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Issam Samiri
PhD Student, Birkbeck, University of London

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▪ Birkbeck, University of London ▪ Malet Street ▪ London ▪ WC1E 7HX ▪

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Issam Samiri

PhD Student, Birkbeck - University of London
contact: isamir01@mail.bbk.ac.uk

Abstract

Firms typically decide their financing before starting the implementation of a new project. The firm's management may become more pessimistic about the project's profitability after financing is raised and reduce spending accordingly. Following an unpredicted negative aggregate productivity shock, the productive sector can enter a low spending mode, thus depressing output further. I use firm-level financial data to provide some empirical justification for this mechanism. I then study the mechanism in a general equilibrium model with money and a supply sector subject to uninsured idiosyncratic productivity shocks. The model reproduces many features of the post-2008 period: large effects of real shocks on output and investment, a less effective expansive monetary policy that is accompanied by high shareholders cash payouts.

JEL classifications: E32; G35; E50

Keywords: DSGE; Firms' spending; Financial Frictions; Productivity; Occasionally Binding Constraints; Dividends; Share buybacks; Great Recession

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1 Introduction

The 2008 Great Recession is associated with the bursting of the American housing bubble. The drop in house prices, combined with leverage effects, wiped out a large proportion of the wealth of households in the United States, leading to a decrease in consumer demand. The banking sector was also heavily exposed to the housing market through asset-backed securities. The deterioration in banks' balance sheet that followed the collapse in the value of mortgage-backed securities dented the confidence in the banking sector in a process that culminated with the bankruptcy of Lehman Brothers in September 2008. This led to a rationing of bank credit available to non-financial firms and increased their financing costs. The drop of aggregate output that followed was both rapid and significant. The Federal Reserve as well as other major central banks reacted swiftly to this chain of events. Short-term interest rates were set to zero and central banks' balance sheets were used to engage in large scale purchase programs aimed at replenishing and stabilising the balance sheet of banks and restoring the flow of credit. By spring 2009, the Federal Reserve stress tests concluded that commercial banks had adequate levels of capital relative to assets, signalling the end of the financial crisis. The trough of the cycle occurred shortly after. However, the recovery that followed was slow. In the words of the European Investment Bank (2016) investment and investment finance report, "the slowness of the recovery in investment by firms [was] disturbing, particularly given the extraordinary monetary stimulus. The continued decline in returns to firm investment suggests that action is needed to raise productivity growth". The corporate sector used the availability of credit to bolster its cash positions but investments in hiring and new capital did not follow. In its report on the use of corporate cash flow (King and Larach (2016)), the Federal Reserve of Chicago notes that "business fixed investment has continued to be sluggish [...] corporate distributions to shareholders have remained near record levels [while] U.S. corporations are holding historically high quantities of liquid assets".

This paper considers the role of money as a store of value that might become more appealing to firms than investing in the production process when large unpredicted negative shocks affect the rates of profit. I embed this mechanism in a general equilibrium model that reproduces some of the stylised facts discussed above, namely: a more volatile business cycle and a traditional expansive monetary policy with muted effects on the real economy and that is accompanied by large cash transfers to corporate shareholders.

In real terms, money deteriorates in value with inflation, but this is less of an issue when inflation is low for an extended period of time while uncertainty regarding the performance of other riskier investments is high. Whatever the level of inflation, as one of the safest ways to store value, money provides a lower limit on the return of viable investments from the perspective of rational, profit maximising agents. At the financing stage, firms target a higher return on investment than the one offered by simply keeping money in their cash accounts. In normal situations, the gross nominal returns on investment targeted by firms are higher than the return provided by cash –i.e. one– as these returns need to be large enough to cover the firm's cost of financing. Investors financing the firm activity (shares and bonds holders) also expect a positive return on investment. Investor rewards, seen as a financing cost from the firm's perspective, represents a lower bound to the expected return on the projects the firm is undertaking for these projects to be considered worthwhile by a rational manager maximizing the firm's profit. Following unexpected drops in productivity between the financing stage and the time of spending, the firm can decide to spend less than the previously set financing. This happens when the marginal return to the firm from producing at maximum capacity (i.e., using all the funds available from the financing stage) is lower than the return generated by simply redistributing cash back to investors (i.e., one).

I study this underspending mechanism in the context of a monetary general equilibrium with money in the utility function (MIU) and a supply sector with heterogeneous productivities. The fluctuations in the model are driven by an exogenous aggregate productivity process common to all firms, firm-level idiosyncratic productivities and fluctuations in the supply of money. The main innovation is that the financing problem facing the firm is considered separately from its spending problem. This gives the management of the firm a more realistic economic agency as they exert their control over the cash raised at the financing stage. Similarly to the working capital model in Christiano and Eichenbaum (1992), firms need to raise financing that covers the cost of labour and capital before the start of the production cycle. Each firm decides its level of financing first. The financing decision is a result of maximising expected profits, considering the prevailing financing costs, the signal available to the firm about its own future productivity and its expectation about future aggregate productivity and prices. Once financing is raised, the level of financing serves as a cap for future production spending. Unlike in other working capital models, this spending constraint can be relaxed. The constraint holds as long as the firm's productivity does not drop below initial expectations by more than an amount that is tied to the previously set financing costs. As a result, a large portion of the productive sector can reduce (increase) spending immediately following unexpected negative (positive) shocks to aggregate productivity. This can make the effect of real shocks more immediate and more severe. In the studied monetary set-up, a positive shock to money supply can increase firms' financing and therefore increase future firms' spending, thus increasing labour, investments and output. This liquidity effect is moderated by the underspending mechanism as the spending of the financially unconstrained firms does not react to the more favourable credit conditions. The studied mechanism contributes to muting the effects of expansive monetary policies.

The mechanism studied in this paper can contribute to understanding the large drop in output in 2008. Given the way my model is set up, this requires a drop in aggregate productivity. Fernald (2014) has documented an important decline in total factor productivity (TFP) growth between 2005 and 2008. More recent productivity data published by the Bureau of Labour Statistics indicate a decline in utilisation-adjusted TFP growth after the end of the recession. In addition, other factors contributing to an unexpected deterioration in firms' profits can achieve a similar effect and push firms to spend less than previously raised financing. For example, a sudden collapse of consumer demand following a deterioration in the households' net worth as in Mian and Sufi (2012) can play a similar role to unexpected drops in productivity. Furthermore, the model's mechanism is studied in a set-up where credit is not rationed. The reason for this choice is two-fold. First, it has been documented that larger corporates with direct access to credit took advantage of this access and tapped the bond market to counteract the decline in bank lending in the early stages of the Great Recession. As a result, these firms could maintain stable overall debt levels throughout the credit cycle (Adrian, Colla, and Shin (2012)). Furthermore, as mentioned above, liquidity was readily available after the early stages of the Great Recession with no significant recovery in terms of output growth. The studied mechanism can therefore contribute to understanding the collapse in output by firms that maintained access to credit markets in the early stages of the Great Recession while providing a potential explanation to the slow recovery that followed the financial crisis.

The model also suggests that when firms are less productive or face less attractive investment opportunities, they tend to distribute part of the excess cash to shareholders. To present some empirical validation of this claim, I build on the work of Fama and French (2001), Grullon and Michaely (2004) and others and study the relationship between the firm's productivity and the level of cash it diverts towards shareholders in the form of dividends and share buybacks. It has been widely documented by corporate finance literature that firms that invest in their production process through research and development, capital expenditure or hirings tend to distribute less cash to shareholders. The empirical work in this paper provides further confirmation of this while focusing on the impact of total factor productivity. I find that firms with low total factor productivity are more likely to distribute cash to shareholders and that they tend to distribute more cash relative to their size, as measured by market capitalisation.

The paper is organized as follows. Section 2 studies the empirical evidence provided by dividends and share buybacks. The general equilibrium model is set out in section 3. This section also provides several theoretical results related to the model's main mechanism and deals with technical issues related to the occasionally binding financing constraints. Section 4 presents the simulation results. Further theoretical and empirical results are presented in the appendix.

Related Literature.— The empirical part of this work builds on the existing finance literature concerned with explaining the levels of cash distributed by firms towards shareholders. These cash distributions take two important forms: dividends and share buybacks. Jensen (1986) argues that, when the firm is facing less attractive investment opportunities, a conflict of interest arises between shareholders and managers, with the latter having an incentive to keep more resources under their control and thus not distributing free cash flows. Share repurchases in this context can work as a way to reassure markets about this potential conflict of interests. Grullon and Michaely (2004) find that repurchasing firms reduce their current levels of capital expenditures and research and development expenses and that their cash balances significantly decline. This corroborates the deterioration of the investment opportunities hypothesis. They also find that, contrary to what is suggested by the signalling hypothesis, the markets do not always react positively to the announcement of share repurchases, as market participants are not always aware of the reduction of investments opportunities available to the firm before the share buyback programme is announced. Hribar, Jenkins, and Johnson (2006) show that there is a strong discontinuity in the probability of accretive share repurchases around the consensus earnings per share (EPS) expected by financial analysts. Firms that would have narrowly missed the analysts' consensus EPS are much more likely to increase their share repurchase activity in the goal of positively affecting their EPS and meeting the consensus than those who narrowly beat the consensus EPS. Almeida, Fos, and Kronlund (2016) exploit this discontinuity to show that EPS-motivated share buybacks are associated with reductions in employment and investments. Fama and French (2001) focus on the more usual way chosen by firms to divert cash towards shareholders: dividends. They study the decline in the distribution of dividends by publicly traded firms in the last 20 years of the twentieth century and relate the said decline to many contributing factors including a change in the characteristics of public firms (firms go public earlier in their development process) and the emergence of competing ways to pay shareholders (mainly share buybacks). The authors also document an empirical inverse relationship between the firms' propensity to pay dividends and the investment opportunity it faces. Since the early 80s, share repurchases make a significant part of the cash flows directed by firms towards investors. I, therefore, construct an index combining both dividends and cash repurchases to account for all cash flows directed towards equity investors as opposed to those being invested in the production processes. This follows the literature concerned with the total cash flow distributed by firms to equity investors. Bagwell and Shoven (1989) give an early account of the increasing roles of share redistribution and take-overs as ways to distribute cash from firms towards equity investors and suggest that yields of return on equity investments should account for these ways of cash distribution. Robertson and Wright (2006) use a total cash flow index that takes into account dividends, share repurchases and net share issues, and use the constructed index to predict stock returns. Imrohoroglu and Tuzel (2014) use total factor productivity (TFP) to predict equity returns and show that while TFP underperforms other indicators such as the market to book ratio in predicting equity returns, low productivity firms earn a significant premium over high productivity firms in the following year. In this paper, I use various firm indicators to explain the propensity of firms to divert cash towards shareholders. Following existing literature, these indicators include investments in capital, research and development and employment. In this regard, my results provide further validation of the idea that firms react to lower investment opportunities by diverting cash towards shareholders. To provide an empirical foundation to the mechanism presented in this paper, I show that besides the investment indicators, total factor productivity helps predict the levels of cash diverted to equity investors. To this effect, I present evidence from repeated cross-sectional logit regressions documenting the propensity of firms to pay shareholders. Additionally, I present dynamic panel data regressions explaining the size of the payout when the firm decides to pay.

This paper explores a firm based financial mechanism while abstracting from the issues related to the inability of agents to raise debt as a result of the worsening in the value of the asset they use as collateral (Kiyotaki and Moore (1997), Bernanke and Gertler (1989) and others). Many authors documented and discussed the role of this sort of financial frictions in the context of the great recession (e.g. Hall (2011) and Mian and Sufi (2012)). I view the present work as complementary to this literature as I explore the consequences of a sudden drop in TFP on the behaviour of firms that do not suffer from a credit constraint and explore the macroeconomic repercussions of such behaviour.

I assume that firms have to finance the production costs before engaging in production. This hypothesis is similar to what is assumed in the working capital models such as in Christiano and Eichenbaum (1992) and Cooley and Quadrini (2006). I also draw on this literature when setting monetary policy: the central bank injects new money in the financial intermediaries to increase the supply of loans available to the production sector. The increase in the money supply is therefore not distributed equally to all agents, which guarantees a role for money in the model's fluctuations. However, I depart from this literature when setting the demand for money. Instead of using a Cash In Advance constraint (CIA) to generate a demand for cash from households, I adopt a Money In the Utility function approach (MIU) to generate demand from households for holding cash. The household demand is complemented by the demand for cash emanating from the firms' financing needs. The approach I adopt for modelling money provides a more realistic form for the demand for money by households and, unlike CIA approaches, does not prevent the underspending mechanism from operating by muting the fluctuations of the firm's revenue.

The studied mechanism provides a potential motivation for the firm to cut spending despite abundant credit by considering the role of money as a store of value. Although hitting the interest rates Zero Lower Bound (ZLB) is not important to the functioning of the model, the motivation for firms to underinvest in the production process is stronger when nominal interest rates are low. The underspending mechanism studied here can be loosely described as a firm based liquidity trap. This connects this work to the literature explaining the slow recovery after the GFC through liquidity traps such as in Guerrieri and Lorenzoni (2017) where the authors build a Bewley-Aiyagari-Hugget type model with households that are subject to a reduction in their borrowing limit. Constrained consumers are then forced to reduce debt and unconstrained consumer have an incentive to increase their precautionary savings. This creates a powerful downward pressure on interest rates. Interest rates decrease sharply as a result and this pushes the economy into a liquidity trap. Eggertsson and Krugman (2012) argue that following a "Minsky moment" where agents realise that debt levels are too high, an aggressive deleveraging cycle begins. This decreases prices and triggers a Fisher debt-deflation cycle. Bacchetta, Benhima, and Kalantzis (2019) build a monetary model with assets scarcity and use it to show that a liquidity trap caused by a persistent deleveraging shock, increases real cash holdings and decreases investment and output in the medium term. The authors argue that quantitative easing can lead to a deeper liquidity trap, while a higher government debt can ease assets' scarcity, helping to exit the liquidity trap, but may harm investment in the medium term. While the underspending mechanism I study becomes stronger when interest rates are low, hitting the lower zero bound is not crucial for its functioning. The same applies to credit constraints that are often assumed in liquidity trap models to limit the borrower's demand for financing. In the model presented here, I do not assume any form of credit rationing and still establish situations where agents prefer cash to real investments. This is achieved by considering the faith of the cash transferred to the borrowing firm when productivity unexpectedly deteriorates between the time financing is raised and the time of production.

2 Empirical evidence

In this section, I present an empirical foundation for the main mechanism of the model. The model's mechanism assumes that firms finance production before using the funds raised to pay for production costs. If the firm's productivity unexpectedly drops between the financing stage and the spending stage, the management of the firm can choose to cancel some of its spending plans made at the financing stage and return a portion of the cash raised to investors without investing it in the production process. To provide an empirical foundation for such mechanism, one would ideally need a way to measure changes in the spending intentions of firms, associate these changes of intention with an increase of the cash diverted towards shareholders and link this process to a worsening in the firm's productivity. The data available to me does not provide a way to measure such a change in the firm's spending intentions. I, therefore, focus on the cash diverted towards investors instead. I construct a measure of the overall cash diverted towards shareholders that includes both dividends and share buybacks ("Distributed Cash"). I then document the marginal effect of total factor productivity and other growth indicators on the propensity to divert cash towards shareholders using cross-sectional logit regressions repeated for every year of the studied sample period. I assume that an increase in shareholder payout beyond what can be explained by the relevant firm's characteristics and cash flow figures signals a reduction in the firm appetite towards spending. Thus, an inverse marginal relationship between productivity and "Distributed Cash" is an indication of a positive marginal relationship between productivity and production spending. To confirm and strengthen the results from the cross-sectional logit regressions, I run a dynamic fixed effect panel data regression explaining the size of the payout made by firms choosing to distribute some cash to shareholders.

2.1 Cash distributed to equity holders

Firms can divert cash towards shareholders in different manners. The method chosen depends, among other things, on the intended recipients, the aim behind the distribution and its tax implications. Namely, firms distribute cash to ordinary equity holders through two important channels:

- **Dividends** are the most common way for a firm to distribute cash to shareholders. They are subject to corporate taxation and taxes on revenue. Dividends are typically paid periodically. This implies that starting to pay dividends or increasing their amount creates an expectation of such behaviour continuing in the future.
- Firms can decide to buy back their own shares (**Share Buybacks**). This can happen through fixed price tender offers, and since 1982 mostly through open market operations.[1] After selling all or part of their shares, ordinary equity holders are subject to taxes on capital gains. Capital gains tax rates are

[1] The 10b-18 rule of 1982 provides guarantees to the firms willing to repurchased their own stock that they would not be in breach of stock manipulation rules if they adhere to certain conditions (Safe Harbor conditions) regarding the manner, timing, price and size of the repurchase. This regulation and others implemented around the same time period simplified the execution of share buybacks and limited the legal liability facing the repurchasing firm.

typically lower than revenue tax rates, they exclude the cost at which the shares were bought and can be netted against capital losses from other investments by the seller. Share repurchases are therefore at a significant advantage relative to dividends from a tax perspective.

Following the more lenient 1982 regulations, share buybacks have emerged in the mid 1980s as a major way to compensate equity holders beside dividend payments. The left panel of figure 1 illustrates this trend and shows the evolution of the average yearly share repurchases versus the annual dividends over time in the sample provided by Compustat for firms based in the United States. The right panel of figure 1 also shows that from the early 1970s a significant number of firms chose to buy their own stock back while not distributing dividends. Taking into consideration both dividends and share buybacks is therefore important when studying how firms decide to divert cash towards shareholders.[2]

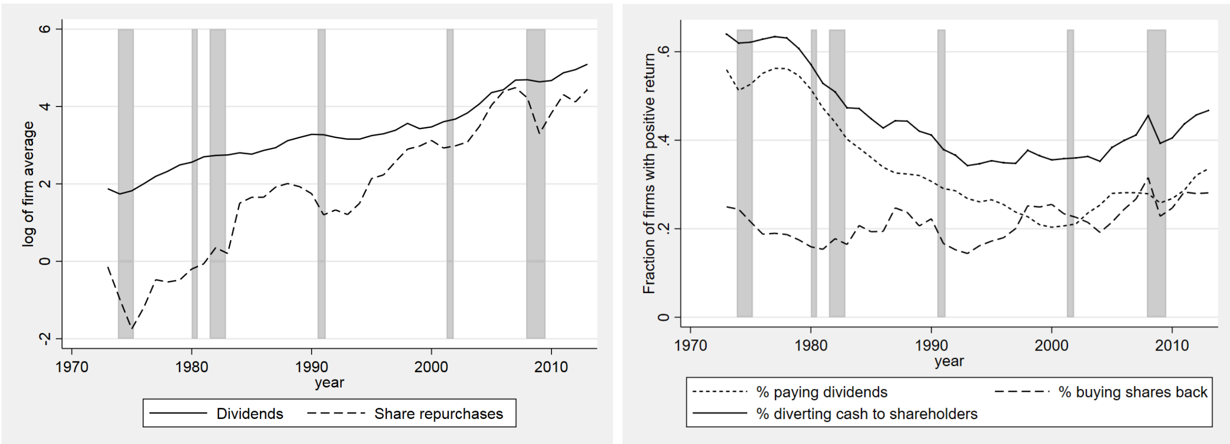

Figure 1: Evolution over time of the average amount distributed through dividends and share buybacks in log format by U.S. firms covered by Compustat (left). Proportion of Compustat U.S. firms with positive cash return to equity holders through: dividends, share buybacks and a combination of the dividend and share buybacks (right). Grey areas indicate NBER recession periods. Appendix B.1 explains how share buybacks are derived and other data treatments.

[2]Firms can also distribute cash towards equity holders through cash financed mergers and acquisitions. I will not focus on this particular channel for two reasons. First, when firms buy shares of other companies during a merger and acquisition process, they are typically paying the shareholders of other companies. More importantly, using cash to finance the acquisition of another company can be considered as a form of investment in the physical, human and intangible capital of the acquired company.

2.2 Data description

I try to explain three figures representing the cash diverted by the firm to the ordinary shareholders: dividends, share repurchases and "Distributed Cash" defined as the sum of both dividends and share buybacks. The "Distributed Cash" is a measure of the overall cash diverted to common shareholders. The cost to the company is different and depends on the tax treatment of dividends and share buybacks. Several firm's characteristics and financial indicators are used to explain the flow of funds towards ordinary shareholders. Three stand out as reflecting the firm's appetite for growth. These are TFP, investment expenses and the market to book ratio. High investment expenses are a direct indication that the firm is in a growth mode while a high market to book ratio can reflect a view by market participants that the firm has a high growth potential. Total Factor Productivity (TFP) is used as a proxy for the firm's efficiency of production and is typically high for growth firms.[3] TFP is obtained following Imrohoroglu and Tuzel (2014)

$$TFP = \frac{g}{k^{0.22} \times l^{0.75}}, \tag{2.1}$$

where g is value added by the firm, the firm-level capital stock k is given by gross plant, property and equipment (PPEGT) and the stock of labour l is given by the number of employees. To remove industry specific TFP effects, the firm level log TFP is corrected by removing 2 digits yearly industry averages. Investment expenses include investment in capital (CAPEX) and research and development (R&D). The market to book ratio is defined as the market value of ordinary equity divided by the previous period's assets' value.[4]

I control for several firm level characteristics and cash-flow figures. These include size related controls, namely, the firm's asset value and market capitalisation. I also control for net income as an indicator of the firm's profitability. High levels of cash and cash equivalent assets may indicate the presence of idle financial resources, which may motivate the firm to reward shareholders. I therefore include a measure of cash and cash equivalent assets to the set of control variables. The number of employees is also included as it serves as a size indicator. Furthermore, the change in the number of employees over time can indicate the firm's wiliness to hire.

[3] See Imrohoroglu and Tuzel (2014).

