Financial Intermediation, Investment Dynamics and Business Cycle Fluctuations

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Abstract

How important are financial friction shocks in business cycles fluctuations? To answer this question, I use micro data to quantify key features of U.S. firm financing. I then construct a dynamic equilibrium model that is consistent with these features and fit the model to business cycle data using Bayesian methods. In my micro data analysis, I find that a substantial 35% of firms' investment is funded using financial markets. The dynamic model introduces price and wage rigidities and a financial intermediation shock into Kiyotaki and Moore (2008). According to the estimated model, this shock explains 35% of GDP and 60% of investment volatility. The estimation assigns such a large role to the financial shock for two reasons: (i) the shock is closely related to the interest rate spread, and this spread is strongly countercyclical and (ii) according to the model, the response in consumption, investment, employment and asset prices to financial shocks resembles the behavior of these variables over the business cycle.

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Is the financial sector an important source of business cycle fluctuations? My model analysis suggests that the answer is 'yes'. I find that financial sector shocks account for 35% and 60% of output and investment volatility, respectively. These are the implications of a dynamic model estimated using the past 20 years of data for the United States.

A key input into the analysis is a characterization of how important financial markets are for physical investment. To this end, I analyze the cash flow statements of all the U.S. public non-financial companies available in Compustat. I find that 35% of the capital expenditures of these firms is funded using financial markets. Of this funding, around 75% is raised by issuing debt and equity and 25% by liquidating existing assets. My analysis at quarterly frequencies suggests that the financial system is crucial in reconciling imbalances between the positive operating cash flows and capital expenditures.

Shocks to financial intermediation can promote or halt the transfer of resources to investing firms and have large effects on capital accumulation and productive activity. To quantify the effects of such shocks on the business cycle, I build a dynamic general equilibrium model with financial frictions in which entrepreneurs, like firms in the Compustat dataset, issue and trade financial claims to fund their investments. The model builds on Kiyotaki and Moore (2008), henceforth KM, and augments their theoretical set-up with price and wage rigidities, and a financial intermediation shock.

In my model, entrepreneurs are endowed with random heterogeneous technologies to accumulate physical capital. Those entrepreneurs who receive better technologies issue financial claims to increase their investment capacity. Entrepreneurs with worse investment opportunities instead prefer to buy financial claims and lend to more efficient entrepreneurs, expecting higher rates of return than those granted by their own technologies.

I introduce stylized financial intermediaries (banks) that bear a cost to transfer resources from entrepreneurs with poor capital accumulation technologies to investors with efficient capital production skills. Banks buy financial claims from investors and sell them to other entrepreneurs. In doing so, perfectly competitive banks charge an intermediation spread to cover their costs (Chari, Christiano, and Eichenbaum (1995), Goodfriend and McCallum (2007) and Cúrdia and Woodford (2010a)).[1] I assume that these intermediation costs vary exogenously over time and interpret these disturbances as financial shocks. When the intermediation costs are higher, the demand for financial assets drops and so does their price. Consequently the cost of borrowing for investing entrepreneurs rises. As a result, aggregate investment and output plunge.

I use Bayesian methods, as in Smets and Wouters (2007) and An and Schorfheide (2007) to estimate a log-linearized version of the model buffeted by a series of random disturbances, including the financial intermediation shock, on a sample of US macroeconomic time series that spans from 1989 to 2010. I include high-yield corporate bond spreads as one of the observables series to identify the financial shock (Gilchrist and Zakrajsek (2011)). I choose priors for financial parameters so that

[1] For a microfoundation of this friction based on Akerlof (1970)'s adverse selection argument, see Kurlat (2010).

the model estimation can be consistent with Compustat evidence on corporate investment financing during the same sample period. The estimation results show that approximately 35% of the variance of output and 60% of the variance of investment can be explained by financial intermediation shocks. The shock is also able to explain the dynamics of the real variables that shaped the last recession, as well as the 1991 crisis and the boom of the 2000s.

Why is the financial shock able to explain such a large fraction of business cycle dynamics? The reason for this lies in the ability of my neo-Keynesian model to generate both booms and recessions of a plausible magnitude and a positive co-movement among all of the real variables, including consumption and investment, following a financial intermediation shock. I find that nominal rigidities and in particular sticky wages (Erceg, Henderson, and Levin (2000)) are the key element in delivering this desirable feature of the model. This is not a trivial result because in a simple frictionless model, a financial intermediation shock acts as an intertemporal wedge (Chari, Kehoe, and McGrattan (2007) and Christiano and Davis (2006)) that affects investment, substituting present with future consumption.

In my model there are two classes of agents: entrepreneurs who optimize their intertemporal consumption profile by trading assets on financial markets and building capital, and workers who consume their labor income in every period. On the intertemporal margin, increased financial intermediation costs lower the real rate of return on financial assets, discourage savings and investment and induce entrepreneurs to consume more in the current period. Additionally, the shock induces a drop in aggregate demand that translates into a downward shift in the demand for labor inputs. When workers cannot re-optimize their wages freely, the decrease in labor demand translates into a large drop in the equilibrium amount of hours worked. As a result, the wage bill falls and so does workers' consumption. The drop in workers' consumption dominates over the rise in entrepreneurs' consumption and the reduction in hours amplifies the negative effect of the shock on aggregate output.

