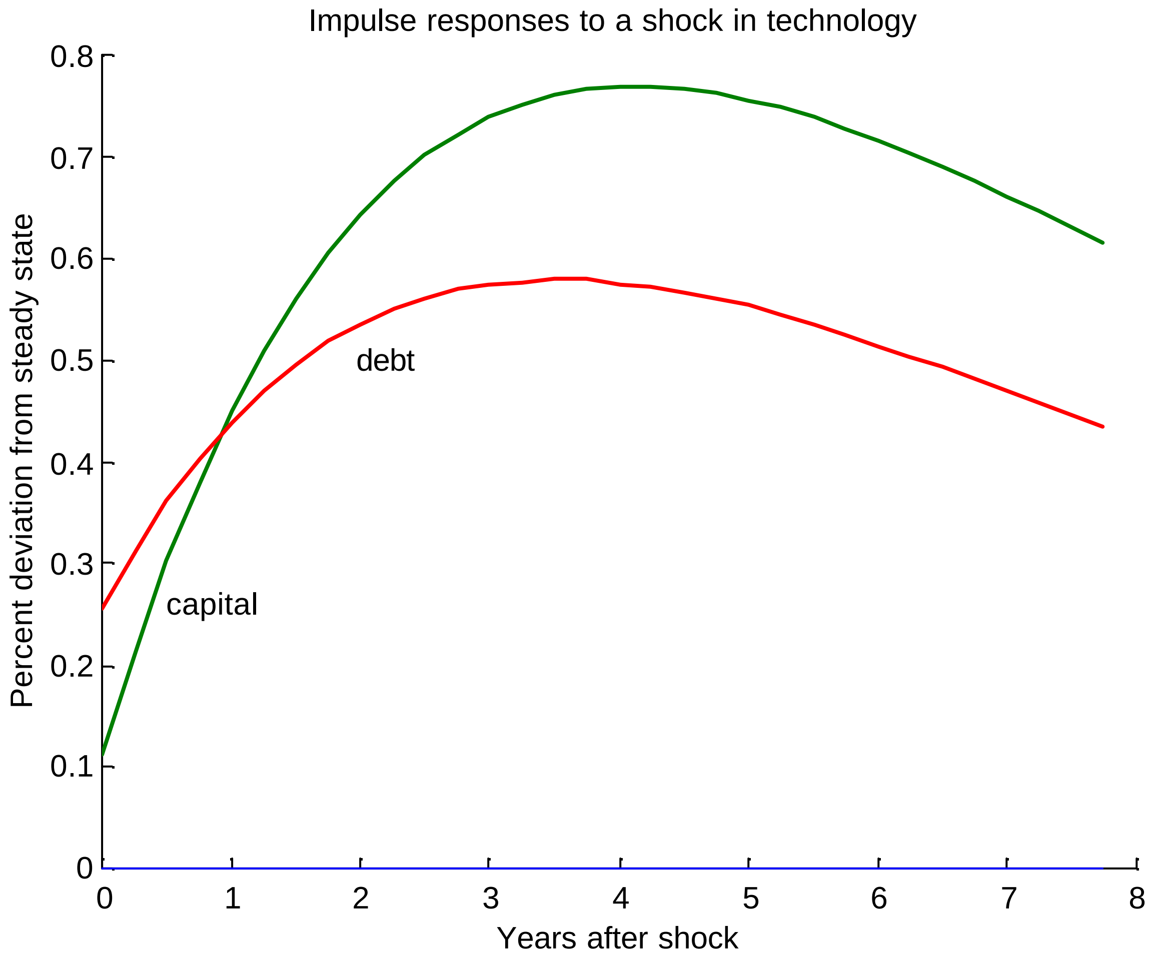

Figure 7: Response of debt and capital to a one percent positive technology shock with a leverage ratio of 50%.

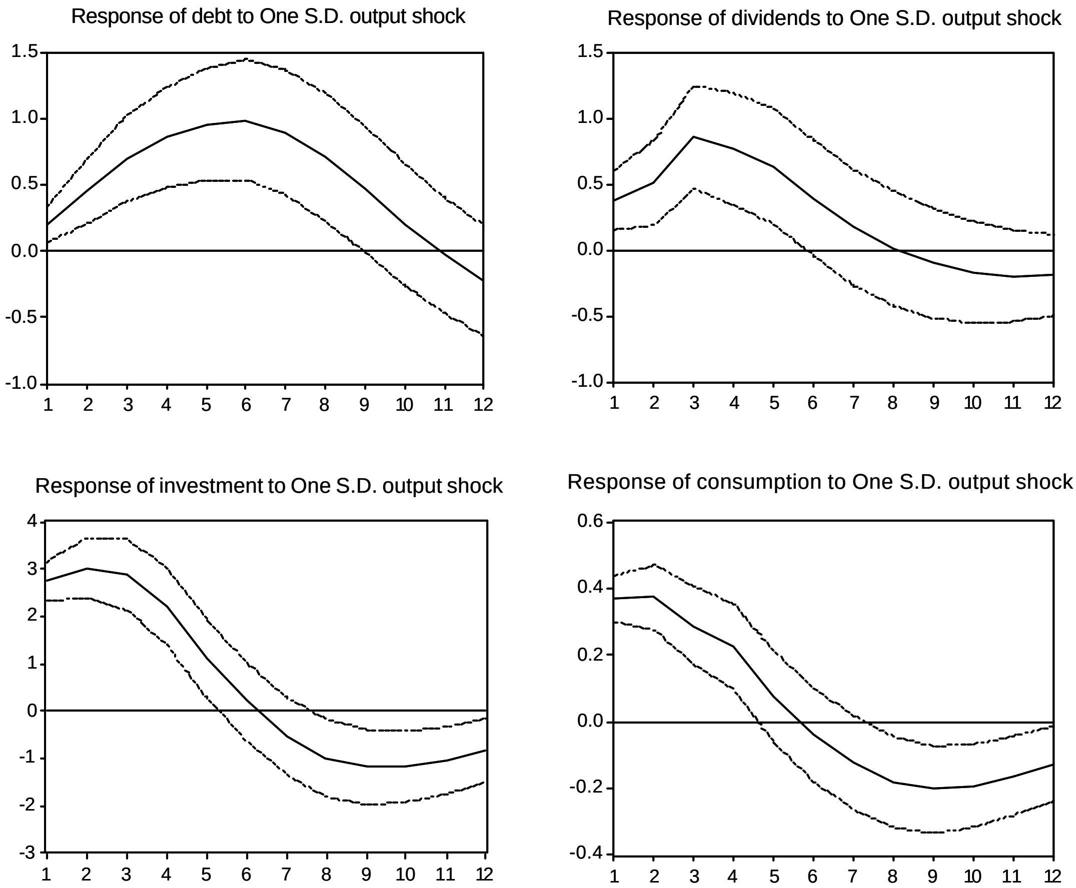

Figure 8: Empirical impulse-responses to output shock. All IRF are derived from a 5 variables VAR including the variable in plot in addition to real GDP (in % deviation from HP trend), inflation rate, commodities inflation rate and interest rate on fed funds. System is estimated on the 1955-2001 period with quarterly observations.