[4] Another definition of the market to book ratio is the market value of the firm divided by its book value. Adopting this definition restricts the size of the sample significantly as the book value data is only available for a small protion of firms.

I use Compustat US data to get or derive all the firm level variables of interest.[5] Following existing corporate finance literature, utilities and financial industry firms are removed from the sample as these companies are subject to specific regulations that impact dividends' distribution. To avoid outliers, firms with no assets are also excluded. Share repurchases are defined, following Fama and French (2001), as the increase in Treasury stock if the Treasury stock is not missing. Following Almeida, Fos, and Kronlund (2016), if the Treasury stock is missing in the current or prior year, share repurchases are measured as the difference between stock purchases and stock issuances using the cash flow statements. If either measures is negative, share repurchases are set to zero for the corresponding period. This data treatment is maintained for the rest of this section.

Many of the studied firm characteristics and financial data vary in magnitude for a single firm throughout the firm's life cycle and between firms of various sizes for a given year. Without any scaling, big firms would influence the regressions' results more than small firms and later periods of the sample would influence the results more than earlier periods due to the combined effects of inflation and capital accumulation. To correct for these effects, I scale all of the variables, except for the market to book ratio that does not require scaling and the assets' value that I keep as an unscaled measure of the size of the firm. Debt, cash holdings, net income, CAPEX, R&D investments, the number of employees and TFP are divided by the value of the previous period's assets.[6] The market capitalisation, is replaced by its percentile equivalent.[7] Dividends, share buybacks and the distributed cash are divided by the previous market capitalisation. All variables, except for the market capitalisation percentile, are Winsorised at the 1% level to correct for the outliers' effect. Appendix B.1 provides more details about the definition of the derived variables as well as a summary of the transformation applied to the data.

2.3 Growth indicators and firms' payouts

Table 1 presents averages of the distributed cash to market capitalisation ratios for observations' subgroups sorted using the growth indicators described in subsection

[5] The cost of labour data is obtained by multiplying the Compustat number of employees by the average wages from the Social Security Administration. As explained in appendix B.1, the cost of labour is useful in the derivation of the firm's value added figure.

[6] These scaling choices are, to a large extent, inspired by Fama and French (2001).

[7] By percentile form of a variable X_t, I mean the transformation $\text{Percentile}_t^X(x) = 100 \times \frac{\text{number of observations satisfying } X_t < x}{\text{number of observations at time } t}$.

2.2. For every fiscal year, I calculate the deciles of all growth indicators and divide the firms every year into groups delimited by two consecutive deciles. I then calculate the average cash returned to market capitalisation ratio for each of the defined groups of observations over the period between 1980 and 2013. The results show a tendency for the average payout ratios to be lower for higher deciles of Market to Book, TFP, CAPEX and R&D spending. This relationship is strongest for the Market to Book decile groups where the average cash returned to market capitalisation ratio monotonically decreases from lower to higher deciles. The average cash distributed to market capitalisation in the 90%-100% market to book decile is 0.47%. It is much higher in the 0%-10% decile at 40.9%. A similar pattern is observed when considering TFP decile groups. The average cash distributed to market capitalisation ratio for 0%-10% TFP decile is 31.0% while it stands at 1.34% for the highest TFP decile. The relationship between TFP and the distributed cash to market capitalisation ratio is mostly decreasing, with the monotony being broken only for the 50%-60% and 60%-70% deciles. The lowest decile in terms of CAPEX spending has an average distributed cash to market capitalisation ratio of 4.15% while the highest decile has an average payout ratio of 1.48%. While there is no clear decreasing behaviour of the distributed cash to market capitalisation ratio with relation to CAPEX deciles, the average payout to market capitalisation ratio is smallest for the 90%-100% decile. R&D spending implied deciles display similar behaviour to the CAPEX implied deciles, with the average distributed cash to market capitalisation being lowest for the 90%-100% decile at 0.26%.

Given that the market capitalisation appears in the nominator of the definition of the market to book ratio and in the denominator of the distributed cash to market capitalisation ratio, the results for the market to book deciles may appear harder to interpret. However, TFP decile groups display similar behaviour to the market to book deciles' groups while market capitalisation plays no role in the definition of TFP.

2.4 Firm's propensity to pay: evidence from repeated cross-sectional logit regressions

In order to explain the decision of the firm's management to pay back investors, I run a series of cross-section logit regressions repeated for every fiscal year between 1980 and 2013, where the dependent variable is the "Distributed Cash" and the

Percentile	Distributed Cash / Market Cap. - Average			
%	Mkt to Book Decile	TFP Decile	CAPEX Decile	R&D Decile
0-10	0.4090	0.3198	0.0415	0.0253
10-20	0.0336	0.1160	0.0577	0.0721
20-30	0.0309	0.0484	0.0355	0.0512
30-40	0.0287	0.0306	0.0476	0.2224
40-50	0.0256	0.0258	0.0782	0.0497
50-60	0.0231	0.0583	0.0761	0.0256
60-70	0.0194	0.0311	0.0686	0.0718
70-80	0.0158	0.0189	0.0727	0.0140
80-90	0.0110	0.0148	0.1108	0.0084
90-100	0.0047	0.0134	0.0148	0.0026

Table 1: Average cash distributed to market capitalisation ratio by growth indicator decile buckets. Growth Indicator decile cut-off points are recomputed for every year of the sample period. The growth indicators are defined, scaled and transformed as described in section 2.2. Data from 1980 to 2013.

explanatory variables of interest are lagged indicators for the firm's appetite to grow: TFP, market to book ratio and the investment expenses (CAPEX and R&D). To avoid competing effects between these growth indicators, separate regressions are run to get the respective marginal effect of TFP, market to book ratio and the combined effects of CAPEX and R&D expenditures. In addition, I run regressions including all the growth indicators to assess their combined effects. The market capitalisation percentile, assets, cash and cash equivalents, net income, debt and number of employees are used as lagged controls in all the regressions. Two-digit industry dummies are also included in the regressions to account for industry-related effects. The repeated logit regressions can be described by the equation

$$y_t = \beta_{x,t} x_{t-1} + \beta_{z,t} z_{t-1} + \text{industry dummies}, \tag{2.2}$$

where y_t is the "distributed cash" variable, x_{t-1} denotes the lagged growth indicator of interest, and z_{t-1} are the lagged controls

$$x_{t-1} := \begin{cases} \text{TFP} \\ \boldsymbol{OR} \\ \text{Market/Book} \\ \boldsymbol{OR} \\ [\text{CAPEX, R\&D}] \\ \boldsymbol{OR} \\ [\text{TFP, Market/Book, CAPEX, R\&D}], \end{cases}$$

$$z_{t-1} = [\text{Market Capitalisation, Assets, Cash, Net Income, Debt, Employees}].$$

Figure 2 reports the estimated coefficients $\beta_{x,t}$ of the growth indicators and the corresponding 95% confidence intervals for the logit regression 2.2, repeated for every year from 1980 to 2013. Figures 14 and 15 provide the same coefficients and confidence intervals over the same time period when the regression 2.2 is used to explain dividends and share buybacks, respectively.

Firms with high growth indicators are less likely to divert cash towards investors, the effects being both economically and statistically significant.[8] Firms with higher market/book, CAPEX and R&D investments have a lower propensity to reward shareholders. This is consistent with Fama and French (2001) who find that firms with high investment opportunities as reflected by high asset growth rates and high market to book ratios are less likely to pay dividends. The results presented here confirm these findings when including share buybacks in the measure of cash diverted towards equity holders. Although TFP has a statistically weaker marginal effect when compared to other growth indicators, its effect remains both statistically and economically significant for most of the studied period.[9] Lower TFP leads to higher propensity to divert cash towards shareholders, thus providing an empirical justification to the model in section 3.

When simultaneously including all the growth indicators in the regressions, the effects of the market to book ratio and R&D dominate the effects of other growth

[8]See appendix B.2 for means and standard deviations of the growth indicators.

[9]TFP underperforms the market to book ratio, possibly because TFP is measured with some noise. For example, the formula 2.1 defining TFP assumes the same exponents for labour and capital for all firms over the full sample period.

indicators (figure 3). The marginal effects of CAPEX and TFP remain negative for most of the studied period but lose their statistical significance in most years. This is consistent with Imrohoroglu and Tuzel (2014) who find that firms with low TFP have significantly higher equity returns in the following year but that the TFP effect is not significant when other predictors, such as the market to book ratio, are used alongside TFP to predict equity returns.

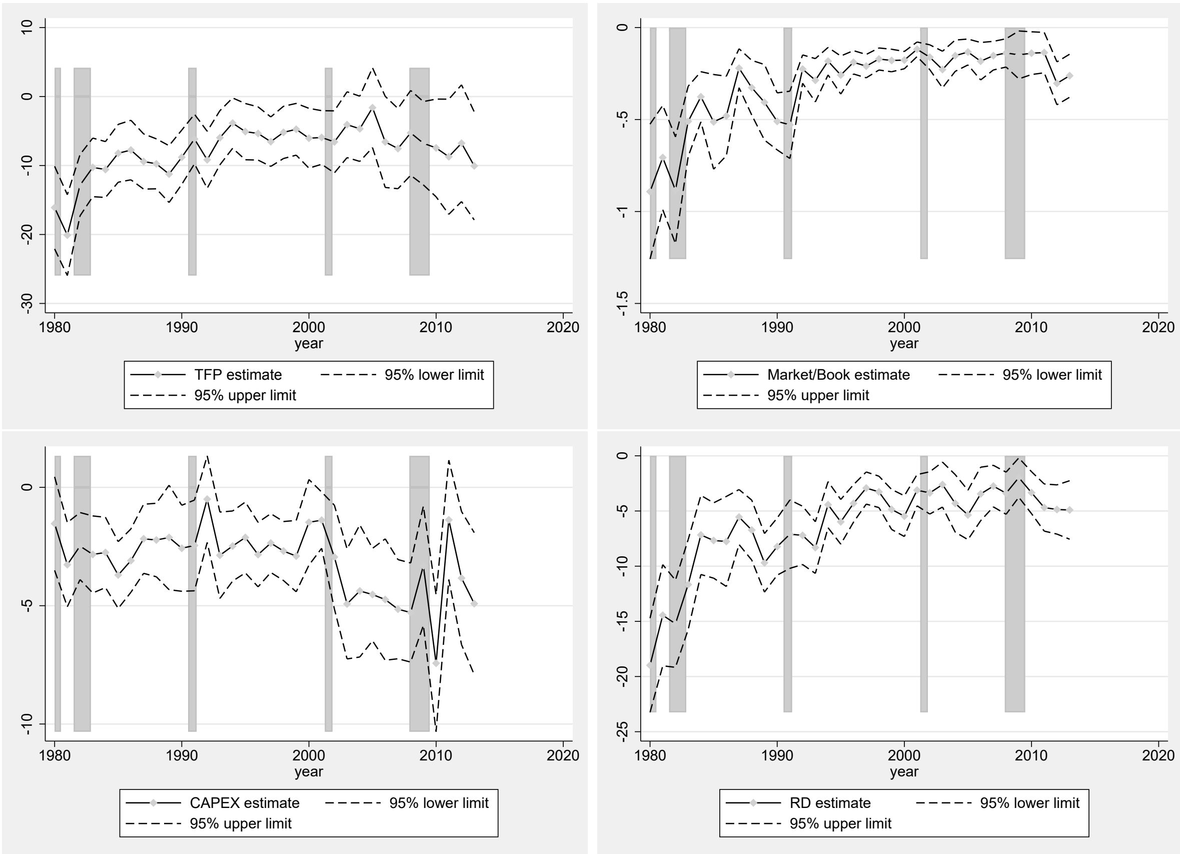

Figure 2: Repeated logit cross-section regressions estimates with 95% confidence boundaries corresponding to the effects of TFP, Market/Book and investment variables (CAPEX and R&D) on the firm's propensity to pay shareholders. The logit regressions are repeated for every year from 1980 to 2013. The TFP marginal effect is estimated without controlling for Market/Book, CAPEX and R&D, The Market/Book marginal effect is estimated without controlling for TFP, CAPEX and R&D and the CAPEX and R&D effects are estimated in the same repeated regressions that exclude both TFP and Market/Book. Controls common to all regressions include market capitalisation, assets, cash, net income, debt and the number of employees. Grey areas indicate NBER recession periods.

The separate marginal effects of the growth indicators on dividends and share buybacks are shown in appendix B.3 (figures 14 and 15). The results indicate that firms with lower TFP are more likely to pay dividends and are more likely to buy their own shares back with this effect being more pronounced in the case of dividends

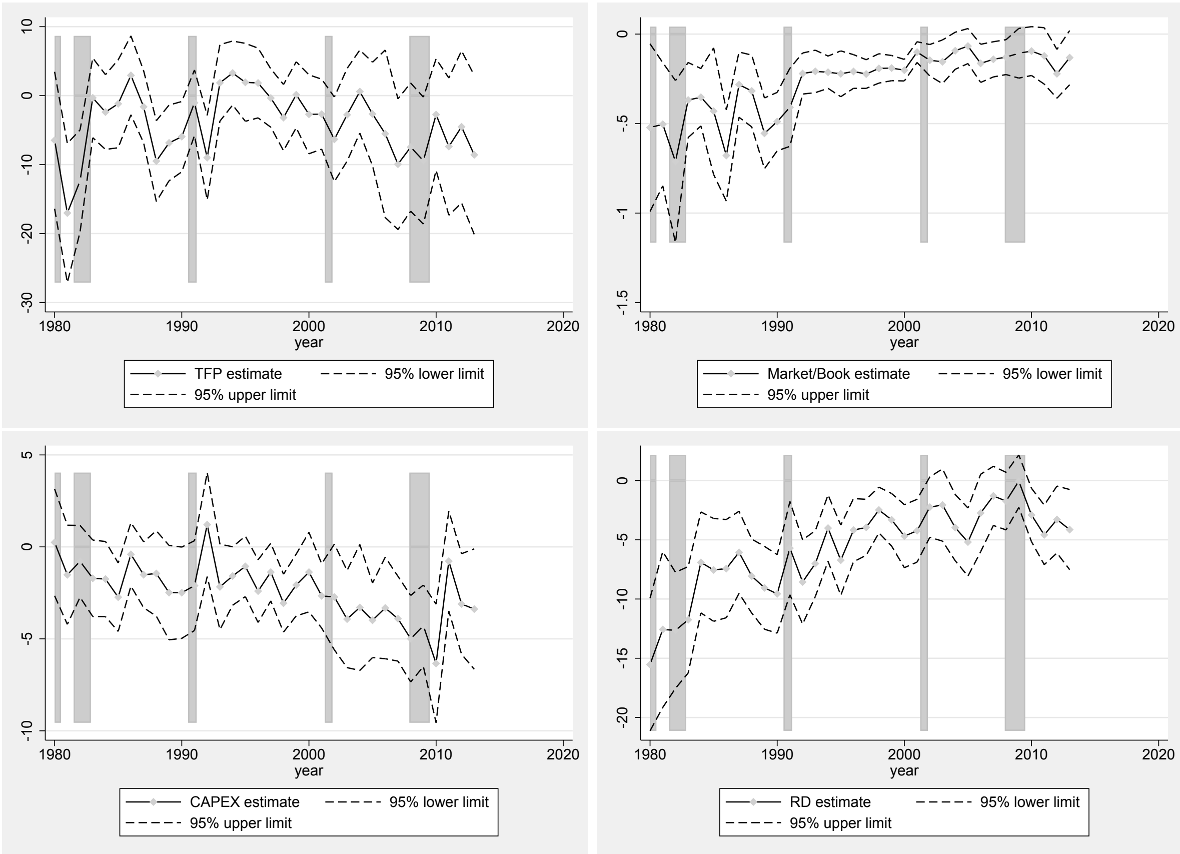

Figure 3: Repeated logit cross-section regressions estimates with 95% confidence boundaries corresponding to the effects of TFP, Market/Book and investment variables (CAPEX and R&D) on the firm's propensity to pay shareholders. The logit regressions are repeated for every year from 1980 to 2013. The regressions include all the growth indicators simultaneously. Controls common to all regressions include market capitalisation, assets, cash, net income, debt and the number of employees. Grey areas indicate NBER recession periods.

payments than in the case of shares buybacks. Furthermore, the market to book ratio and R&D spending effects are maintained when considering the propensity to pay dividends and repurchase shares separately. Firms with lower market to book ratio are more inclined to pay dividend and buy their shares back and the same applies for firms with low R&D spending. The magnitude of both the market to book effect and the R&D effects is stronger when explaining the propensity to pay dividends.

The marginal effects of the used controls are presented in appendix B.3. The results confirm the literature findings regarding the relationship between some of the firm's characteristics and the propensity to pay shareholders. Large firms, meaning those with large assets and high market capitalisation tend to distribute more cash towards equity holders. Furthermore, as one may expect, firms that are burdened by relatively high debt levels are less likely to pay equity investors, the debt effect being significant for almost every year of the studied time period. Lastly, the evidence from the logit regressions shows no significant impact of cash holdings on the propensity to pay. This is not an intuitive result. It is legitimate to suspect that high levels of cash holdings may indicate a low investment opportunity and therefore incite the firm to pay equity holders. I propose two possible justifications for the non intuitive cash effect. First, the static nature of the regressions does not allow for taking into account the firm's idiosyncratic need of holding cash. For example, firms may keep hold of relatively high cash amounts because of a lack of access to capital markets, thus a high cash holding relative to assets might reflect that the firm is still in an early development stage and has not reached the size where it can rely on capital markets to help manage its cash flows. Firms that are still in the early stages of their development are less likely to reward shareholders through cash distributions. This might counteract the possible positive effect of cash holdings on shareholders rewards.[10] Moreover, the absence of dynamic effects of cash holdings makes it harder to interpret the results. To correct for these issues, I run several dynamic fixed effects regressions explaining the size of the cash diverted towards shareholders.

2.5 Size of payout: evidence from dynamic fixed effects regressions

After considering the propensity of firms to divert any cash at all towards shareholders, I now turn to the size of the payout, expressed as a fraction of the previous period's market capitalisation. To capture the strong persistence of cash distributions and to control for non time varying firm level characteristics, I exclude observations where no cash has been returned and run a two-way fixed effect dynamic panel data regression to explain the size of the cash returned to ordinary equity holders during the period between 1980 and 2013. Similarly to the static regressions case, each of the main growth indicators are included in a separate regression to assess its effect in absence of other indicators. I also present the results of a regression including all the growth indicators to show which ones maintain a significant effect in the presence of the others. The size of the overall cash distributed to shareholders is a strongly persistent process. This requires the inclusion of multiple lagged dependent variables in the regressions. To deal with the issue of estimating the coefficients of the lagged

[10] The negative correlation between the cash to asset ratio and the value of the firm's assets appears to give some credit to this explanation (table 7 of appendix B.2).

dependent variables, I exclude firms with less than 15 observations within the sample period, this guarantees that the average number of time observations per firm is higher than 20 in all regressions.[11] The latter condition restricts the size of the sample substantially. To increase the sample size, I exclude the sparsely populated R&D variable from all regressions.[12] The model can be summarised as follows

$$y_t = \sum_{i=1}^{3} \beta_i y_{t-i} + \beta_x x_{t-1} + \beta_z z_{t-1} + \text{fixed effects} + \text{time dummies}, \tag{2.3}$$

where y_t is the distributed cash expressed as a fraction of the previous period's market capitalisation, x_{t-1} denotes the growth indicators of interest

$$x_{t-1} := \begin{cases} \text{TFP} \\ \boldsymbol{OR} \\ \text{Market/Book} \\ \boldsymbol{OR} \\ \text{CAPEX} \\ \boldsymbol{OR} \\ [\text{TFP, Market/Book, CAPEX}], \end{cases}$$

and z_{t-1} are the same controls as in the logit regressions presented in subsection 2.4.

The results in table 2 confirm the strong persistence of the size of the payout. Furthermore, all growth indicators have economically and statistically significant effects when other growth indicators are excluded. The Akaike information criteria show that the market to book ratio outperforms TFP and CAPEX as a growth indicator. This is confirmed by the results of the model that uses all growth indicators as explanatory variables (Full Model). In this model, the market to book ratio is the only growth indicator with a statistically significant coefficient at the 0.001 confidence level. The dynamic regressions' results confirm that large firms by assets' value tend to pay more relative to their market capitalisation with the estimated coefficient being statistically and economically significant and stable in value in all regressions. In the presence of the market to book ratio in the regression, the latter result is extended to

[11] See Nickell (1981) and Bruno (2005) for more on the issue of estimating dynamic panel data regressions with a large number of units and a small number of observations per unit.

[12] Excluding R&D expenses for the repeated logit regressions does not affect the estimation results in a way that undermines the conclusion made in subsection 2.4.

large firms by market capitalisation. In the absence of the book to market ratio as an explanatory variable, net income has a negative and statistically significant effect on the distributed cash. This effect changes sign and becomes statistically insignificant in the presence of the market to book ratio. As predicted above, when controlling for the firm's idiosyncratic effects and taking dynamic aspects into account, firms with relatively high cash holdings tend to pay shareholders more. This is consistent with the agency theory presented by Jensen (1986), stipulating that firms holding large sums of idle cash have an incentive to distribute more through dividends and share buybacks to reassure shareholders on the potential conflict of interest where corporate managers keep large cash amounts on the firm's balance sheet as a way to increase resources under their control. Finally, the size of the distributed cash decreases with the number of employees. This indicates that when controlling for the firm's fixed effects, changes in the number of employees represent a proxy for investment in the labour force.

	Full Model	TFP Effect	Market/Book Effect	Investment Effect
L.Dist. Cash	0.166***	0.181***	0.167***	0.180***
L2.Dist. Cash	0.0439***	0.0489***	0.0448***	0.0475***
L3.Dist. Cash	0.0423***	0.0461***	0.0433***	0.0449***
L.TFP	-0.0481	-0.122*		
L.Market/Book	-0.00447***		-0.00463***	
L.CAPEX	-0.0147**			-0.0239***
L.Market Cap. percentile	0.000176**	0.00000163	0.000187**	0.0000364
L.Assets	0.000000385***	0.000000493***	0.000000387***	0.000000453***
L.Cash	0.0310***	0.0268***	0.0314***	0.0256***
L.Net Income	0.0113	-0.0144*	0.00814	-0.0125*
L.Debt	-0.0182***	-0.0191***	-0.0192***	-0.0176***
L.Employees	-0.238***	-0.279***	-0.245***	-0.266***
Constant	0.0262***	0.0317***	0.0249***	0.0309***
AIC	-100793.7	-100567.1	-100786.5	-100585.9

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Two-way fixed effects dynamic model for the size of the **cash distributed**.

The dynamic fixed effect regression results for the size of dividends and share buybacks are presented in the appendix.[13] The results show that both dividends and share buybacks sizes are persistent processes with dividends' size showing stronger persistence. When explaining the size of dividends and share buybacks separately from each other, TFP fails to have a statistically significant effect even when other

[13]See tables 11 and 12 of the appendix.

growth indicators are excluded from the regression. This provides extra motivation to consider the combined "distributed cash" variable. Firms investing in capital expenditure tend to execute smaller share buybacks operation, while CAPEX investments do not appear to affect the size of dividends. Large firms by market capitalisation or assets tend to pay large dividends relative to their market capitalisation with assets' size having little impact on the size of dividends. On the other hand, large firms by assets are more likely to complete larger share buyback operations with little effect attributed to the market capitalisation percentile. Higher net income increases the size of dividends while not impacting the size of share buybacks operations. The results also suggest that firms use share buybacks more than dividends to manage relatively high cash balances. Finally, hiring reduces the size of both dividends and share buybacks relative to market capitalisation.

2.6 Summary of the empirical results

After considering empirical evidence linking the firm's appetite to grow to its propensity to pay shareholders and the size of the payouts, it appears that firms with an ability and appetite for growth divert less cash towards shareholders. I measure the appetite/ability to grow using the market to book ratio, investment expenses and TFP. While the market to book ratio performs better than other growth indicators in explaining distributions to shareholders, the TFP's marginal effect on the propensity to pay and size of the payouts is significant both in economic and statistic terms in the absence of other growth indicators.[14] As predicted by the theory, firms holding large sums of cash are more likely to divert cash towards shareholders. This relationship fails to appear in the repeated static logit regressions that do not control for the changes in cash levels and for the firm idiosyncratic effects but is shown in the fixed effect dynamic regression explaining the size of shareholders payout.

The model developed in section 3 assumes that profit maximising firms can choose to distribute some of the cash at their disposal to shareholders instead of spending to produce, following unpredicted drops in productivity. The evidence presented above can serve as an empirical justification to the mechanism linking TFP to spending.

[14] The market to book ratio is derived using the share price. It is reasonable to assume that market participants take into account information regarding the firm's productivity and investment expenses when setting their beliefs about the share price. Additionally, TFP is a noisy measure of the firm's production efficiency. It is therefore not surprising that the market to book ratio is a superior measure of the firm's ability/wiliness to grow.

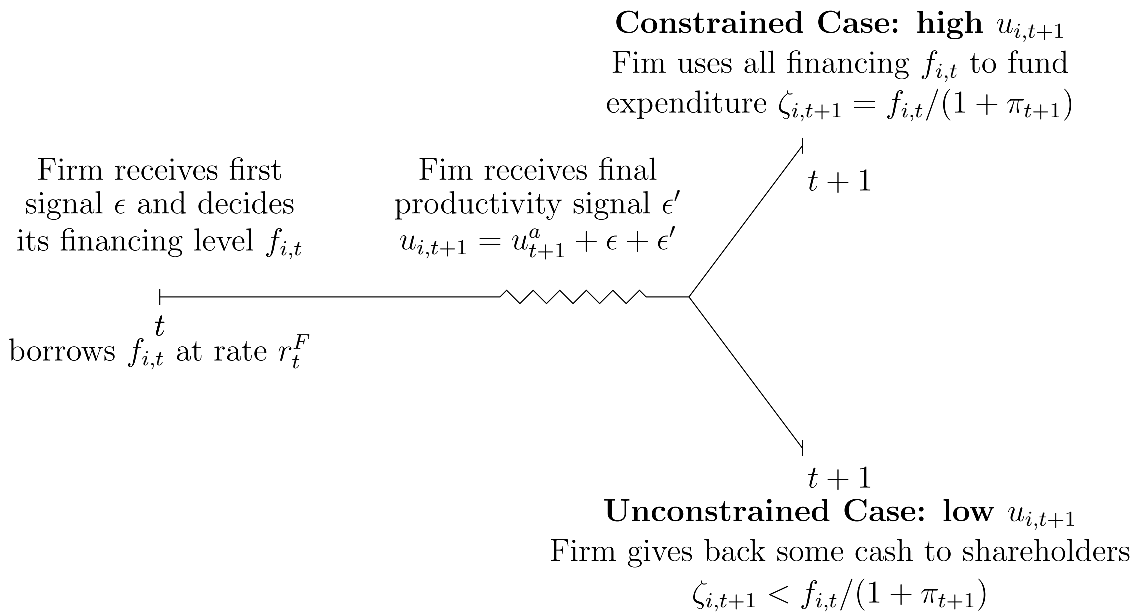

Figure 4: Timeline of the firm financing-spending process.

3 The model

In this section, I build a general equilibrium model that illustrates the underspending mechanism described in the introduction. In order to study the incentive of the firm to underspend, I separate the firm's financing problem from its spending problem. The firm first sets its financing based on its assessment of productivity at the financing stage. Production spending is decided some time after the financing stage and the previously set financing acts as an upper limit for potential spending. Following some unpredicted deterioration in productivity between the financing stage and spending stage, the firm can set spending at a lower level than the financing constraint.

In the set-up I consider, households maximize their utility to decide consumption and leisure subject to a budget constraint. The single consumption good is produced by firms that are constrained by a Cobb-Douglas production function. Financial intermediaries finance production through loan issuance and in the absence of credit risk, all firms face the same interest rate: r^F_t. The diagram in figure 4 explains the firm's financing/spending decision process: the firm i decides its real financing $f_{i,t}$ at time t knowing its first productivity signal ϵ and raises the required amount before discovering the new productivity $e^{u_{i,t+1}} = e^{u^a_{t+1}+\epsilon+\epsilon'}$ just before producing at time $t+1$, where u^a_{t+1} denotes an aggregate log-productivity process and ϵ' a final idiosyncratic shock the firm's log-productivity. At time $t+1$, the profit-maximizing firm assesses its own productivity and the prevailing wages and prices, then chooses whether to spend all the raised financing $f_{i,t}/(1+\pi_{t+1})$ (constrained spending case) or to spend less than the raised financing level $\zeta_{i,t+1} < f_{i,t}/(1+\pi_{t+1})$ (unconstrained spending case). Note here that the real financing is impacted by the level of inflation π_{t+1} between the financing stage and the time of production.

The firm financing is provided by banks that are themselves financed through household's deposits and money injections from the monetary authority. The commercial bank is supposed to operate with zero profit so that the monetary injections are passed to the borrowing firms in the form of higher available loan principals at lower interest rates charged.

The model builds on the working capital model in Christiano and Eichenbaum (1992) while introducing the financing/spending time friction explained above, heterogeneity in the firms' productivities and some changes to the way demand for money is introduced. The remainder of this section details the behaviours of households, firms, commercial banks and the monetary authority before commenting on the level of productivity drop required for firms to enter an underspending mode. I then provide several analytical results regarding the distribution of financing and the aggregation of financing, spending and production. These results simplify the calibration and simulation of the model.

3.1 Households

Households derive utility from leisure and consumption. Their utility function takes the form

$$\mathscr{U}_t = \ln(c_t) + \frac{\psi}{1-\nu}\left(\frac{M_t^H}{P_t}\right)^{1-\nu} - \frac{\chi}{1+\eta} l_t^{1+\eta}, \tag{3.1}$$

where l_t denotes the household's labour, c_t consumption, M_t^H the households' money holdings, P_t the price of the consumption good, ψ is a paramter that help control the level of real money holdings by households, ν is the curvature on the utility form holding real cash balances, η the curvature on dislike of labour and χ is a parameter that controls for households' dislike of labour. The direct demand by households for real money balances can be justified by a role played by money to simplify transactions.[15] Consumers maximise their expected lifetime utility discounted at rate β under their

[15]See Croushore (1993) on the equivalence between money in the utility function and a shopping-time model.

budget constraint in order to set their consumption, their leisure time $1 - l_t$, their savings through real capital k_{t+1}, their real money holdings $m_t^H := M_t^H / P_t$ and how much they save through (real) deposits b_t

$$\max_{c_s, l_s, b_s, k_{s+1}, m_s^H} \mathbf{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \mathscr{U}_s, \tag{3.2}$$

subject to the sequence budget constraint

$$m_s^H + c_s + k_{s+1} + b_s \leq \frac{m_{s-1}^H}{1+\pi_t} + (1-\delta) k_s + r_s^K k_s + r_{s-1} \frac{b_{s-1}}{1+\pi_t} + w_s l_s + \Pi_s^F + \Pi_s^B, \tag{3.3}$$

where w is the real wage, r the gross nominal interest rate on deposits and r^K the real net rate of return on capital. The terms Π^F and Π^B represent the real profits distributed respectively by the firms and the banks, both owned by households. Equity investors (i.e., households) are assumed to cover the debt payment shortfall in the case where the firm's proceeds do not cover its debt obligations. This means that the real profit Π^F provided by the firm to households can be negative and helps avoid firms' bankruptcies.

Solving the household's optimisation problem, the nominal interest rate r_t and the (real) cost of renting capital r_t^K satisfy the Euler equation

$$1 = \beta r_t \mathbf{E}_t \frac{c_t}{(1+\pi_{t+1}) c_{t+1}}, \tag{3.4}$$

$$1 = \beta \mathbf{E}_t r_{t+1}^K \frac{c_t}{c_{t+1}} + (1-\delta) \frac{c_t}{c_{t+1}}. \tag{3.5}$$

In addition, the households' problem yields the labour supply condition

$$\chi c_t = w_t l_t^{-\eta} \tag{3.6}$$

and the demand for real money

$$(m_t^H)^\nu = \psi \frac{r_t}{r_t - 1} c_t. \tag{3.7}$$

3.2 Firms

I assume the existence of a production sector populated by firms with heterogeneous productivities

$$y_{i,t} = e^{u_{i,t}} \left(k_{i,t}^{\alpha} l_{i,t}^{1-\alpha}\right)^{\gamma}, \tag{3.8}$$

where i denotes the firm, $k_{i,t}$ the capital and $l_{i,t}$ the labour it uses, α is the share of capital, γ a return to scale parameter and $e^{u_{i,t}}$ a firm specific stochastic productivity process. Within the studied framework, increasing returns to scale would imply infinite financing demand and constant return to scale would lead to undetermined levels of firm financing. Empirically, many studies could not reject the constant return to scale hypothesis on the industry level while others point towards a slightly decreasing returns to scale.[16] Decreasing returns to scale are therefore used as a source of curvature in the profit function that guarantees a unique solution to the financing problem ($\gamma < 1$).[17]

The firm specific log-productivity has idiosyncratic components ϵ_i and ϵ_i' and an aggregate component u_t^a

$$u_{i,t} = u_t^a + \epsilon_{i,t-1} + \epsilon_{i,t}', \tag{3.9}$$

where $\epsilon_{i,t-1}$ and $\epsilon_{i,t}'$ have the respective static cumulative distribution F_ϵ and $F_{\epsilon'}$, normalised such that $\int_\epsilon e^\epsilon dF_\epsilon = \int_{\epsilon'} e^{\epsilon'} dF_{\epsilon'} = 1$. The variable ϵ and ϵ' are assumed to be independent of each other and of the aggregate log-productivity u_t^a. The shock $\epsilon_{i,t-1}$ is known to the firm at time $t-1$ and the shock $\epsilon_{i,t}'$ is not resolved before the production time t. The shock $\epsilon_{i,t-1}$ can be interpreted as a signal available to the firm at the time of financing $t-1$ about its productivity at time of production t. Note here that $\int_{\epsilon'} e^{\epsilon'} dF_{\epsilon'} = 1$ and the independence of ϵ, ϵ' and u_t^a imply that

$$\mathbf{E}_{t-1} e^{u_{i,t}} = e^{\epsilon_{i,t-1}} \mathbf{E}_{t-1} e^{u_t^a}. \tag{3.10}$$

In other words, the expected TFP of the firm at time t, conditional on the information available at time $t-1$ is a function of $\epsilon_{i,t-1}$ and the expected aggregate productivity at time t. As long as one keeps in mind the times the static variables ϵ and ϵ' are

[16] Syverson (2004), Olley and Pakes (1996) and others could not statistically reject the constant return to scale hypothesis. Other studies find slight to moderate decreasing return to scale, for example, Gao and Kehrig (2017).

[17] This is consistent with the literature concerned with heterogeneous firms as for or example in Restuccia and Rogerson (2008) and Bartelsman, Haltiwanger, and Scarpetta (2013).

determined, one can simply write

$$u_{i,t} = u_t^a + \epsilon + \epsilon'. \tag{3.11}$$

The aggregate log-productivity u_t^a is assumed to follow an $AR(1)$ process with the volatility parameter σ_a and mean-reversion ρ_a.

$$u_t^a = \rho_a u_{t-1}^a + \sigma_a e_t.$$

The firm finances production using loan contracts that are issued by financial intermediaries. In the absence of default risk, which I assume, all firms face the same rate r_t^F. At time t, each firm decides the nominal financing amount $P_t f_{i,t}$ that will potentially be invested in the next period's production process ($f_{i,t}$ denotes real financing and P_t the price of the consumed good). To do so, the firm maximises its expected real profit

$$\max_{f_{i,t}} \mathbf{E}_t \Pi_{i,t+1}^F. \tag{3.12}$$

The firm's real profit is a function of future sales proceeds y_{t+1}, the real gross cost of financing $r_t^F \frac{f_{i,t}}{1+\pi_{t+1}}$ and the the real unspent financing $\frac{f_{i,t}}{1+\pi_{t+1}} - w_{t+1} l_{i,t+1} - r_{t+1}^K k_t$

$$\Pi_{i,t+1}^F = y_{i,t+1} - r_t^F \frac{f_{i,t}}{1+\pi_{t+1}} + \left\{ \frac{f_{i,t}}{1+\pi_{t+1}} - w_{t+1} l_{i,t+1} - r_{t+1}^K k_t \right\} \tag{3.13}$$

The unspent financing term $\left\{ \frac{f_{i,t}}{1+\pi_{t+1}} - w_{t+1} l_{i,t+1} - r_{t+1}^K k_t \right\}$ is nil when the firm is constrained at the spending stage and positive otherwise. Note that no discounting of the profit is needed because all the cash-flows of the firm happen at time $t+1$. As long as the discounting rate is known at time t, which I assume, discounting plays no role in the firm's financing problem.[18] It is also useful to note that real financing $f_{i,t}$ is determined by the aggregate shock at time t and the type ϵ, one can therefore adopt the notation $f_{i,t} = f_{\epsilon,t}$.

At period $t+1$, the representative firm chooses labour $l_{i,t+1}$ and rented capital $k_{i,t+1}$ to maximise profit with spending being constrained by the previously set level of financing $f_{i,t}/(1+\pi_{t+1})$ corrected for inflation. The terms $f_{i,t}$ and $r_t f_{i,t}$ in the profit function expression 3.13 are predetermined at time t, so the profit maximisation

[18] A common practice is to assume that the firm uses the real discount rate $(1/r_t)\mathbf{E}_t(1+\pi_{t+1})$.

simplifies to

$$\max_{l_{i,t+1},k_{i,t+1}} y_{i,t+1} - w_{t+1}l_{i,t+1} - r^K_{t+1}k_{i,t+1}, \tag{3.14}$$

$$\text{s.t. } w_{t+1}l_{i,t+1} + r^K_{t+1}k_{i,t+1} \leq \frac{f_{i,t}}{1+\pi_{t+1}}. \tag{3.15}$$

Increasing returns to scale being excluded ($\gamma < 1$), it is a priori not obvious whether the constraint 3.15 holds or not. Let us define $\zeta_{i,t+1}$ as the cost of production $t+1$

$$\zeta_{i,t+1} := w_{t+1}l_{i,t+1} + r^K_{t+1}k_{i,t+1}. \tag{3.16}$$

From the first order conditions of the spending problem 3.14

$$r^K_{t+1}k_{i,t+1} = \alpha\zeta_{i,t+1} \tag{3.17}$$

$$w_{t+1}l_{i,t+1} = (1-\alpha)\zeta_{i,t+1} \tag{3.18}$$

Exploiting the first order conditions above, one can rewrite production as a function of the expenditure level $\zeta_{i,t+1}$, productions costs and the stochastic productivity[19]

$$y_{i,t+1} = e^{u_{i,t+1}}\frac{\zeta^\gamma_{i,t+1}}{\lambda^\gamma_{t+1}}, \tag{3.19}$$

where λ_{t+1} represents the marginal cost of production at time $t+1$.

$$\lambda_{t+1} = \frac{(r^K_{t+1})^\alpha w^{1-\alpha}_{t+1}}{\alpha^\alpha(1-\alpha)^{1-\alpha}} \tag{3.20}$$

The firm's financing problem simplifies to the problem below, where the firm has to decide its level of real spending given the previously set financing constraint

$$\max_{\zeta_{i,t+1}} e^{u_{i,t+1}}\frac{\zeta^\gamma_{i,t+1}}{\lambda^\gamma_{t+1}} - \zeta_{i,t+1}, \tag{3.21}$$

$$\text{s.a. } \zeta_{i,t+1} \leq \frac{f_{i,t}}{1+\pi_{t+1}}. \tag{3.22}$$

If the financing constraint is not binding ($\zeta_{i,t+1} < \frac{f_{i,t}}{1+\pi_{t+1}}$), the firm sets labour such

[19]This formulation of production justifies the decreasing returns to scale assumption. The firm profit function at time $t+1$ is $e^{u_{i,t+1}}\frac{\zeta^\gamma_{i,t+1}}{(\lambda_{t+1})^\gamma} - \zeta_{i,t+1}$. Clearly, if $\gamma = 1$ spending can be undetermined and if $\gamma > 1$, firms would prefer to spend an infinite amount and the financing demand would be infinite as a result.

as the marginal return on spending is one, the same as the marginal return on cash

$$\gamma e^{u_{i,t+1}} \frac{\zeta_{i,t+1}^{\gamma-1}}{\lambda_{t+1}^{\gamma}} = 1. \tag{3.23}$$

Or equivalently,

$$\zeta_{i,t+1} = \gamma y_{i,t+1}. \tag{3.24}$$

In other words, when unconstrained by financing, firms set their expenditure at a level where they are indifferent between producing and simply distributing cash to shareholders. The condition 3.23 yields the following inequality verified by underspending firms

$$\gamma e^{u_{i,t+1}} \frac{f_{i,t}^{\gamma-1}}{(1+\pi_{t+1})^{\gamma-1}\lambda_{t+1}^{\gamma}} \leq 1. \tag{3.25}$$

The latter condition stipulates that, for unconstrained firms, the marginal return on spending at the constraint is less than the marginal return of distributing cash to shareholders. This underspending characterisation can be rewritten as follows

$$\epsilon' \leq \xi_{t+1}(\epsilon), \tag{3.26}$$

where the cutting point $\xi_{t+1}(\epsilon)$ depends (a priori) on the signal ϵ received by the firm at the time of financing and is defined as

$$\xi_{t+1}(\epsilon) = -\ln(\gamma) - u_{t+1}^{a} - \epsilon + \ln\left(\frac{\lambda_{t+1}^{\gamma} f_{\epsilon,t}^{1-\gamma}}{(1+\pi_{t+1})^{1-\gamma}}\right). \tag{3.27}$$

Everything else being equal, underspending is more (less) likely when ϵ, ϵ' and u_{t+1}^{a} are lower (higher), the previously set real financing $f_{i,t}$ is higher (lower), the real marginal cost of production λ_{t+1} are higher (lower) and inflation π_{t+1} is lower (higher). The formulae below summarise the results established so far regarding spending and production

$$\zeta_{i,t+1} = \min\left\{\frac{f_{i,t}}{1+\pi_{t+1}}, \left(\gamma \frac{e^{u_{i,t+1}}}{\lambda_{t+1}^{\gamma}}\right)^{1/(1-\gamma)}\right\}, \tag{3.28}$$

$$y_{i,t+1} = \min\left\{\frac{e^{u_{i,t+1}} f_{i,t}^{\gamma}}{(1+\pi_{t+1})^{\gamma}\lambda_{t+1}^{\gamma}}, \left(\gamma^{\gamma} \frac{e^{u_{i,t+1}}}{\lambda_{t+1}^{\gamma}}\right)^{1/(1-\gamma)}\right\}. \tag{3.29}$$

Note how inflation plays a direct role in setting production spending and production only if the firm is constrained by previous financing.[20]

3.3 Financial intermediation and monetary policy

Following Christiano and Eichenbaum (1992), a direct monetary channel is operated by injecting money in financial intermediary to help finance the loans extended to production firms. The representative bank provides the firms with the loan $f_{i,t}$ charging the gross nominal rate r_t^F. The bank finances its loans operations using households deposits b_t and a monetary injection from the central bank that is proportional to the existing nominal stock of money

$$f_t = b_t + x_t^B \frac{m_{t-1}}{1+\pi_t}, \tag{3.30}$$

where $f_t := \int_i f_{i,t} dF_\epsilon dF_{\epsilon'}$ is the aggregate real bank lending, $m_{t-1}/(1+\pi_t)$ is the existing total real stock of money inherited from the previous time period and x_t^B is the relative change in the stock of money. The bank profit function is then

$$\Pi_{t+1}^B = r_t^F f_t - r_t b_t. \tag{3.31}$$

Or equivalently

$$\Pi_{t+1}^B = r_t^F x_t^B \frac{m_{t-1}}{1+\pi_t} + (r_t^F - r_t) b_t. \tag{3.32}$$

The monetary authority provides the financial intermediaries with the new money in the goal of easing credit conditions for firms. This prevents the increase in the money supply from being distributed equally to all agents and guarantees a role for money in the model's fluctuations. Following Christiano and Eichenbaum (1995), I assume that the bank's profit is zero ($\Pi_{t+1}^B = 0$). This yields

$$r_t^F f_t = r_t b_t. \tag{3.33}$$

I assume that the money growth x_t^B follows the AR(1) process

$$x_t^B = (1-\rho_m) x^B + \rho_m x_{t-1}^B + \sigma_m v_t, \tag{3.34}$$

[20] Inflation plays an indirect role in setting the production spending and the production of unconstrained firms through its influence on the cost of producing λ_{t+1}.

where x^B is the steady state value of x_t^B, σ_m is the volatility of innovations, ρ_m is the autocorrelation parameter and v_t is an $i.i.d$ error term that is independent of all other shocks in the model.

The assumption that money is directly injected in the financial intermediaries can be justified by the ability of central banks to affect lending through the use of open-market operations (Christiano and Eichenbaum (1992)). All the stock of money available at the end of the production cycle is inherited by the households and is either kept in real cash balances to facilitate transactions or deposited with the financial intermediary

$$\frac{m_{t-1}}{1+\pi_t} = m_t^H + b_t. \tag{3.35}$$

The latter money clearing condition, combined with the household demand for money emanating from utility maximisation as described by equation 3.1, helps determine prices in the model.

$$\frac{m_{t-1}}{1+\pi_t} = \left(\psi \frac{r_t}{r_t - 1} c_t\right)^{1/\nu} + b_t. \tag{3.36}$$

It is important to note that unlike in Christiano and Eichenbaum (1992), the household decisions in terms of consumption, money holding and saving are not set before the injection of new money by the monetary authority. While the new money is not distributed equally to all agents, it still influences the decisions of households. For instance, through increasing inflation, the monetary injection increases the nominal rate r_t and pushes households to save more through deposits at the expense of holding money.

3.4 Equilibrium and market clearing

The equilibrium is realised when prices (w_t, r_t^H, r_t) and the quantities c_t, b_t, l_t, $f_{i,t}$, $\zeta_{i,t}$, $l_{i,t}$ and $k_{i,t}$ are such that firms maximise expected profit at the financing stage subject to the technology constraint and maximise profit at the spending stage subject to the technology and financing constraints, households maximise utility subject to their budget constraint and the various markets within the economy clear. These markets are:

- The good's market where all the production is either consumed by households or used to accumulate physical capital

$$y_t := \int_{\epsilon,\epsilon'} y_{i,t} dF_\epsilon dF_{\epsilon'} = c_t + k_t - (1-\delta)k_{t-1}. \tag{3.37}$$

- The labour market, where households labour supply must meet firms' labour demand

$$l_t = \int_{\epsilon,\epsilon'} l_{i,t} dF_\epsilon dF_{\epsilon'}. \tag{3.38}$$

- The market for real capital, where the capital accumulated by households is used by firms in the following time period

$$k_{t+1} = \int_{\epsilon,\epsilon'} k_{i,t+1} dF_\epsilon dF_{\epsilon'}. \tag{3.39}$$

- The loan market where households' supply of deposits and the monetary transfer to banks $x_t^B \frac{m_{t-1}}{1+\pi_t}$ must meet the production sector financing demands

$$b_t + x_t^B \frac{m_{t-1}}{1+\pi_t} = \int_\epsilon f_{\epsilon,t} dF_\epsilon. \tag{3.40}$$

3.5 Theoretical results

In this subsection, I provide several theoretical results that help in solving and simulating the underspending model. These results do not depend on the distributions of ϵ and ϵ', nor do they depend on the assumed monetary policy. I start by providing a debt financing equation describing the firms' demand for loans.

Proposition 1. *The firms' financing demand satisfies the following condition*

$$r_t^F = \mathbf{E}_t \max\left\{1, \gamma \frac{(1+\pi_{t+1})^{1-\gamma} e^{u_{i,t+1}}}{\lambda_{t+1}^\gamma f_{i,t}^{1-\gamma}}\right\}. \tag{3.41}$$

Proof. The spending and production expressions 3.28 and 3.29 yield the derivatives of spending and production with regard to debt financing

$$\frac{\partial \zeta_{i,t+1}}{\partial f_{i,t}} = \mathbf{1}_{\epsilon' > \xi_{t+1}(\epsilon)} \frac{1}{1+\pi_{t+1}}, \tag{3.42}$$

$$\frac{\partial y_{i,t+1}}{\partial f_{i,t}} = \mathbf{1}_{\epsilon' > \xi_{t+1}(\epsilon)} \gamma \frac{e^{u_{i,t+1}} f_{i,t}^{\gamma-1}}{(1+\pi_{t+1})^\gamma \lambda_{t+1}^\gamma}. \tag{3.43}$$

Hence the first order condition emanating from problem financing problem 3.12 is given by 3.41. ∎

Proposition 1 shows that, when underspending by firms is possible, money provides a floor for the marginal return on nominal debt financing $P_t f_{i,t}$ (the floor being 1). This extra protection afforded to firms while they keep hold of cash pushes them to increase their demand for new financing. Exploiting the independence of the final idiosyncratic productivity shock ϵ' of the signal ϵ and of the aggregate productivity shock u^a_{t+1}, I can rewrite the financing condition 3.41 as the per the corollary below.

Corollary 1. *The firms' financing demand satisfies the following condition*

$$r^F_t = \mathbf{E}_t \left[F_{\epsilon'} \left(\xi_{t+1}(\epsilon) \right) + e^{-\xi_{t+1}(\epsilon)} \int_{\xi_{t+1}(\epsilon)}^{+\infty} e^{\epsilon'} dF_{\epsilon'} \right], \tag{3.44}$$

where ξ_{t+1} is the cutting point for ϵ' below which firm i underspends and is defined as above

$$\xi_{t+1}(\epsilon) = -\ln(\gamma) - u^a_{t+1} - \epsilon + \ln \left(\frac{\lambda^{\gamma}_{t+1} f^{1-\gamma}_{\epsilon,t}}{(1+\pi_{t+1})^{1-\gamma}} \right).$$

Equation 3.44 cannot be solved individually for each firm. Rather, the full distribution of firms' debt financing is jointly determined such as 3.44 holds for all values of ϵ in the support of the distribution F_ϵ. This is because the distribution of financing decided today, influences the distributions of inflation π_{t+1} and production costs λ_{t+1} in the following time period. Proposition 2 provides the firms' financing distribution $(f_{\epsilon,t})$ given the level of aggregate debt financing $f_t := \int_\epsilon f_{\epsilon,t} dF_\epsilon$. This simplifies the model substantially and helps in providing single equations determining aggregate financing, aggregate spending and aggregate production. Proposition 2 assumes that the net financing rates facing the firm are positive. This guarantees a finite demand for financing by individual firms. Unlike in the liquidity trap models, zero interest rates are not important for the functioning of the underspending mechanism.

Proposition 2. *Assume that the firms are facing a positive net financing rate $r^F_t >$ 1. Then the following results stand*

i The critical value of ϵ' below which the firm enters an underspending mode is independent of the signal ϵ received at the financing time and is given by

$$\xi_{t+1} = (1-\gamma)\ln(A) - \ln(\gamma) + \ln \left(\frac{\lambda^{\gamma}_{t+1} f^{1-\gamma}_{t}}{(1+\pi_{t+1})^{1-\gamma}} \right) - u^a_{t+1}, \tag{3.45}$$

where $f_t := \int_\epsilon f_{\epsilon,t} dF_\epsilon$ is the aggregate debt financing and $A := \left(\int_\epsilon e^{\epsilon/(1-\gamma)} dF_\epsilon\right)^{-1}$ is a normalisation constant that is determined by the distribution F_ϵ.

ii The distribution of the firms' debt financing is given by

$$f_{i,t} = A f_t e^{\epsilon/(1-\gamma)}, \tag{3.46}$$

where A and f_t are as defined above.

iii The aggregate debt financing satisfies

$$r_t^F = \mathbf{E}_t \left[F_{\epsilon'} \left(\xi_{t+1}\right) + e^{-\xi_{t+1}} \int_{\xi_{t+1}}^{+\infty} e^{\epsilon'} dF_{\epsilon'} \right], \tag{3.47}$$

where ξ_{t+1} as defined in 3.45.

Proof. First write the firm dependent critical value of ϵ' below which the firm underspends in the form

$$\xi_{t+1}(\epsilon) = \underline{\xi}_{t+1} + \overline{\xi}_{t,\epsilon}. \tag{3.48}$$

where by definition

$$\begin{aligned}
\underline{\xi}_{t+1} &:= (1-\gamma)\ln(A) - \ln(\gamma) + \ln\left(\frac{\lambda_{t+1}^{\gamma} f_t^{1-\gamma}}{(1+\pi_{t+1})^{1-\gamma}}\right) - u_{t+1}^a, \\
\overline{\xi}_{t,\epsilon} &:= -(1-\gamma)\ln(A) + (1-\gamma)\ln(f_{i,t}/f_t) - \epsilon, \\
f_t &:= \int_\epsilon f_{\epsilon,t} dF_\epsilon, \\
A &:= \left(\int_\epsilon e^{\epsilon/(1-\gamma)} dF_\epsilon\right)^{-1}.
\end{aligned}$$

Note that $\underline{\xi}_{t+1}$ does not depend of on the signal ϵ and $\overline{\xi}_{t,\epsilon}$ is function of ϵ and the state of the economy at time t. From equation 3.44, the variable $\overline{\xi}_{t,\epsilon}$ is solution to the equation

$$r_t^F = \mathscr{H}_t(\overline{\xi}_{t,\epsilon}), \tag{3.49}$$

where $\mathscr{H}_t(X) := \mathbf{E}_t \left[F_{\epsilon'} \left(\underline{\xi}_{t+1} + X\right) + e^{-\underline{\xi}_{t+1} - X} \int_{\underline{\xi}_{t+1}+X}^{+\infty} e^{\epsilon'} dF_{\epsilon'} \right]$ is a function of $\overline{\xi}_{t,\epsilon}$ that is independent of the signal ϵ with a derivative verifying: $\frac{d\mathscr{H}}{dX}(X) < 0$, $\lim_{X\to-\infty} \frac{d\mathscr{H}}{dX}(X) = -\infty$ and $\lim_{X\to+\infty} \mathscr{H}(X) = 1 < r_t^F$.[21] The equation 3.49 has therefore a unique so-

[21]One can prove that $\frac{d\mathscr{H}}{dX}(X) = -\mathbf{E}_t e^{-\underline{\xi}_{t+1} - X} \int_{\underline{\xi}_{t+1}+X}^{+\infty} e^{\epsilon'} dF_{\epsilon'}$.

lution that is independent of the signal ϵ:

$$\bar{\xi}_{t,\epsilon} = \bar{\xi}_t. \tag{3.50}$$

The definition of $\bar{\xi}_{t,\epsilon}$ then yields the distribution of debt financing

$$f_{i,t} = A f_t e^{(\epsilon+\bar{\xi}_t)/(1-\gamma)}. \tag{3.51}$$

Combining the equation above, the definition of the aggregate loan financing $f_t := \int_\epsilon f_{i,t} dF_\epsilon$ and the definition of the constant $A = \left(\int_\epsilon e^{\epsilon/(1-\gamma)} dF_\epsilon\right)^{-1}$ implies that $\bar{\xi}_t = 0$. Hence the first result of the proposition and the distribution of debt financing described by the equation 3.46. Combining 3.46 and 3.49 with $\underline{\xi}_{t+1} = \xi_{t+1}$ yields the financing equation 3.47. ■

I now turn to the aggregate spending $\zeta_{t+1} := \int_i \zeta_{i,t+1} dF(i)$ that I write using the result in 3.28 and the results in proposition 2

$$\zeta_{t+1} = \left(\frac{\gamma e^{u^a_{t+1}}}{\lambda^\gamma_{t+1}}\right)^{1/(1-\gamma)} \int_{\epsilon,\epsilon'} e^{\frac{\epsilon+\epsilon'}{1-\gamma}} \mathbf{1}_{\epsilon' \leq \xi_{t+1}} dF_\epsilon dF_{\epsilon'} + \int_{\epsilon,\epsilon'} \frac{f_{\epsilon,t}}{1+\pi_{t+1}} \mathbf{1}_{\epsilon' > \xi_{t+1}} dF_\epsilon dF_{\epsilon'}. \tag{3.52}$$

The first term in the right-hand side of the equation above represents spending by unconstrained firms while the second term reflects spending by constrained firms.

Similarly, I write the aggregate production $y_t := \int y_{i,t} dF_\epsilon dF_{\epsilon'}$ using the expression 3.29 for individual firm production

$$y_{t+1} = \left(\frac{\gamma^\gamma e^{u^a_{t+1}}}{\lambda^\gamma_{t+1}}\right)^{1/(1-\gamma)} \int_{\epsilon,\epsilon'} e^{\frac{\epsilon+\epsilon'}{1-\gamma}} 1_{\epsilon' \leq \xi_{t+1}} dF_{\epsilon'} dF_\epsilon + \frac{e^{u^a_{t+1}}}{(1+\pi_{t+1})^\gamma \lambda^\gamma_{t+1}} \int_{\epsilon,\epsilon'} e^{\epsilon+\epsilon'} f^\gamma_{\epsilon,t} \mathbf{1}_{\epsilon' > \xi_{t+1}} dF_{\epsilon'} dF_\epsilon. \tag{3.53}$$

Exploiting the independence of ϵ' of ϵ, one can rewrite the aggregate spending and aggregate production as a function of the previously set debt financing and the variable ξ.

Proposition 3. *The aggregate firm spending $\zeta_{t+1} := \int_\epsilon \zeta_{i,t} dF_\epsilon dF_{\epsilon'}$ and aggregate (real) output $y_{t+1} := \int_\epsilon y_{i,t} dF_\epsilon dF_{\epsilon'}$ are given by*

$$\zeta_{t+1} = \left[e^{-\frac{\xi_{t+1}}{1-\gamma}} \int_{\epsilon'=-\infty}^{\xi_{t+1}} e^{\frac{\epsilon'}{1-\gamma}} dF_{\epsilon'} + 1 - F_{\epsilon'}(\xi_{t+1})\right] \frac{f_t}{1+\pi_{t+1}}, \tag{3.54}$$

$$y_{t+1} = \frac{1}{\gamma}\left[e^{-\frac{\xi_{t+1}}{1-\gamma}}\int_{\epsilon'=-\infty}^{\xi_{t+1}} e^{\frac{\epsilon'}{1-\gamma}} dF_{\epsilon'} + e^{-\xi_{t+1}}\int_{\epsilon'=\xi_{t+1}}^{+\infty} e^{\epsilon'} dF_{\epsilon'}\right]\frac{f_t}{1+\pi_{t+1}}. \tag{3.55}$$

where as defined above $A := \left(\int_\epsilon e^{\epsilon/(1-\gamma)} dF_\epsilon\right)^{-1}$ *and* $\xi_{t+1} := (1-\gamma)\ln(A) - \ln(\gamma) + \ln(\frac{\lambda_{t+1}^{\gamma} f_t^{1-\gamma}}{(1+\pi_{t+1})^{1-\gamma}}) - u_{t+1}^a$.

Proof. This proposition is derived from expressions 3.52 and 3.53 and the results of proposition 2 by remarking that ϵ and ϵ' are independent and using the identity

$$\frac{\gamma e^{u_{t+1}^a}}{\lambda_{t+1}^{\gamma}} = A^{1-\gamma} e^{-\xi_{t+1}} \left(\frac{f_t}{1+\pi_{t+1}}\right)^{1-\gamma}$$

to replace for the term $\frac{\gamma e^{u_{t+1}^a}}{\lambda_{t+1}^{\gamma}}$. The latter identity is derived from the definition of ξ_{t+1}. ■

Note that in the absence of underspending ($\xi_{t+1} << 0$), the aggregate financing is equal to the previously set debt financing $\zeta_{t+1} = f_t/(1+\pi_{t+1})$ and the aggregate output is determined by the previously set aggregate debt financing, the new aggregate shock and the new wage : $y_{t+1} = \frac{1}{A^{1-\gamma}} \frac{e^{u_{t+1}^a}}{\lambda_{t+1}^{\gamma}} \frac{f_t^{\gamma}}{(1+\pi_{t+1})^{\gamma}}$. It is also useful to note that the formulae of proposition 3 immediately yield the aggregate underspending as a proportion of the aggregate debt financing

$$\frac{f_t/(1+\pi_{t+1}) - \zeta_{t+1}}{f_t/(1+\pi_{t+1})} = e^{-\frac{\xi_{t+1}}{1-\gamma}} \int_{\epsilon'=-\infty}^{\xi_{t+1}} \left(e^{\frac{\xi_{t+1}}{1-\gamma}} - e^{\frac{\epsilon'}{1-\gamma}}\right) dF_{\epsilon'}. \tag{3.56}$$

The aggregate underspending causes the following loss in production

$$\frac{f_t}{\gamma(1+\pi_{t+1})} \int_{\epsilon'=-\infty}^{\xi_{t+1}} \left(e^{\epsilon'-\xi_{t+1}} - e^{\frac{\epsilon'-\xi_{t+1}}{1-\gamma}}\right) dF_{\epsilon'}. \tag{3.57}$$

The loss in production as a result of underspending, should not be interpreted as a welfare loss. The next section will show that, in the steady state, higher underspending can correspond to a higher utility for households.

4 Model simulations and results

In this section, I present and comment the model's simulations and steady results and explain the calibration process. Exploiting the aggregation results of section

3, the model is calibrated in the steady state and simulated using second order approximations in Dynare.

4.1 Steady state calibration

Before calibrating the model and studying its steady state behaviour, I need to specify the assumed distributions of the idiosyncratic productivity shocks ϵ and ϵ'. These shocks are assumed to follow a Gaussian distribution with a standard deviations σ_ϵ and $\sigma_{\epsilon'}$ and means μ_ϵ and $\mu_{\epsilon'}$. The normalisation conditions $\int_\epsilon e^\epsilon dF_\epsilon = \int_{\epsilon'} e^{\epsilon'} dF_{\epsilon'} = 1$ yield

$$\mu_\epsilon = -(\sigma_\epsilon)^2/2, \tag{4.1}$$

$$\mu_{\epsilon'} = -(\sigma_{\epsilon'})^2/2. \tag{4.2}$$

The model equations implied by this specification of the distributions F_ϵ and $F_{\epsilon'}$ are presented in appendix A.1.

Following Bartelsman, Haltiwanger, and Scarpetta (2013), I assume modest return to scale and set $\gamma = 0.95$. The volatility parameter of the productivity signal ϵ is set to $\sigma_\epsilon = 7.5\%$ for the model steady state to match the standard deviation of log employment in the United States at 1.2 as in Poschke (2018). The volatility of the final productivity shock $\sigma_{\epsilon'}$ is key in setting the fraction of underspending firms in the steady state $\Phi(\frac{\sigma_{\epsilon'}}{2} + \frac{\xi}{\sigma_{\epsilon'}})$. I identify the underspending firms with those buying back shares in section 2's data. This parameter is set to $\sigma_{\epsilon'} = 0.92\%$ to match a steady state where 20% of firms buy shares back (figure 1). Furthermore, the parameter ψ is chosen so that the steady state of money balances to deposits m^H/m matches the M1/M2 ratio for the United States at 25%. The remaining parameters are standard and are borrowed from the literature (table 3).

The effects of the parameter σ_ϵ on steady-state variables are shown in figure 5. Around its calibrated value, the parameter σ_ϵ has little effect on the underspending mechanism and other aggregate variables in the steady state. This changes when the value of σ_ϵ is high enough as the steady-state capital and debt financing moves exponentially with the volatility of the productivity signal ϵ.[22] However, the impact on underspending remains small even for large values of σ_ϵ. On the other hand, the level of underspending in the economy is sensitive to the volatility of the final id-

[22]This behaviour is caused by the variation of the constant $1/A = \int_\epsilon e^{\epsilon/(1-\gamma)} dF_\epsilon = e^{\sigma_\epsilon^2/(2(1-\gamma)^2)}$. This constant enters the expressions of steady-state output, spending and capital (see appendix A.2).

iosyncratic productivity shock $\sigma_{\epsilon'}$ while other steady-state variables are less sensitive to changes in $\sigma_{\epsilon'}$ (figure 6). This justifies the calibration choice.

I then show in figure 7 the steady-state effects of the annualised net real deposit rate $(1/\beta)^4 - 1$ that is determined by the preference discounting parameter. When steady-state real deposit rates are small underspending becomes more widespread among firms. This is an important feature of the model and is related to the fact that the underspending mechanism becomes more potent when the loan interest rates are low. When real deposit rates drop lower while the steady-state inflation remains constant, the financing rates facing firms also drops lower. Faced with lower loan rates, firms target lower returns on financing as they set the level of loans so that, in expectation, the net return from production matches the net financing cost. When the targeted returns are lower, smaller productivity drops cause the marginal return on producing, using all available funds, to be lower than one (i.e., lower than the marginal return on cash). This increases the underspending critical point ξ below which the final idiosyncratic shock ϵ' pushes the firms to underspend, causing more aggregate underspending in the steady state. The increase in underspending when β is high is accompanied by a sharp increase in steady-state loan financing and a less sharp increase in capital and output. The sharp increase in loan financing is a consequence of the higher demand for financing by firms in response to lower financing costs. This demand is exacerbated by the underspending mechanism as firms view the possibility to underspend as protection from lower returns on financing in case of unexpected negative shocks to productivity. The increase in steady-state capital is chiefly caused by the inclination of the more patient household to save through capital accumulation. Higher capital when β is high causes a more moderate increase in output as steady-state labour remains fairly stable.

Figure 8 shows the effect of the steady state inflation $\pi = x^B$ on the model's steady state variables. Within the assumed monetary policy framework, the injection of money is used by financial intermediaries to reduce the loan rate relative to the deposit rates. As explained above, lower financing rates lead to the firm targeting lower returns on the borrowing at the financing stage. This increases underspending in the steady state as lower drops in productivity makes the firms unconstrained by the previous financing. The "liquidity effect" associated with the monetary injections increases debt financing in the steady state and by extension increases capital, labour, output and consumption. Finally, the welfare implications of liquidity injections are shown in figure 9, where I present the effect of the level of money injection x^B on the households' utility including and excluding the utility derived from holding real money balances. In the assumed monetary set-up, inflation has a positive impact on welfare as it helps increase the proportion of firms that are unconstrained by financing in the steady state.

4.2 Simulation Results

I present impulse response functions illustrating the dynamic effects of the model's main mechanism. Figure 10 compares impulse responses of the model with the firm's underspending mechanism (main model) to a version of the model where the financing constraints are always binding (benchmark model). The figure shows the impulse responses of the main model variables to an unpredicted negative shock to aggregate productivity (1× standard deviations). In the benchmark model, the financing constraint is always biding. This means that nominal spending is decided in the previous period. Following a surprise negative shock to aggregate productivity, It takes an extra time period for firms to set spending lower. As a result, the trough of labour, investment and output is not reached immediately after the shock. In the absence of the underspending mechanism the nominal spending on wages is predetermined, so the real spending on wages decreases only because of the higher inflation.[23] The increase in inflation is partially compensated by the decrease in real wages, leading to a small drop in labour. The muted reaction of labour moderates the reaction of output to the shock. This in turn mutes the reaction of real investment. Assuming the calibration of the main model detailed above, 20% of the firms underspend in the steady state. Following a negative shock to productivity, these firms can adjust their spending lower and others will follow suit as the aggregate negative shock reduces their marginal return on spending to fund production (the proportion of underspending firms jumps from 20% to 27%). This pushes real aggregate spending lower immediately. Hence the more immediate reaction of labour, investment, output and consumption in the main model.

As explained above, the model's mechanism is more potent in low real rates, low inflation environment. This is an environment where nominal loan rates are low, which pushes firms to target a low return from its production operations as the financing cost it needs to pay back is lower. Targeting a low return from production at the financing time implies that smaller drops in productivity are enough to make firms

[23] Recall that $w_t l_t = (1-\alpha)\zeta_t = (1-\alpha) f_{t-1}/(1+\pi_t)$ when spending is always constrained.

prefer cash to spending on production. More firms underspend as a result. Following an unexpected aggregate productivity drop, more firms would reduce spending in this low nominal loan rate environment as shown in figure 11. This figure shows similar effects to those shown in figure 10 but the magnitude of these effects is higher given that the underspending mechanism is more potent with the new calibration. This confirms the finding of subsection 4.1. The prevailing interest and inflation rates are important in deciding both dynamic and in steady state effects of the underspending mechanism.

I now turn to the monetary implication of the underspending mechanism. Figure 12 shows the impulse responses to an unexpected positive shock in money supply of the main model, with underspending, and the benchmark model, where firms are always constrained by the previous financing. Immediately after the money supply shock, inflation increases in both models. The rise in inflation causes real wages to drop when the underspending mechanism is absent. This depresses labour supply and in turn brings output, investment and consumption down. When firms can underspend (main model), the subgroup of unconstrained firms react to higher inflation by spending more on wages and capital. This helps mute the effect of inflation on real wages and moderates the fall in labour supply. The fall in output, investments and consumptions is also moderated by the underspending mechanism as a result. Furthermore, underspending affects the reaction of debt financing to the monetary shock. The cash injection is used by financial intermediaries to increase credit supply to firms while lowering the charged interest rates. The possibility of underspending provides a floor to the future nominal return from financing. This floor is one, i.e. the same as the nominal return from holding cash. This option to underspend at a later stage encourages firms to borrow more in the presence of the underspending mechanism. Hence a larger positive reaction of debt financing to the monetary shock in the main model relative to the benchmark model. The positive debt financing reaction increases the level of financing and therefore introduces more slack in the firms' future spending. Hence higher levels of aggregate underspending in the periods following the shock. In the absence of the model's main mechanism, the increase in firm financing leads to higher firm spending in the periods following the monetary shock. In the main model, this increase is moderated by the more widespread underspending that is caused by higher real financing.[24] Overall, the presence of

[24]As suggested by the equation 3.45 for the critical level of ϵ' below which firms underspend increases with the previously set nominal aggregate debt financing.

the underspending mechanism mutes the immediate consequences of inflations and slightly moderates the impact of the monetary injection on future spending, labour, output and investments.

In a calibration set-up that assumes more patient households (higher β), the steady state loan rate is lower and more firms underspend in the steady state as a result. This impacts the reaction of aggregate variables to monetary shocks in the presence of the underspending mechanism. Impulse response to a surprise positive monetary shock for $\beta = 0.998$ are shown in figure 13. In the presence of underspending, the larger proportion of firms that are unconstrained by financing in the steady state fully counteract the effect of inflation on real wages by increasing their spending. This maintains labour supply at the same level immediately following the shock. Therefore, output also remains stable, in the presence of underspending, at the time of the monetary shock. In the main model, there is a sharp increase in debt financing but most of this increase of financing is distributed to households in the form of cash and not used to fund extra production. On the other hand, the behaviour of the benchmark model without the underspending mechanism is similar to the one noted when analysing the results for the standard calibration (figure 12). Assuming more patient households (high β), the reaction of most of the main model's variables to the monetary shock is quite muted. This includes real wages, labour, output, investment, consumption and the loan rate. The exception being the more pronounced reaction in terms of debt financing and the subsequent increase in underspending. This can be explained by the fact that the option to underspend is worth more to firms when loan rates are lower as this underspending option becomes more likely to be acted upon at a later stage. Taking this into account firms raise more debt and subsequently distribute more cash to shareholders.[25] The analysis here suffers from the fact that I assume no possibility of bankruptcy. This assumption makes firms less concerned about future underspending. Arguably, a model with longer-lived firms and precautionary cash hoarding motives would counteract the effect of defaults and maintain demand for debt higher.

In summary, the underspending mechanism makes the effects of real shocks more immediate and more severe and dampens the immediate effects of higher inflation. This is a result of the set of unconstrained firms reacting to real negative (positive) shocks by decreasing (increasing) spending. Following an unexpected negative shock

[25] In the language of quantitative finance and equity options, the underspending option is "in the money", meaning it is likely to be worth something positive at its exercise time, which in our case, is the next time period.

to productivity, firms do not have to wait an additional time period for the effect of the newly set financing to impact spending. Some firms will reduce both spending and financing immediately when a sudden negative real shock hits the economy, thus causing a more immediate and more severe drop in output. Within the assumed monetary framework, an increase in the stock of money relaxes lending conditions and provides firms with more credit as a result. When spending is always constrained, the increase in firm financing is accompanied by an increase in firm spending in the following time-period, leading to higher labour and higher output. This effect is dampened in the presence of the underspending mechanism as the behaviour of the set of financially unconstrained firms is not impacted by the easing in credit supply. Environments where underspending is more widespread (e.g. environments where the loan rates are low) increase both the real and monetary effects of the underspending mechanism.

5 Conclusion

I presented a financial mechanism rooted in the way firms change their behaviour towards setting current expenditure as a reaction to unexpected negative shocks to productivity. When affected by unexpected drops in their productivity, firms can react by reducing spending to lower levels than those permitted by the financial resources at their disposal. I showed that this underspending mechanism can make the effects of real shocks more immediate and more severe while dampening the effects of monetary shocks. I also showed that environments where firms face low nominal loan rates, are favourable to the functioning of the underspending mechanism and strengthen its effects. The results I present suggest that policymakers should take firms' underspending into account when forming a picture of the economy in the view of informing policy.

To provide empirical validation of the model, I study the effect of productivity on the propensity of firms to pay shareholders back and on the size of these payouts. I show that higher firm-level productivity lowers both the likelihood and the levels of the payouts. I assume that part of the cash diverted towards investors would have been spent on improving or increasing production had the firm decided against rewarding shareholders in the short term. The latter assumption and the negative empirical relationship between productivity and investor payouts indicate that firms decrease spending to respond to negative productivity shocks.

The model I present has limitations. For instance, it assumes that the firm is very short-lived and, as a result, does not consider the long term impact of the firms' decisions regarding investments in physical and human capital. Furthermore, the model does not allow for firms bankruptcies, nor does it capture precautionary saving motives in an explicit form. These issues have been ignored to keep the analysis simple and the model analytically tractable. Tackling these limitations is left for future research.

Model parameter	**Value**
Households preferences	
β discount factor	0.99
η curvature on labour	1
χ disutility of labour	7.4
ν curvature on real money	2
ψ real money demand	0.2%
Technology	
γ return to scale	0.95
α capital share	0.33
ρ_a aggregate TFP persistence	0.8
σ_a aggregate TFP volatility	1%
δ depreciation rate of capital	2.5%
σ_ϵ volatility of productivity signal	7.5%
$\sigma_{\epsilon'}$ volatility of final productivity shock	0.92%
Money Supply	
x^B steady state money supply	0.5%
ρ_m persistence of monetary shocks	80%
σ_m volatility of monetary shocks	0.25%

Table 3: Assumed and calibrated model parameters.

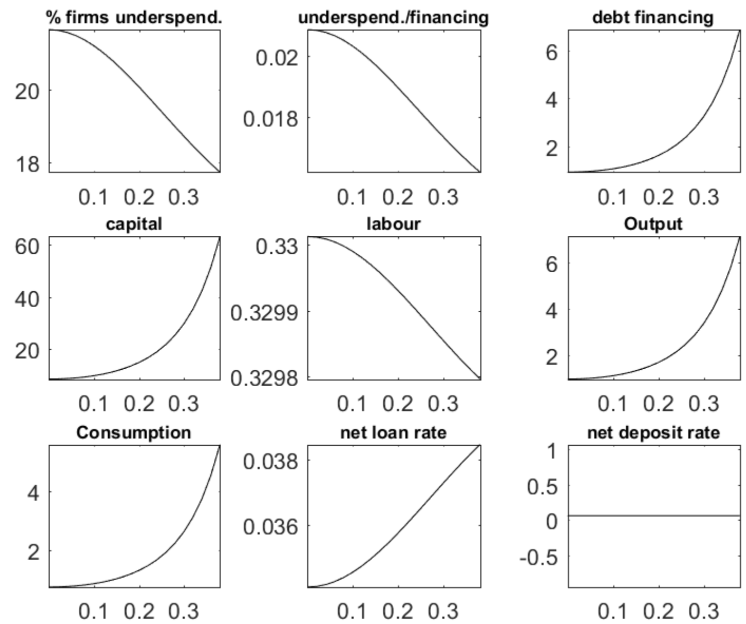

Figure 5: Effect of the volatility of the productivity signal perceived by the firm at the time of financing σ_ϵ on steady state variables. All rates are net and annualised.

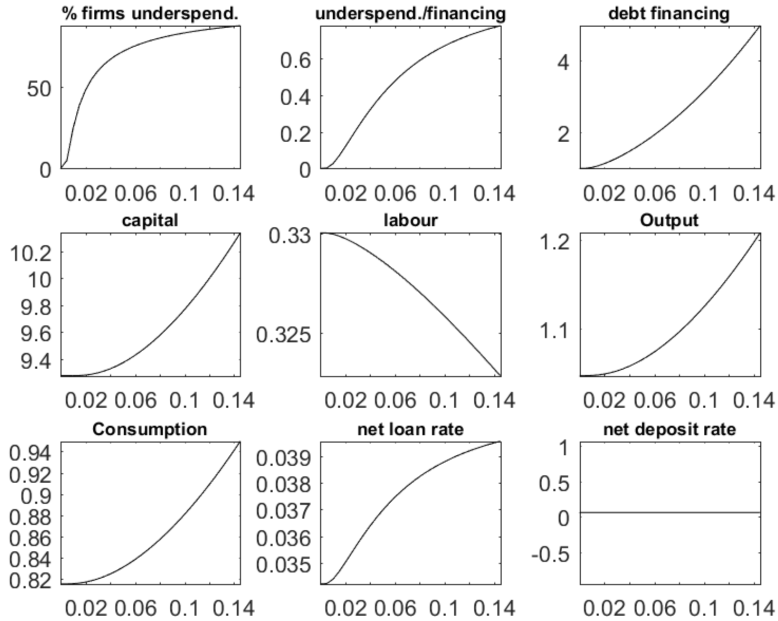

Figure 6: Effect of the volatility of the final idiosyncratic productivity shock $\sigma_{\epsilon'}$ on steady state variables. All rates are net and annualised.

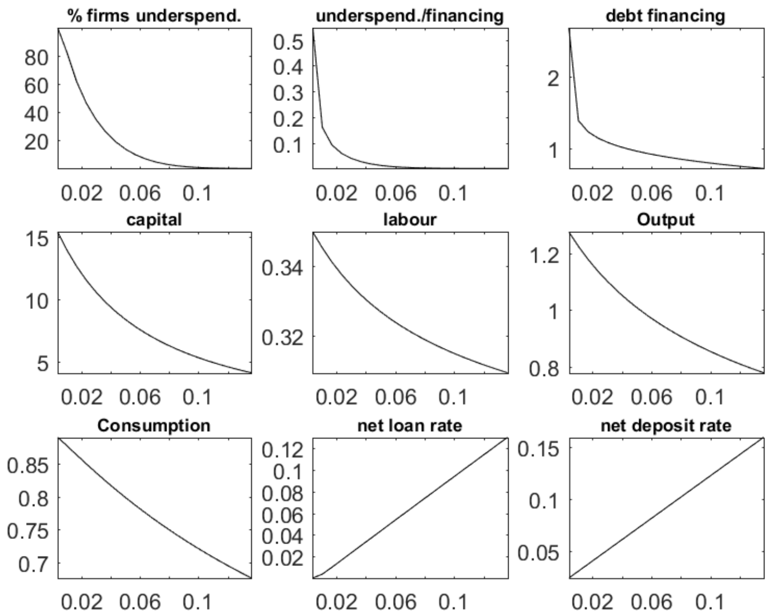

Figure 7: Effect of the steady state annualised net real deposit rate $(1/\beta)^4 - 1$ on steady state variables. All rates are net and annualised.

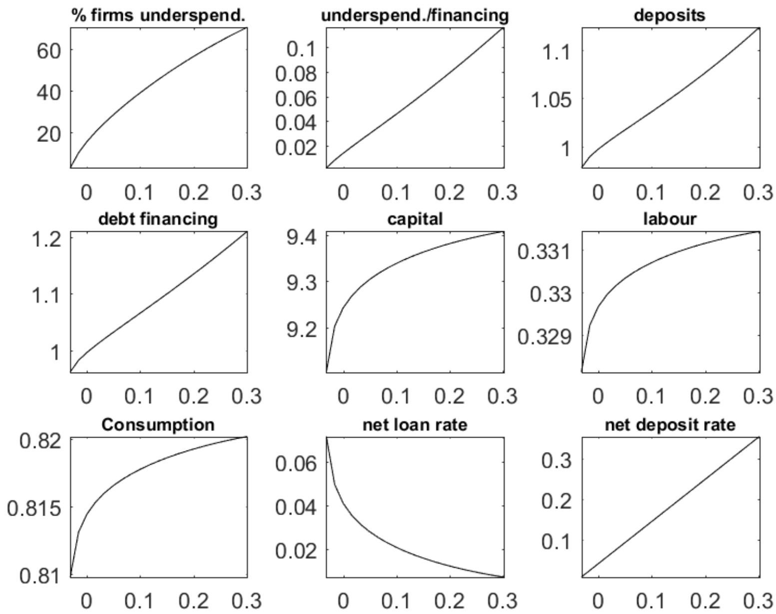

Figure 8: Effect of the assumed steady state money injection $(1 + x^B)^4 - 1$ on steady state variables. All rates are net and annualised.

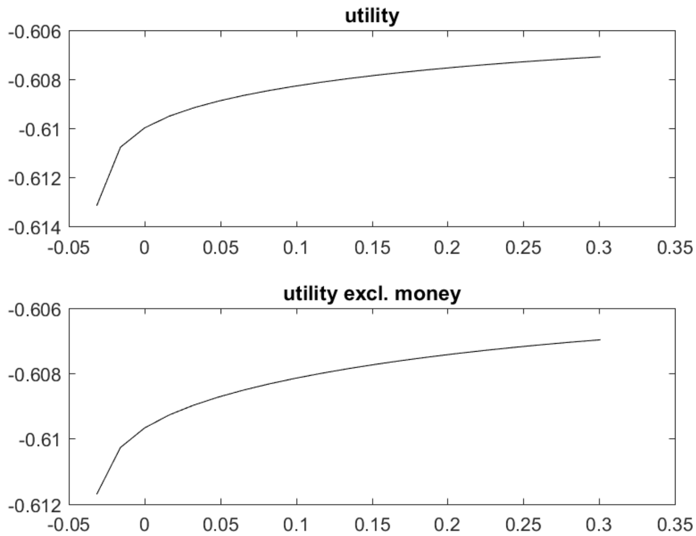

Figure 9: Effect of the assumed steady state money injection $(1 + x^B)^4 - 1$ on steady state household's utility and steady state household's utility excluding the utility derived from money.

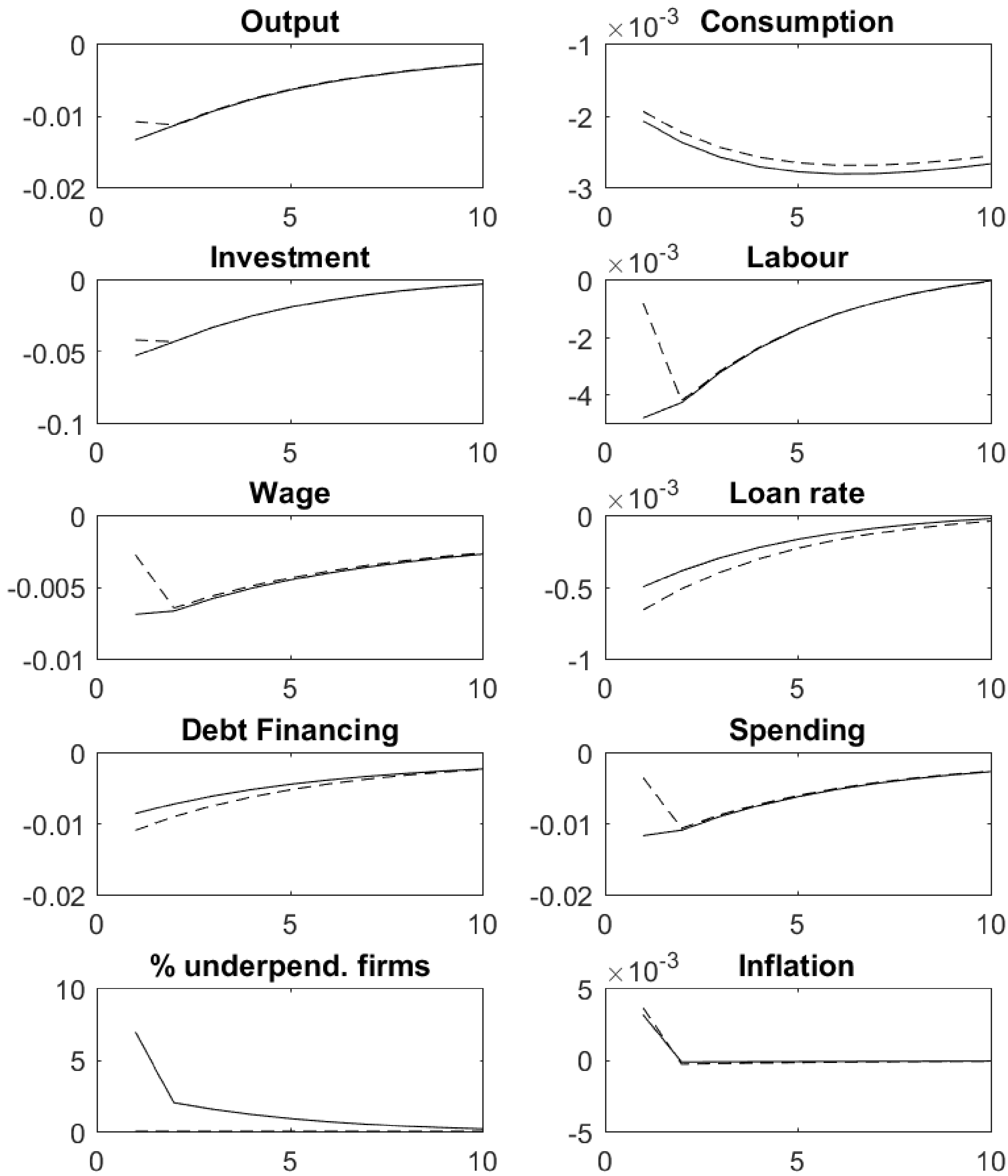

Figure 10: Impulse response functions following a negative 1× standard deviation shock to aggregate log TFP (u_t^a). The main model is compared to a model where the financing constrain is always binding (Benchmark, dashed line). All variables are expressed in real terms and logarithmic form with the exception of inflation, loan rates and the % of underspending firms.

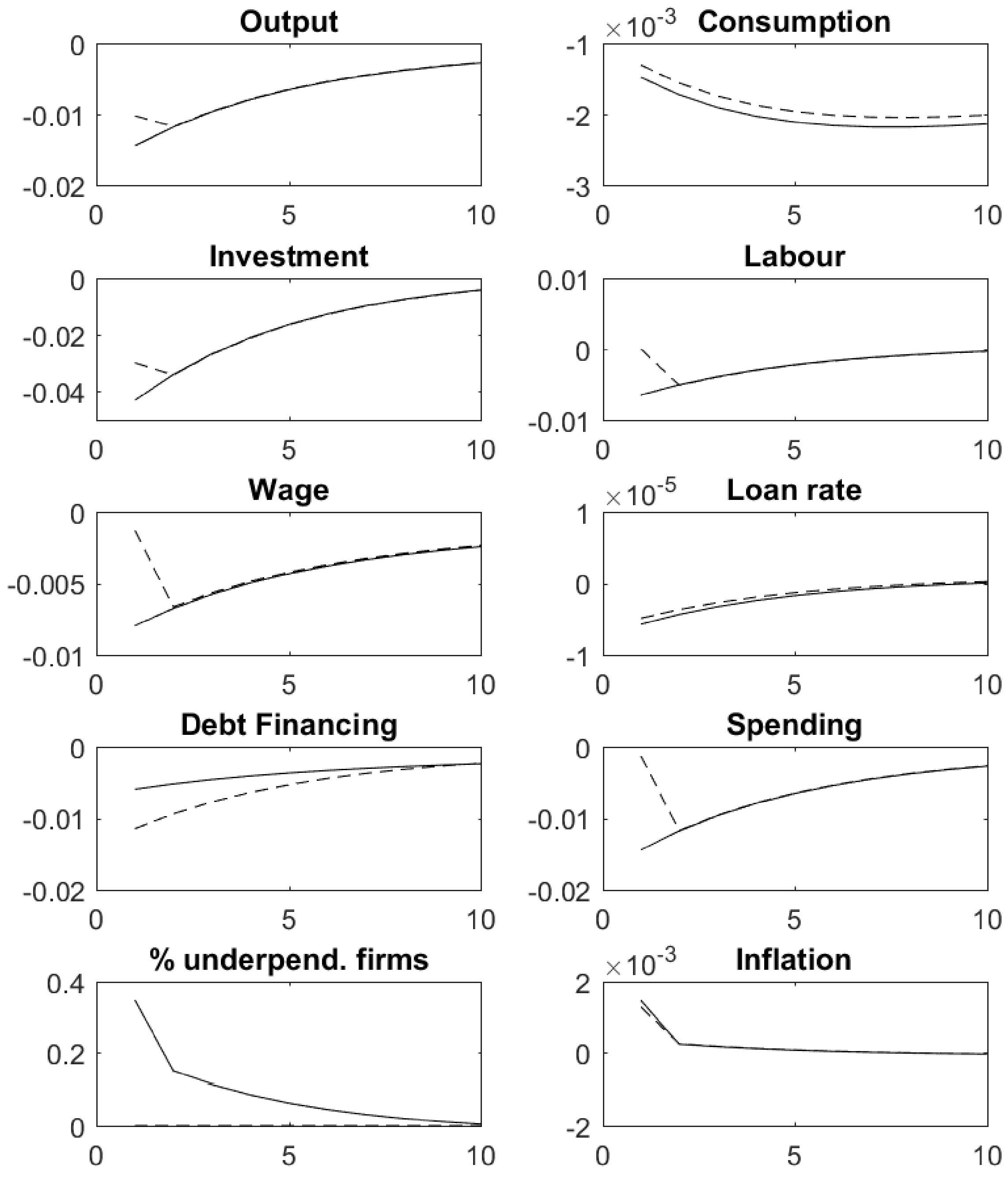

Figure 11: Impulse response functions following a negative 1× standard deviation shock to aggregate log TFP (u_t^a) assuming a high preferences discount factor $\beta = 0.999$ and low steady state inflation $x^B = 0.01\%$. The main model is compared to a model where the financing constrain is always binding (Benchmark, dashed line). All variables are expressed in real terms and logarithmic form with the exception of inflation, loan rates and the % of underspending firms.

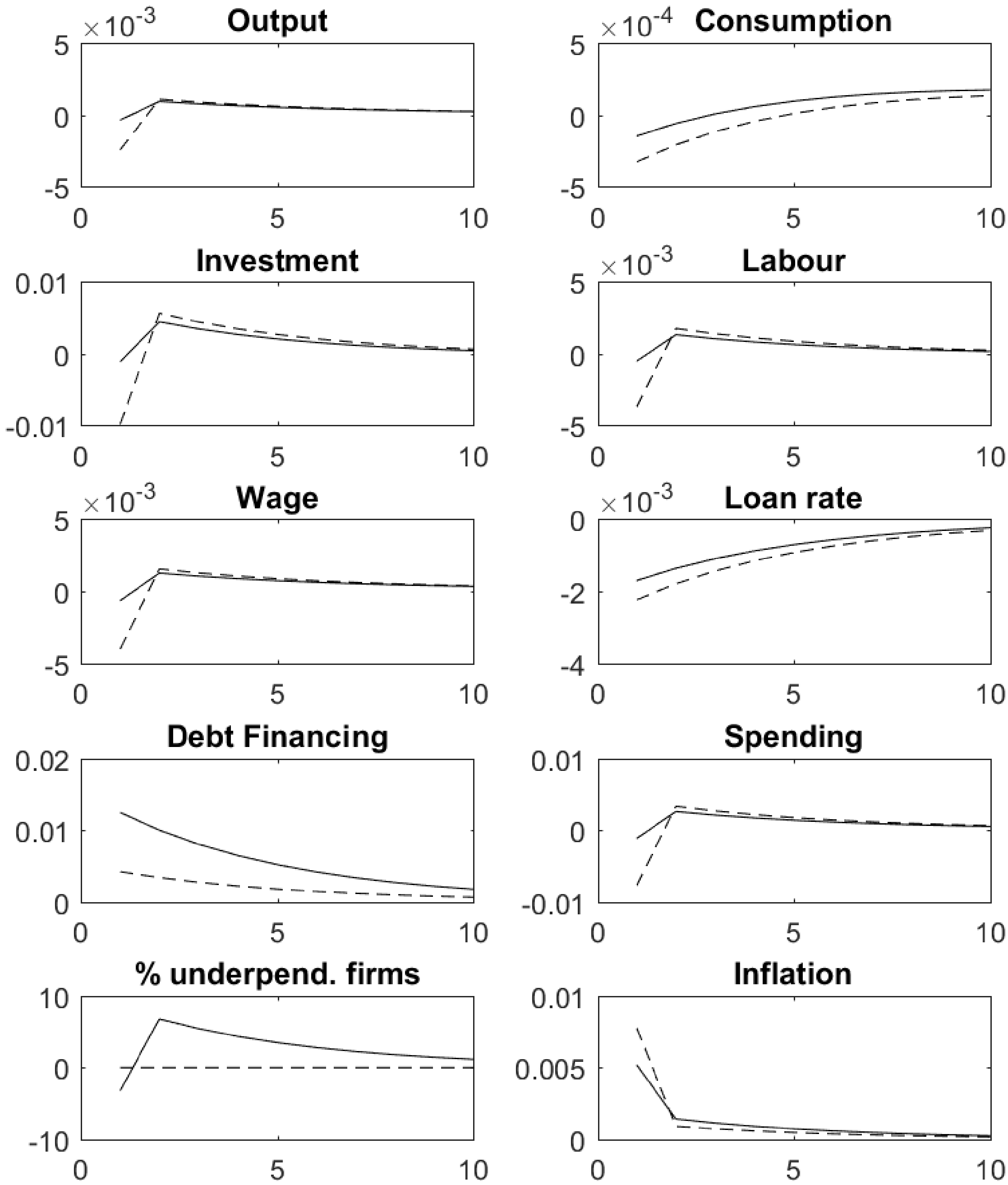

Figure 12: Impulse response functions following a positive 1× standard deviation shock to money supply (x_t^B). The main model is compared to a model where the financing constrain is always binding (Benchmark, dashed line). All variables are expressed in real terms and logarithmic form with the exception of inflation, loan rates and the % of underspending firms.

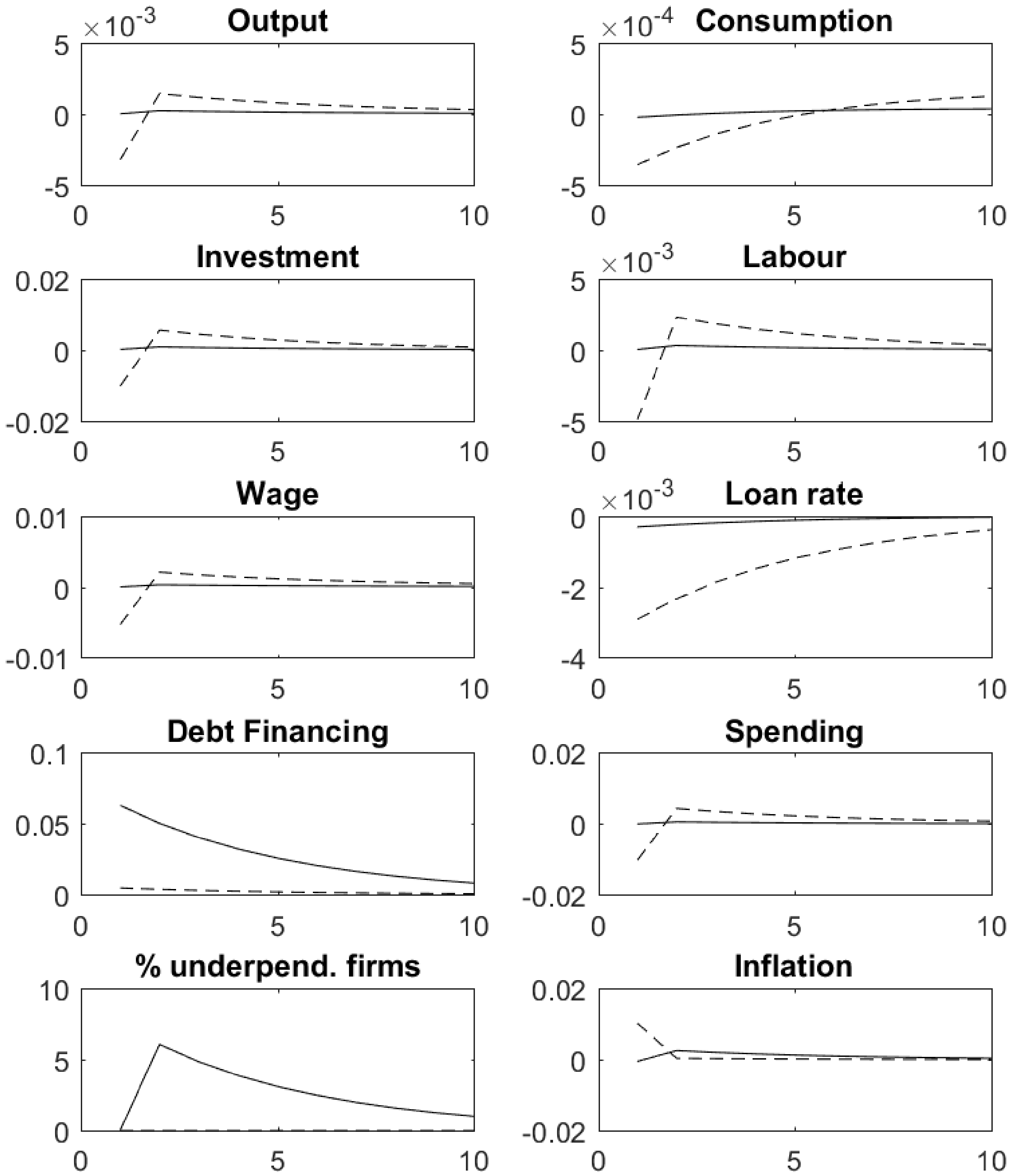

Figure 13: Impulse response functions following a positive 1× standard deviation shock to money supply (x_t^B) assuming a high preferences discount factor $\beta = 0.998$. The main model is compared to a model where the financing constrain is always binding (Benchmark, dashed line). All variables are expressed in real terms and logarithmic form with the exception of inflation, loan rates and the % of underspending firms.

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A Technical appendix

A.1 Model equations

I write the model equations assuming the distribution of ϵ and ϵ' in section 4.1.[26]

$$c_t + k_{t+1} - (1-\delta)k_t = y_t, \tag{A.1}$$

$$(1-\alpha)\zeta_t = w_t l_t, \tag{A.2}$$

$$\alpha\zeta_t = r_t^K k_{t-1}, \tag{A.3}$$

$$\mathbf{E}_t \frac{1}{(1+\pi_{t+1})y_{t+1}} = \beta r_t \mathbf{E}_t \frac{1}{(1+\pi_{t+1})(1+\pi_{t+2})y_{t+2}}, \tag{A.4}$$

$$\chi c_t = w_t l_t^\eta \tag{A.5}$$

$$\xi_{t+1} := (1-\gamma)\ln(A) - \ln(\gamma) + \ln\left(\frac{\lambda_{t+1}^\gamma f_t^{1-\gamma}}{(1+\pi_{t+1})^{1-\gamma}}\right) - u_{t+1}^a. \tag{A.6}$$

$$m_t = \frac{1+x_t^B}{1+\pi_t} m_{t-1} \tag{A.7}$$

$$r_t^F = \frac{(1+\pi_t)b_t}{(1+\pi_t)b_t + m_{t-1}x_t^B} r_t, \tag{A.8}$$

$$f_t = b_t + m_{t-1}x_t^B/(1+\pi_t), \tag{A.9}$$

$$(m_t^H)^\nu = \psi \frac{r_t}{r_t - 1} c_t, \tag{A.10}$$

$$\frac{m_{t-1}}{1+\pi_t} = m_t^H + b_t, \tag{A.11}$$

$$\zeta_{t+1} = \frac{1}{A} e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}} \left(\frac{\gamma e^{u_{t+1}^a}}{\lambda_{t+1}^\gamma}\right)^{1/(1-\gamma)} \Phi\left(\frac{\xi_{t+1}}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) + \frac{f_t}{1+\pi_{t+1}} \Phi\left(-\frac{\sigma_{\epsilon'}}{2} - \frac{\xi_{t+1}}{\sigma_{\epsilon'}}\right), \tag{A.12}$$

$$\begin{aligned} y_{t+1} = {} & \frac{1}{A} e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}} \left(\frac{\gamma^\gamma e^{u_{t+1}^a}}{\lambda_{t+1}^\gamma}\right)^{1/(1-\gamma)} \Phi\left(\frac{\xi_{t+1}}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) \\ & + \frac{1}{A^{1-\gamma}} \frac{e^{u_{t+1}^a} f_t^\gamma}{(1+\pi_{t+1})^\gamma \lambda_{t+1}^\gamma} \Phi\left(\frac{\sigma_{\epsilon'}}{2} - \frac{\xi_{t+1}}{\sigma_{\epsilon'}}\right), \end{aligned} \tag{A.13}$$

$$r_t^F = \mathbf{E}_t\left[e^{-\xi_{t+1}}\Phi\left(\frac{\sigma_{\epsilon'}}{2} - \frac{\xi_{t+1}}{\sigma_{\epsilon'}}\right) + \Phi\left(\frac{\sigma_{\epsilon'}}{2} + \frac{\xi_{t+1}}{\sigma_{\epsilon'}}\right)\right]. \tag{A.14}$$

[26] To derive the model equations in the case of a Gaussian distribution for ϵ', I use the following result: If X is a Gaussian variable with mean μ and standard deviation σ and α and x are two constant, then $\mathbf{E}\left[e^{\alpha X}\mathbf{1}_{X<x}\right] = e^{\alpha\mu+\alpha^2\sigma^2/2}\Phi\left(\frac{x-\mu}{\sigma} - \alpha\sigma\right)$ and $\mathbf{E}\left[e^{\alpha X}\mathbf{1}_{X>x}\right] = e^{\alpha\mu+\alpha^2\sigma^2/2}\Phi\left(\alpha\sigma - \frac{x-\mu}{\sigma}\right)$.

A.2 Steady state equilibrium

The steady state (SS) variables are noted without the time subscript. The SS inflation is given by

$$\pi = x^B. \tag{A.15}$$

The SS gross deposit rate r and net capital rental rate are derived from the saving Euler equation

$$r = \frac{1}{\beta}(1+\pi). \tag{A.16}$$

$$r^K = \frac{1}{\beta} - 1 - \delta. \tag{A.17}$$

I will express the remaining SS variables as a function of the critical final productivity shock below which the firm underspends ξ. Then, I will provide a way to solve for ξ so that all SS variables are determined.

First note that the cost of financing facing the firms in the steady state can be expressed as a function of ξ using the financing equation A.14.

$$r^F = e^{-\xi}\Phi\left(\frac{\sigma_{\epsilon'}}{2} - \frac{\xi}{\sigma_{\epsilon'}}\right) + \Phi\left(\frac{\sigma_{\epsilon'}}{2} + \frac{\xi}{\sigma_{\epsilon'}}\right). \tag{A.18}$$

Now note that, from the aggregation equations for output and spending, the quantities $\lambda^{\frac{\gamma}{1-\gamma}} y$ and $\lambda^{\frac{\gamma}{1-\gamma}}\zeta$ can be expressed as a function of ξ and the model parameters

$$\lambda^{\frac{\gamma}{1-\gamma}}\zeta = \frac{\gamma^{\frac{1}{1-\gamma}}}{A}\left[e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}}\Phi\left(\frac{\xi}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) + e^{\frac{\xi}{1-\gamma}}\Phi\left(-\frac{\sigma_{\epsilon'}}{2} - \frac{\xi}{\sigma_{\epsilon'}}\right)\right], \tag{A.19}$$

$$\lambda^{\frac{\gamma}{1-\gamma}} y = \frac{\gamma^{\frac{\gamma}{1-\gamma}}}{A}\left[e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}}\Phi\left(\frac{\xi}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) + e^{\frac{\gamma\xi}{1-\gamma}}\Phi\left(\frac{\sigma_{\epsilon'}}{2} - \frac{\xi}{\sigma_{\epsilon'}}\right)\right]. \tag{A.20}$$

Given A.19 and A.20, I obtain the ratio y/ζ as a function of the variable ξ and the model's parameters

$$\frac{y}{\zeta} = \gamma\frac{e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}}\Phi\left(\frac{\xi}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) + e^{\frac{\gamma\xi}{1-\gamma}}\Phi\left(\frac{\sigma_{\epsilon'}}{2} - \frac{\xi}{\sigma_{\epsilon'}}\right)}{e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}}\Phi\left(\frac{\xi}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) + e^{\frac{\xi}{1-\gamma}}\Phi\left(-\frac{\sigma_{\epsilon'}}{2} - \frac{\xi}{\sigma_{\epsilon'}}\right)} \tag{A.21}$$

I combine the labour provision equation 3.6 with the good clearing identity ($c + \delta k = y$) and the capital first order condition ($r^K k = \alpha\zeta$) to determine steady state labour as a function of ζ and the model's parameters

$$l^{-1-\eta} = \frac{\chi}{1-\alpha}\left(\frac{y}{\zeta} - \frac{\alpha\delta}{r^K}\right). \tag{A.22}$$

This, combined with the firm's labour first order condition ($w = (1-\alpha)\zeta/l$), determines the SS production cost λ as a function of ξ, ζ and the model's parameters

$$\lambda = \left(\frac{r^K}{\alpha}\right)^{\alpha} \left(\frac{\zeta}{l}\right)^{1-\alpha}. \tag{A.23}$$

Combine A.23 with A.19 to get ζ as a function of ξ and the model's parameters

$$\zeta^{\frac{1-\alpha\gamma}{1-\gamma}} = \frac{\gamma^{\frac{1}{1-\gamma}}}{A} \left(\frac{\alpha}{r^K}\right)^{\frac{\alpha\gamma}{1-\gamma}} l^{\frac{(1-\alpha)\gamma}{1-\gamma}} \left[e^{\frac{\gamma\sigma_{\epsilon'}^2}{2(1-\gamma)^2}} \Phi\left(\frac{\xi}{\sigma_{\epsilon'}} - \frac{1+\gamma}{2(1-\gamma)}\sigma_{\epsilon'}\right) + e^{\frac{\xi}{1-\gamma}} \Phi\left(-\frac{\sigma_{\epsilon'}}{2} - \frac{\xi}{\sigma_{\epsilon'}}\right)\right]. \tag{A.24}$$

The later result yields the SS production cost λ, the SS output y, the SS wage $w = (1-\alpha)\zeta/l$, the SS capital $k = \alpha\zeta/r^K$, the SS consumption $c = y - \delta\alpha\zeta/r^K$ and the SS real money $(m^H)^{\nu} = \psi\frac{r}{r-1}c$ as a function of ξ and the model's parameters. The aggregate debt is deduced as a function of wages and ξ using A.6

$$f = \frac{1}{A}(1+\pi)\left(\frac{\gamma e^{\xi}}{w^{\gamma}}\right)^{\frac{1}{1-\gamma}}. \tag{A.25}$$

The SS individual financing firms debt levels are then expressed using 3.46 and the SS real money is derived from the money demand condition A.10. The SS real saving is deduced by combining the money clearing equation A.11 with equation A.9

$$b = \frac{f - x^B m^H}{1 + x^B}, \tag{A.26}$$

and the total stock of real money is $m = (1+x^B)(m^H + b)$.

After expressing all the SS variable of the model as a function of ξ and the model parameters, I solve for ξ using the bank zero profit condition

$$b = \frac{r^F}{r} f. \tag{A.27}$$

For the model's parameters I consider here, I verify numerically that the latter equation has a unique solution. Once, the SS variable ξ is known, the remaining steady state variables are determined in a straightforward manner.

B Empirical appendix

B.1 Data and derived variables

These variables are reported directly by the data: assets' value, cash and cash equivalent, net income, CAPEX spending, R&D spending and the number of employees. Other variables are derived as follows.

Market Capitalisation = "Common Shares Outstanding" × "Price Close - Annual - Calendar";

Debt = "Debt in Current Liabilities - Total" + "Long-Term Debt - Total";

Market to Book = "Market Capitalisation" / "Assets - Total";

Value Added = "Operating Income Before Depreciation" + "Employees" x "Average Wage from the Social Security Administration";

Share Buybacks = 1 year change in "Treasury Stock - Common", if the above is negative or missing use: "Purchase of Common and Preferred Stock" minus "Sale of Common and Preferred Stock". If both figures are negative or missing, Share Buybacks are set to zero for the corresponding period.

Except for the assets value, all the variables are scaled either using the percentile form of the variable or through division by the previous time period's assets or the previous market capitalisation. All the variables but those in percentile form are 1% Winsorised to deal with outlier values. These data transformations are summarised in table 4.

B.2 Descriptive Statistics

I present the summary statistics of the indicators used to construct the regressions variable in table 5, the summary statistics of the transformed variables are in table 6. The correlation matrix of the variables as used in the regressions are in table 7.

B.3 More Empirical Results

Further empirical results are presented in this subsection. I present the logit regression results for the marginal effects of each of the growth indicators while excluding other

	Divided by prev. assets	Percentile	Divided by prev. market cap.	Winsorised (1%)
Assets				✓
Cash Dist.			✓	✓
Dividends			✓	✓
Share Buybacks			✓	✓
Productivity	✓			✓
Market to Book				✓
Market Cap.		✓		
Cash	✓			✓
Net Income	✓			✓
Debt	✓			✓
CAPEX	✓			✓
R&D	✓			✓
Employees	✓			✓

Table 4: Summary of transformation applied to the models' variables.

	mean	sd	min	p1	p25	p50	p75	p99	max
Cash Dist.	73.89	601.32	0.00	0.00	0.00	0.00	5.14	1503.00	67643.80
Dividends	47.02	389.75	0.00	0.00	0.00	0.00	2.04	982.00	67643.80
Shares Buy.	23.64	313.91	0.00	0.00	0.00	0.00	0.00	461.59	34420.00
TFP	1.21	2.23	0.00	0.13	0.82	1.03	1.28	4.21	283.51
Market Cap.	2256.37	13201.11	0.00	0.67	21.74	107.18	619.62	43294.66	1819781.88
CAPEX	148.67	977.18	-401.61	0.00	0.77	5.20	34.44	2760.00	65028.00
RD	85.50	487.32	-0.55	0.00	0.19	2.72	17.11	2015.00	14035.29
Assets	2200.24	13328.37	0.50	0.98	20.94	106.47	601.96	39042.00	797769.00
Cash	212.67	1406.27	-40.00	0.00	1.25	8.54	52.37	4007.00	91052.00
Net Income	91.63	1056.33	-98696.00	-353.71	-2.32	1.39	18.78	2285.29	125000.00
Debt	668.75	5355.19	0.00	0.00	1.67	16.85	168.75	11122.70	523762.00
Employees	9.21	37.64	0.00	0.00	0.16	0.85	4.35	144.78	2200.00

Table 5: Summary statistics of the unscaled data used to construct the dependent and independent variables used in the various regressions: all cash variables are in millions of U.S. dollars, the number of employees is in thousands, data for the 1980-2013 period.

growth indicators in figures 14 and 15. In addition, I present the complete results of the logit regressions including all growth indicators results and explaining, respectively, the propensity to return cash, to pay dividends and to buy shares back in figures 16 to 18.

	mean	sd	min	p1	p25	p50	p75	p99	max
Cash Dist.	0.02	0.04	0.00	0.00	0.00	0.00	0.02	0.24	0.24
Dividend	0.01	0.02	0.00	0.00	0.00	0.00	0.01	0.12	0.12
Share Buy.	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.17	0.17
TFP	0.02	0.04	0.00	0.00	0.00	0.00	0.01	0.23	0.23
Market/Book	1.78	2.75	0.05	0.05	0.45	0.90	1.84	17.17	17.17
CAPEX	0.09	0.13	0.00	0.00	0.02	0.05	0.10	0.76	0.76
RD	0.08	0.13	0.00	0.00	0.00	0.03	0.11	0.72	0.72
Mkt. Cap. %	39.70	22.70	1.00	1.00	20.00	40.00	59.00	80.00	85.00
Assets	1513.10	4736.80	0.67	0.98	20.94	106.47	601.96	31001.40	31001.40
Cash	0.19	0.31	0.00	0.00	0.02	0.08	0.22	1.81	1.81
Net Income	-0.04	0.28	-1.50	-1.50	-0.06	0.03	0.08	0.43	0.43
Debt	0.29	0.26	0.00	0.00	0.08	0.24	0.41	1.37	1.37
Employees	0.01	0.02	0.00	0.00	0.00	0.01	0.02	0.10	0.19

Table 6: Summary statistics of the scaled variables used in the regression models, data for the 1980-2013 period.

	Cash Dist.	Div.	Shares Buy.	TFP	Mkt/Book	CAPEX	R&D	Mkt Cap.	Assets	Cash	Net Inc.	Debt	Empl.
Cash Dist.	1.00	0.65	0.75	-0.13	-0.15	-0.07	-0.18	0.15	0.13	-0.12	0.13	-0.00	-0.03
Div.	0.65	1.00	0.05	-0.16	-0.14	-0.05	-0.21	0.24	0.19	-0.15	0.15	0.01	-0.02
Shares Buy.	0.75	0.05	1.00	-0.06	-0.10	-0.07	-0.10	0.05	0.05	-0.06	0.07	-0.02	-0.02
TFP	-0.13	-0.16	-0.06	1.00	0.24	0.09	0.17	-0.47	-0.17	0.20	0.07	-0.01	0.24
Mkt/Book	-0.15	-0.14	-0.10	0.24	1.00	0.25	0.50	0.15	-0.07	0.63	-0.21	-0.06	0.10
CAPEX	-0.07	-0.05	-0.07	0.09	0.25	1.00	0.09	0.08	-0.04	0.13	-0.01	0.26	0.17
R&D	-0.18	-0.21	-0.10	0.17	0.50	0.09	1.00	-0.08	-0.12	0.58	-0.50	-0.16	-0.08
Mkt. Cap.	0.15	0.24	0.05	-0.47	0.15	0.08	-0.08	1.00	0.46	0.02	0.27	0.02	-0.12
Assets	0.13	0.19	0.05	-0.17	-0.07	-0.04	-0.12	0.46	1.00	-0.09	0.10	0.03	-0.15
Cash	-0.12	-0.15	-0.06	0.20	0.63	0.13	0.58	0.02	-0.09	1.00	-0.24	-0.14	0.04
Net Inc.	0.13	0.15	0.07	0.07	-0.21	-0.01	-0.50	0.27	0.10	-0.24	1.00	-0.02	0.06
Debt	-0.00	0.01	-0.02	-0.01	-0.06	0.26	-0.16	0.02	0.03	-0.14	-0.02	1.00	0.09
Empl.	-0.03	-0.02	-0.02	0.24	0.10	0.17	-0.08	-0.12	-0.15	0.04	0.06	0.09	1.00

Table 7: Correlation matrix of regressions' variables (1980-2013).

B.4 Tests

The studied dependent variables follow strongly persistent processes. Failing to correct for such persistence can cause serial correlation tests to fail. I present the serial correlation test in table 9. The tests show that serial correlation is either statistically insignificant or too low to seriously affect the result of the regressions.

Running dynamic panel data models for a large number of units and a small number of observations per unit comes with the issue of a biased estimate of the coefficient of the lagged dependent variables. The absence of an important serial correlation in the error terms provides an indication that there is little underestimation of the lagged variables coefficient if any. To gain more confidence around this issue, regressions are run where the number of observations per firm is unrestricted, is required to be higher than 30 ($T \geq 30$) (table 10) . The results show that, as expected by the theory, a low number of observation

	Full Model	TFP Effect	Market/Book Effect	Investment Effect
L.Dist. Cash	0.0830***	0.0939***	0.0839***	0.0938***
L2.Dist. Cash	0.00819	0.0120	0.00882	0.0105
L3.Dist. Cash	0.00273	0.00468	0.00363	0.00407
L.TFP	-0.0824**	-0.158***		
L.Market/Book	-0.00443***		-0.00470***	
L.CAPEX	-0.0138***			-0.0244***
L.MArket Cap. percentile	0.000208***	-0.0000430	0.000230***	0.0000208
L.Assets	0.000000425***	0.000000573***	0.000000413***	0.000000510***
L.Cash	0.0323***	0.0237***	0.0324***	0.0221***
L.Net Income	0.0199***	0.00491	0.0161***	0.00305
L.Debt	-0.0170***	-0.0184***	-0.0182***	-0.0163***
L.Employees	-0.218***	-0.268***	-0.234***	-0.269***
Constant	0.0328***	0.0418***	0.0310***	0.0394***
AIC	-201928.0	-201460.3	-201897.9	-201460.1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Dynamic two way fixed effect model FE model explaining the size of distributed cash, no exclusion of firms based on the number of observations.

per unit leads to underestimating the autoregressive coefficients. The differences in the lagged dependent variables estimates remain small when increasing the minimum number of observations per firm from 15 to 30.

	Cash Dist. Resid.	Div. Resid.	Shares Buy. Resid.
L.residuals	-0.0234*	-0.0189	0.0173
L2.residuals	-0.0176	-0.00106	0.0215*
L3.residuals	-0.0184	-0.00385	-0.00282
L4.residuals	-0.0150	-0.00580	-0.0132
L5.residuals	-0.0263**	-0.0153	-0.0220**
L6.residuals	-0.0201*	-0.000362	-0.00750
L7.residuals	-0.0178*	0.00615	-0.0253**
Constant	0.000251***	-0.000524***	-0.0128***
Observations	20660	20660	20738

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Autocorrelation tests (Full Models).

	Cash Dist	T $\geq$ 15	T $\geq$ 30	Div	T$\geq$ 15	T $\geq$ 30	Share Buy	$\geq$ 15	T $\geq$ 30
L.Dist. Cash	0.083***	0.17***	0.19***						
	(0.0079)	(0.010)	(0.017)						
L2.Dist. Cash	0.0082	0.044***	0.052***						
	(0.0068)	(0.0080)	(0.013)						
L3.Dist. Cash	0.0027	0.042***	0.059***						
	(0.0071)	(0.0083)	(0.015)						
L.Dividends				0.37***	0.47***	0.47***			
				(0.013)	(0.017)	(0.033)			
L2.Dividends				0.066***	0.089***	0.13***			
				(0.011)	(0.014)	(0.027)			
L3.Dividends				0.027**	0.046***	0.062**			
				(0.0085)	(0.010)	(0.021)			
L.Share Buybacks							0.028**	0.12***	0.10***
							(0.010)	(0.014)	(0.023)
L2.Share Buybacks							-0.032***	-0.0024	0.016
							(0.0098)	(0.013)	(0.020)
L3.Share Buybacks							-0.023*	0.026	0.018
							(0.011)	(0.014)	(0.019)
Observations	53104	25298	8971	39786	23474	8902	29393	12282	4474

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Lagged dependent variables tests. The lagged variables coefficients from the model including all firms are shown next to estimates of the same coefficients from a models excluding firms with less than 15 observations and 30 observations respectively.

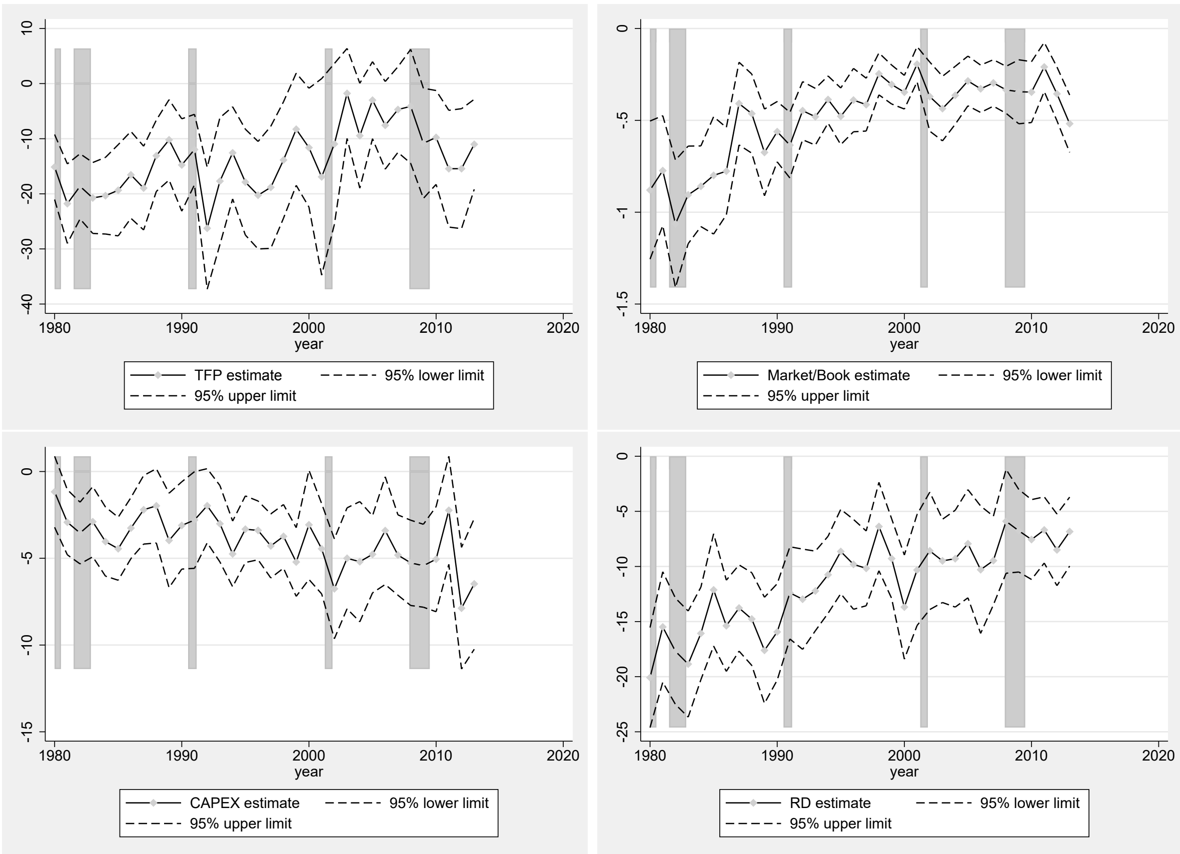

Figure 14: Repeated logit cross-section regressions estimates with 95% confidence boundaries corresponding to the effects of TFP, Market/Book and investment variables (CAPEX and R&D) on the firm's propensity to pay shareholders through **dividends**. The logit regressions are repeated for every year from 1980 to 2013. The TFP marginal effect is estimated without controlling for Market/Book, CAPEX and R&D, The Market/Book marginal effect is estimated without controlling for TFP, CAPEX and R&D and the CAPEX and R&D effects are estimated in the same repeated regressions that exclude both TFP and Market/Book. Controls common to all regressions include: market capitalisation, assets, cash, net income, debt and the number of employees. Grey areas indicate NBER recession periods.

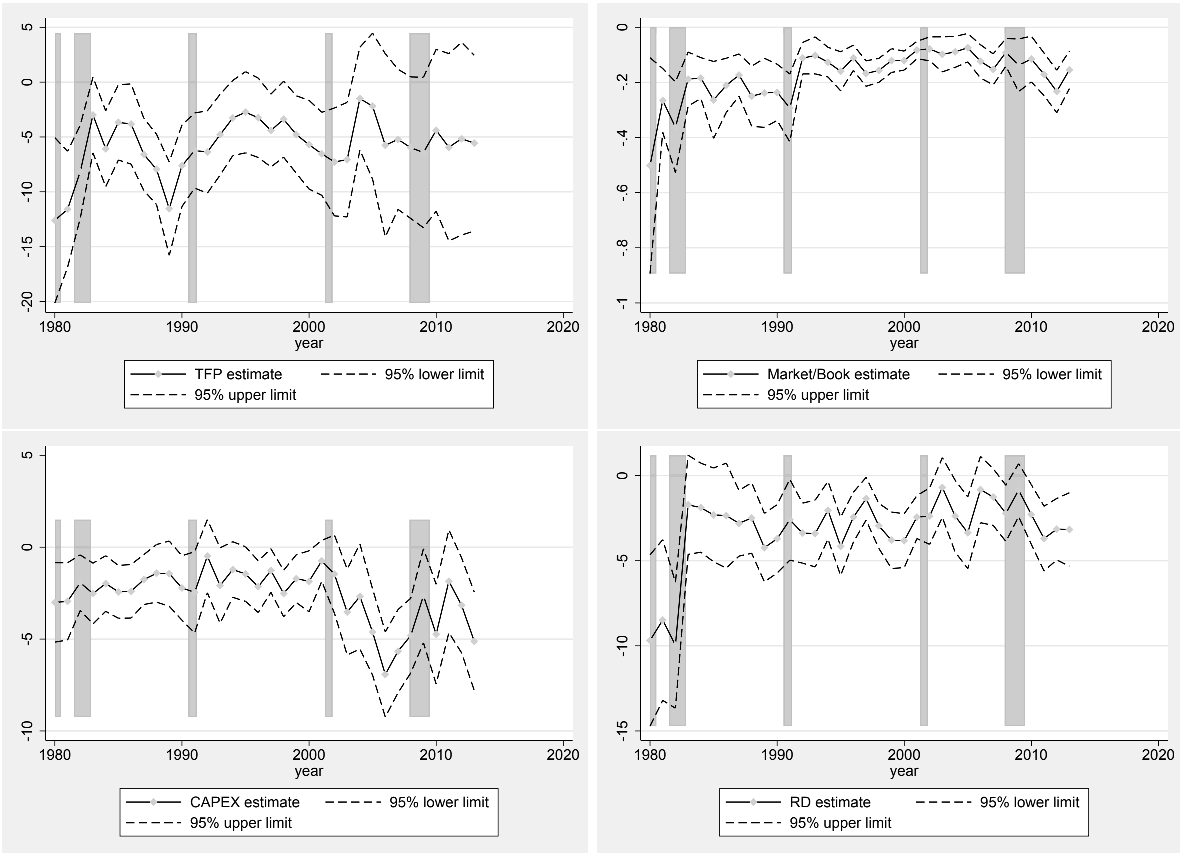

Figure 15: Repeated logit cross-section regressions estimates with 95% confidence boundaries corresponding to the effects of TFP, Market/Book and investment variables (CAPEX and R&D) on the firm's propensity to pay shareholders through **share buybacks**. The logit regressions are repeated for every year from 1980 to 2013. The TFP marginal effect is estimated without controlling for Market/Book, CAPEX and R&D, The Market/Book marginal effect is estimated without controlling for TFP, CAPEX and R&D and the CAPEX and R&D effects are estimated in the same repeated regressions that exclude both TFP and Market/Book. Controls common to all regressions include: market capitalisation, assets, cash, net income, debt and the number of employees. Grey areas indicate NBER recession periods.

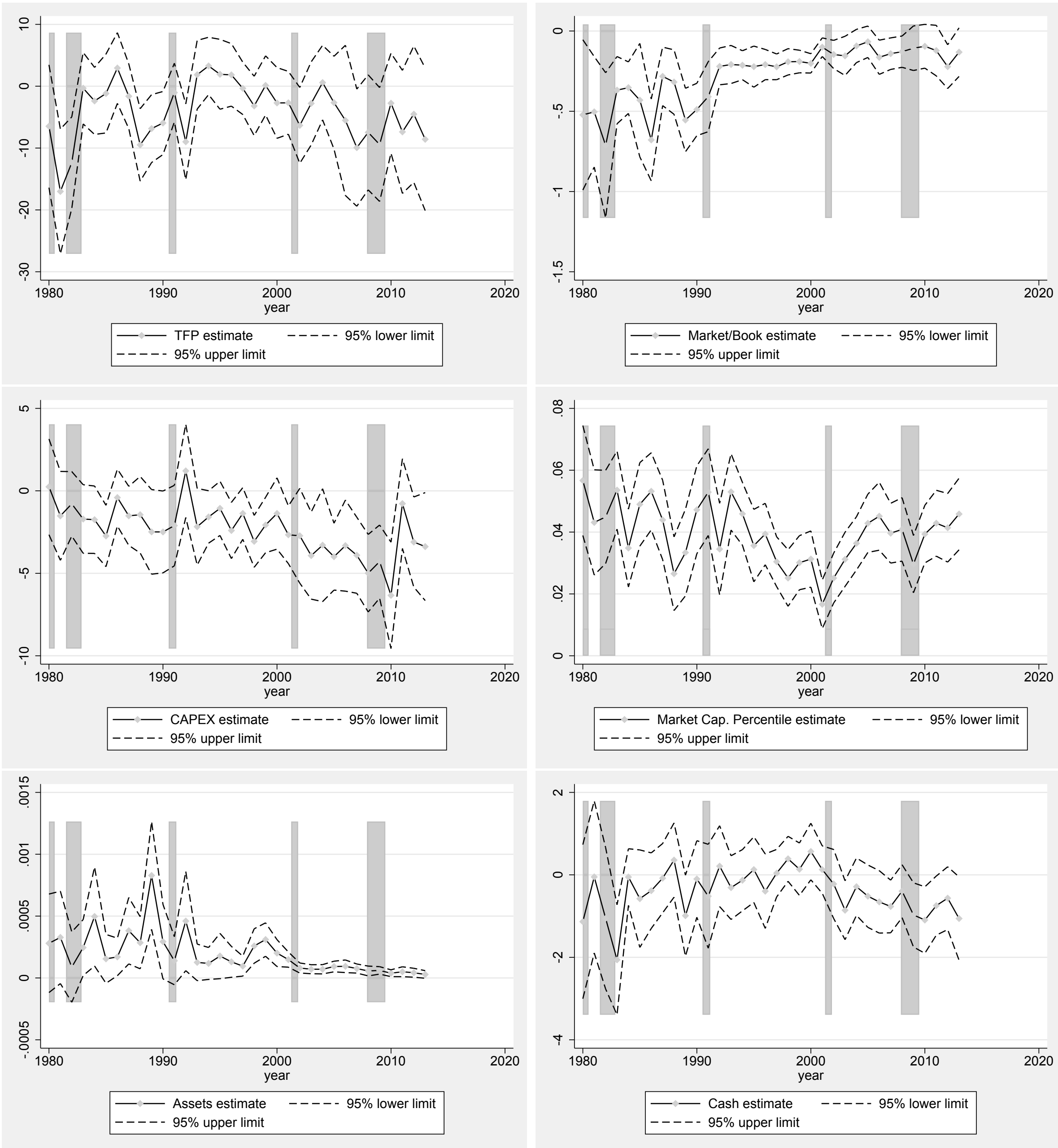

Figure 16: Repeated logit cross-section regressions estimates with 95% confidence boundaries for the full model explaining the **distributed cash** (continued below).

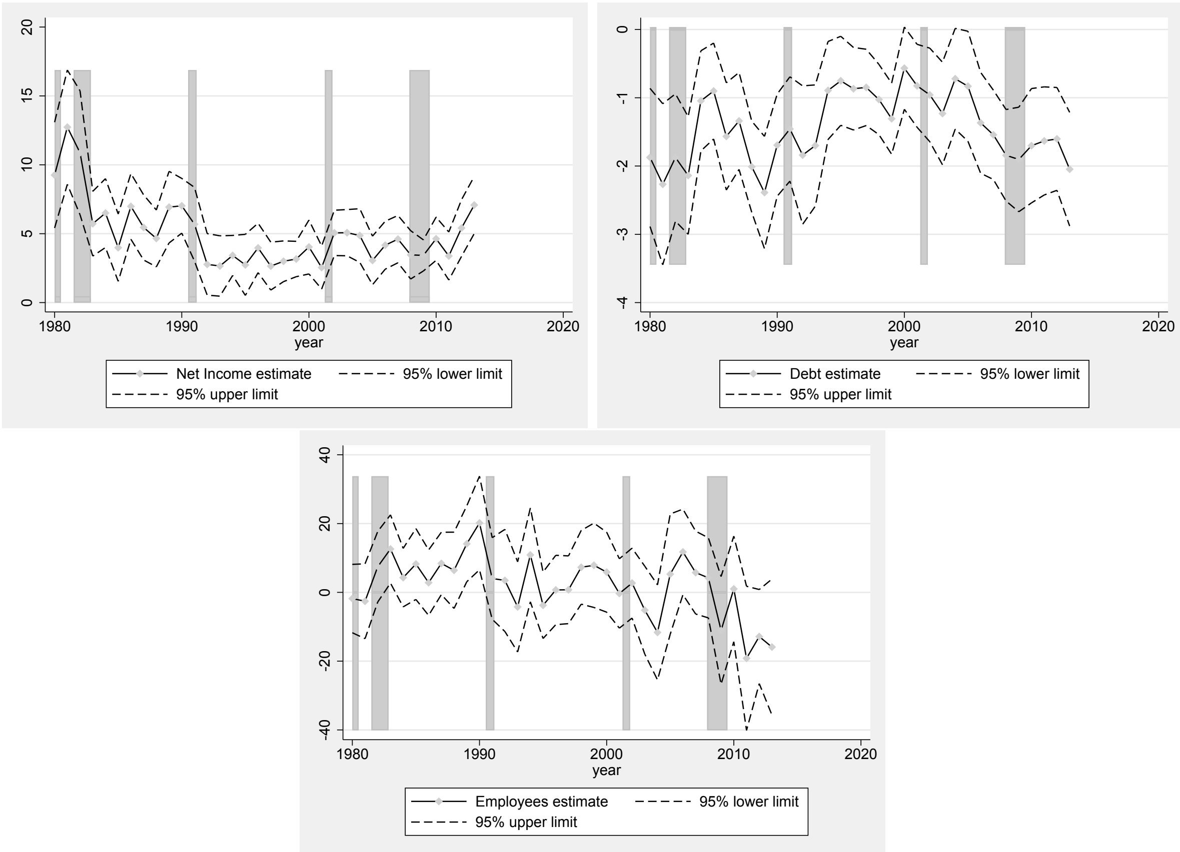

Figure 16: Repeated logit cross-section regressions estimates with 95% confidence boundaries for the full model explaining the **distributed cash**.

	Full Model	TFP Effect	Market/Book Effect	Investment Effect
L.Dividends	0.467***	0.476***	0.468***	0.477***
L2.Dividends	0.0888***	0.0889***	0.0882***	0.0892***
L3.Dividends	0.0460***	0.0464***	0.0456***	0.0469***
L.TFP	-0.0272	-0.0421		
L.Market/Book	-0.00129***		-0.00127***	
L.CAPEX	0.00334			0.000873
L.Market Cap. percentile	0.000115***	0.0000685**	0.000121***	0.0000769***
L.Assets	8.34e-08***	0.000000101***	7.69e-08**	9.52e-08***
L.Cash	0.00437**	0.00335*	0.00417**	0.00331*
L.Net Income	0.00501	-0.00102	0.00504	-0.00204
L.Debt	-0.00129	-0.00103	-0.00108	-0.00111
L.Employees	-0.0396*	-0.0482**	-0.0381*	-0.0490**
Constant	0.00388*	0.00562***	0.00365*	0.00501**
AIC	-144153.6	-144041.2	-144151.5	-144036.0

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: Dynamic two way fixed effect model FE model explaining the size of **dividends**.

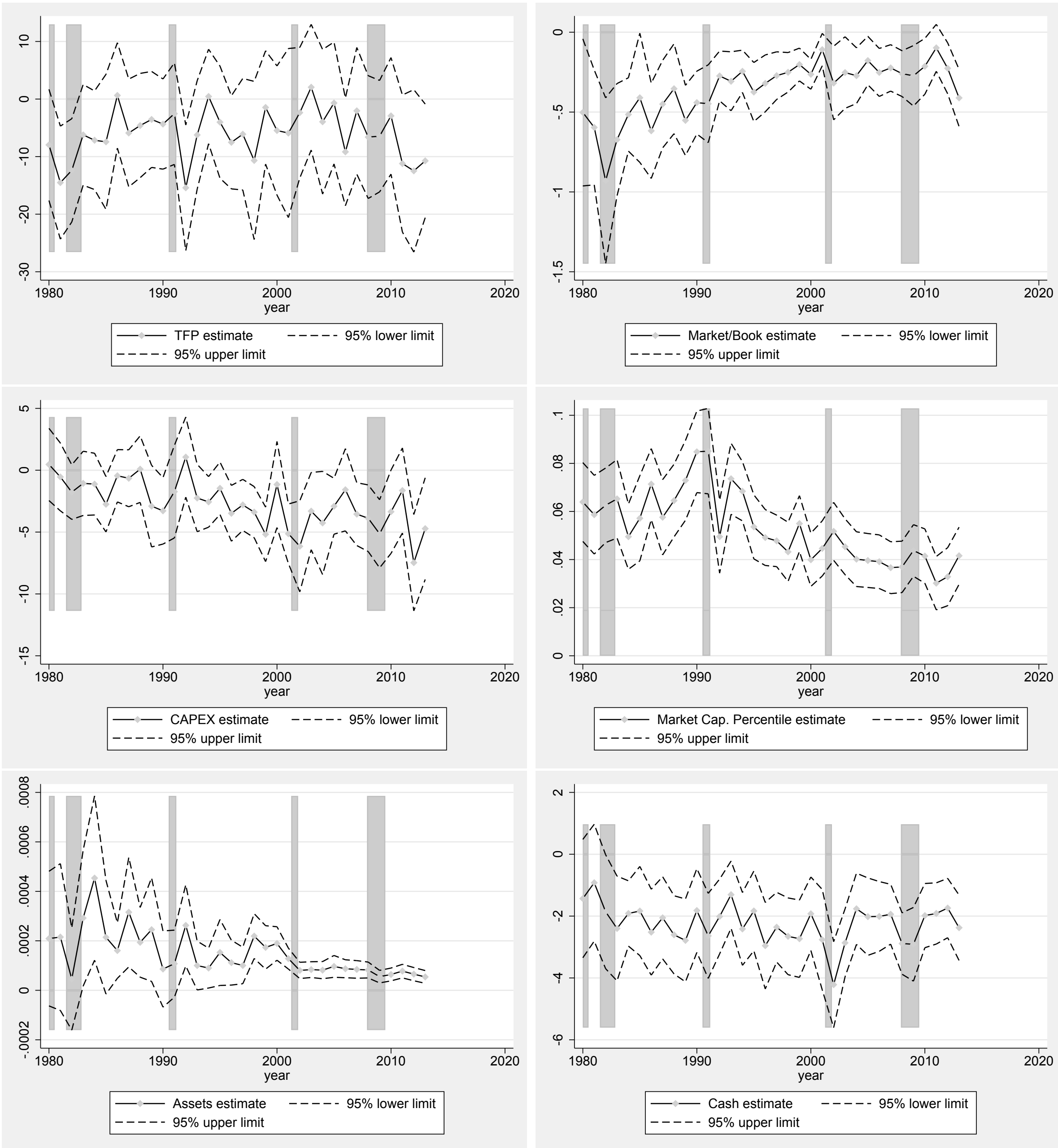

Figure 17: Repeated logit cross-section regressions estimates with 95% confidence boundaries for the full model explaining the propensity to pay **dividends** (continued below).

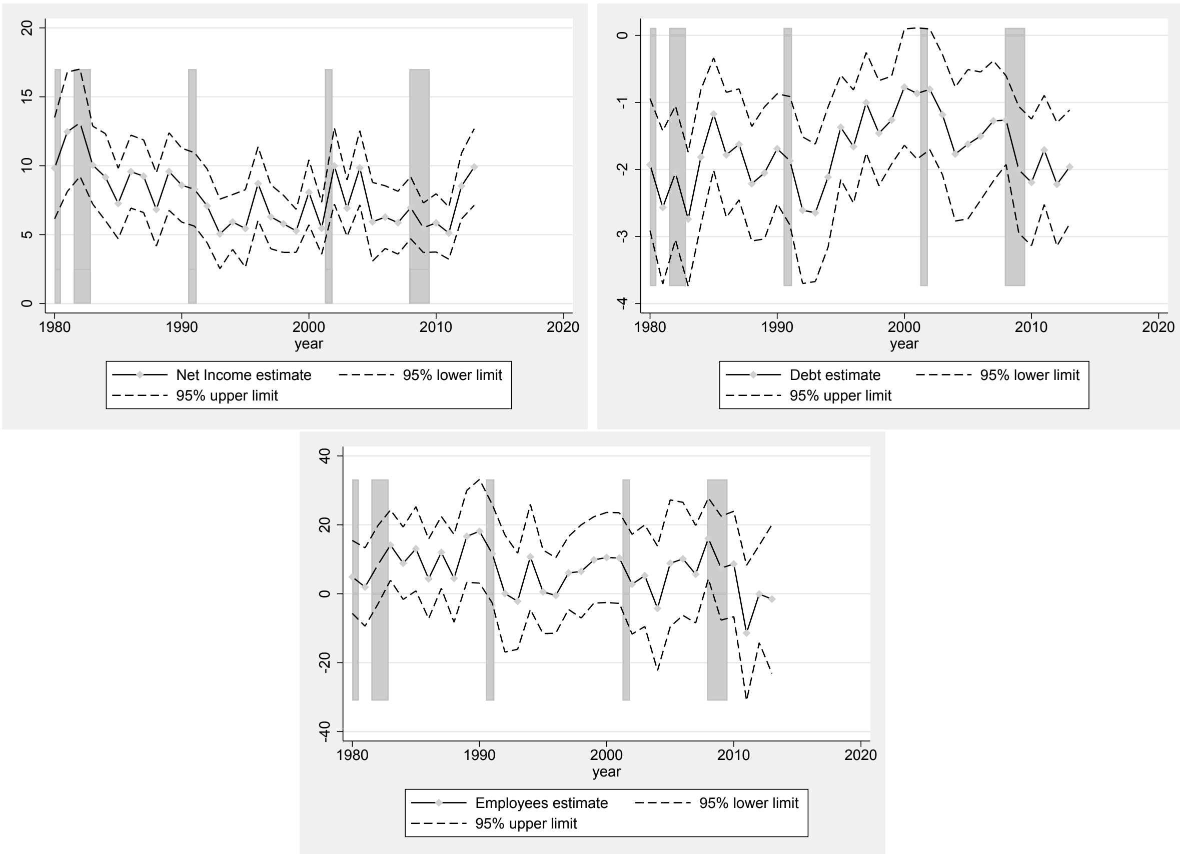

Figure 17: Repeated logit cross-section regressions estimates with 95% confidence boundaries for the full model explaining the propensity to pay **dividends**.

	Full Model	TFP Effect	Market/Book Effect	Investment Effect
L.Shares Buybacks	0.116***	0.129***	0.117***	0.127***
L2.Shares Buybacks	-0.00244	0.000751	-0.00152	-0.000444
L3.Shares Buybacks	0.0258	0.0291*	0.0269*	0.0275*
L.TFP	0.0657	-0.0198		
L.Market/Book	-0.00346***		-0.00358***	
L.CAPEX	-0.0226**			-0.0297***
L.Market Cap. percentile	0.000110	-0.0000460	0.0000927	-0.0000310
L.Assets	0.000000254**	0.000000376***	0.000000276**	0.000000352***
L.Cash	0.0301***	0.0257***	0.0310***	0.0251***
L.Net Income	0.00510	-0.0160*	0.00344	-0.0113
L.Debt	-0.0201***	-0.0214***	-0.0216***	-0.0193***
L.Employees	-0.272***	-0.317***	-0.288***	-0.298***
Constant	0.0273***	0.0327***	0.0275***	0.0331***
AIC	-49301.8	-49219.3	-49295.4	-49236.4

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: Dynamic two way fixed effect model FE model explaining the size of **share buybacks**.

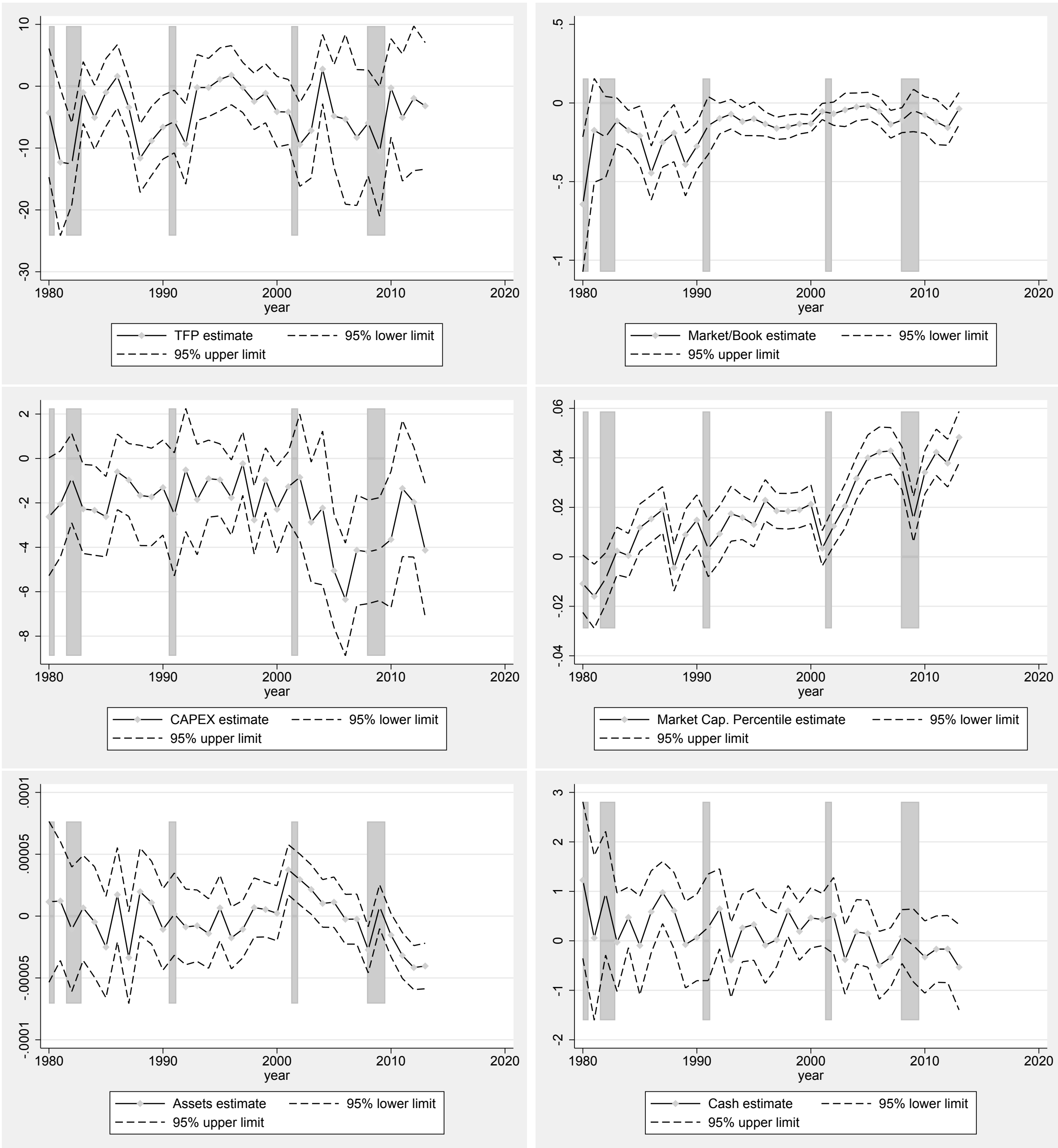

Figure 18: Repeated logit cross-section regressions estimates with 95% confidence boundaries for the full model explaining **share buybacks** (continued below).

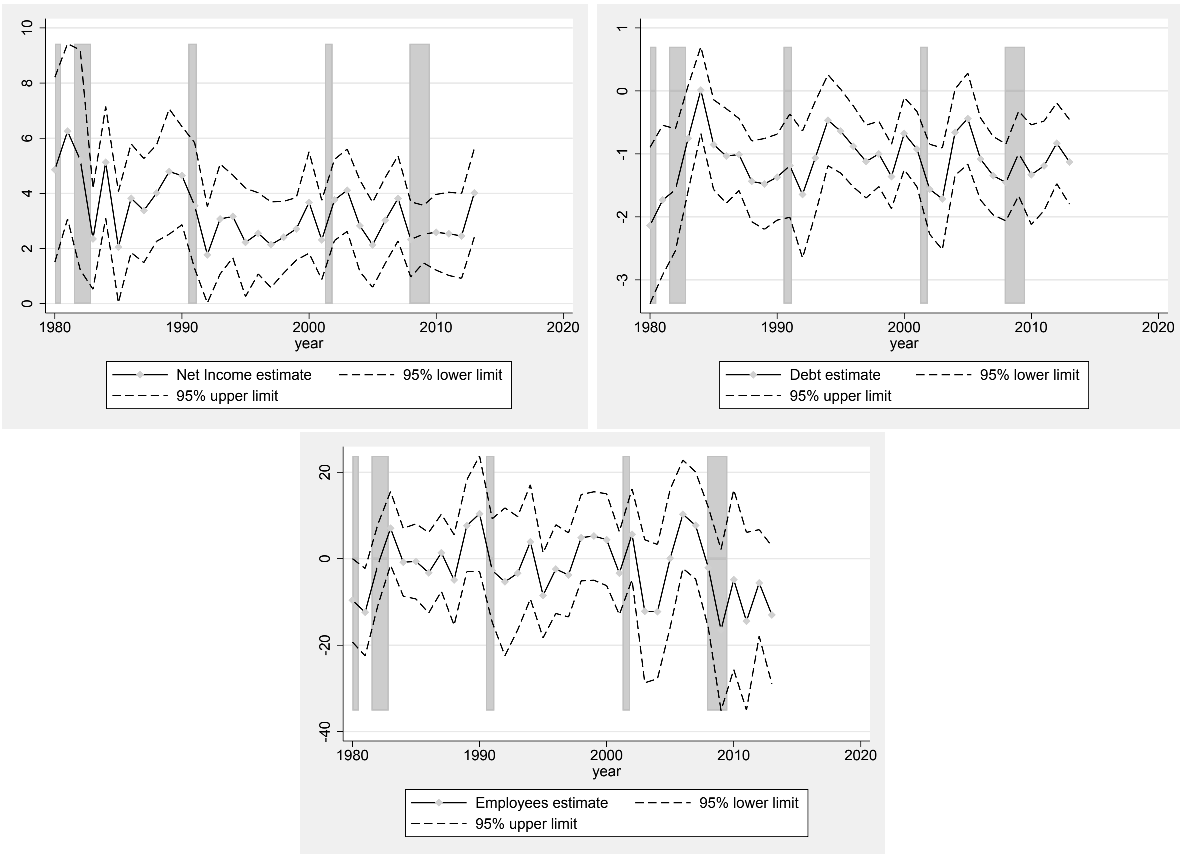

Figure 18: Repeated logit cross-section regressions estimates with 95% confidence boundaries for the full model explaining **share buybacks**.