Under flexible wages, instead, aggregate consumption and investment move in opposite directions in response to a financial intermediation shock. I re-estimate the model without wage rigidities and verify that financial disturbances are in fact able to explain only 9.5% and 49% of output growth and investment growth variance at business cycle frequencies, compared to 35% and 60% in the benchmark sticky-wage case.

The estimation also allows me to quantify the role of the different structural shocks to output dynamics during the Great Recession. Running counterfactual experiments on the estimated model using the series of smoothed shocks, I find that total factor productivity has increased during the recession, as documented in Fernald (2009). The positive shocks to TFP helped reduce the drop in output by 0.5% at the deepest point of the recession and increase the speed of the recovery. Similarly, I find that positive innovations in government spending reduced the size of the recession by 1% of GDP at the trough. Public sector deficits are beneficial in the model, in the spirit of policy experiments in Kiyotaki and Moore (2008) and Guerrieri and Lorenzoni (2011): when conditions on financial markets worsen, credit constrained entrepreneurs benefit from holding an increasing stock of government bonds (i.e. liquid assets) that help them self-insure against idiosyncratic risk.

This paper is related to the literature that explores and quantifies the relations between financial imperfections and macroeconomic dynamics. A large part of the literature has focused on the ability of financial market frictions to amplify aggregate fluctuations. In this tradition Kiyotaki and Moore (1997) first analyzed the macroeconomic implications of the interaction of agency costs in credit contracts and endogenous fluctuations in the value of collateralizable assets, followed by Carlstrom and Fuerst (1997) and Bernanke, Gertler, and Gilchrist (1999) who first introduced similar frictions in dynamic general equilibrium models.

Among research that explores the role of shocks that originate on financial markets as possible drivers of cyclical fluctuations, Christiano, Motto, and Rostagno (2010) estimate a general equilibrium model of the US and Euro Area economies, in which a financial shock can hit in the form of unexpected changes in the distribution of entrepreneurial net worth and riskiness of credit contracts. They find that this 'risk' shock can account for approximately 30% of fluctuations in aggregate output. [2].

My model is close in its set-up to KM. They focus on financial market transactions and on the aggregate implications of a shock to the degree of liquidity of private assets. The liquidity shock takes the form of a drop in the fraction of assets that can be liquidated to finance new investment projects. Their model, where prices and wages are perfectly flexible, has two unappealing features.

First of all, while, the KM liquidity shock does lead to a reduction in investment, consumption instead rises on impact, and the negative effect on output is limited. As mentioned above, I find that introducing nominal rigidities and in particular sticky wages can correct this feature of the model. Jerman and Quadrini (2011) also underline the importance of labor markets in the transmission of financial shocks by calibrating and then estimating a dynamic general equilibrium model where firms issue debt and equity to finance both their investment and their working capital needs. In their set-up, a financial shock corresponds to a tightening of firms' borrowing constraints. If the adjustment of equity financing in substitution of debt is costly, reduced borrowing capacity in the model translates into weaker labor demand and generates a recession.

A second unappealing feature of KM is that the primary impact of their liquidity shock on the price of equity operates through a supply channel, under plausible calibrations of the model parameters. By restricting the supply of financial claims on the market, a negative liquidity shock results in a rise in their price. Shi (2011) extends their model and documents this finding extensively, questioning the ability of liquidity shocks to generate meaningful business cycle dynamics. To obtain

[2]Christiano, Trabandt, and Walentin (2011) confirm these findings in the estimation of a small-open economy model of the Swedish economy

a positive co-movement of asset prices and output, I instead introduce random disturbances in the financial intermediation technology.

My modeling of these financial intermediation shocks is inspired by work from Kurlat (2010) on the macroeconomic amplification effects of adverse selection in trading of heterogeneous financial securities. He shows that an adverse selection friction in a model with heterogeneous assets maps into a tax-wedge on financial transactions in a framework with homogeneous securities similar to KM. In my work, I translate this tax wedge into a financial intermediation cost in the spirit of Chari, Christiano, and Eichenbaum (1995), Goodfriend and McCallum (2007) and Cúrdia and Woodford (2010a). Moreover I assume the cost to be time-varying and subject to exogenous independent shocks over time.

Another example of a model where financial shocks originate within the financial sector is Gertler and Karadi (2011). In their model intermediaries are not subject to technology shocks but face endogenous balance sheet constraints. They use a calibrated version of the model to evaluate the effects of non-conventional monetary policies that can overcome intermediaries' lending restrictions.

To conclude, I briefly compare my analysis with that of Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010). They work with a liquidity shock modeled as in KM. An advantage of my intermediation shock is that it corresponds closely to an observed variable, namely, the interest rate spread. In addition, Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) focus is on the period of the recent financial turmoil and the associated monetary policy challenges. I study the past 20 years of data using Bayesian estimation and model evaluation methods. In relation to Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010), my analysis confirms that financial shocks were the driving force in the recent recession. However, I also find that these shocks have been important in the past 20 years.

The paper is structured so to offer an empirical description of corporate investment financing from the Compustat quarterly data in section 1. Section 2 describes the features of the model. Section 3 discusses the estimation strategy, the prior selection on the model parameters and significant moments. Section 4 presents the model estimation results and section 5 concludes.

1 Empirical Evidence on Investment Financing: the Compustat Cash-Flow Data

This section of the paper is devoted to an empirical analysis of the degree of dependence of firms' capital expenditures on financial markets. My objective is to quantify the fraction of quarterly corporate investment in physical capital that firms fund by accessing financial markets as opposed to using current operative cash flows. Here I also distinguish between the role of primary markets (debt or equity financing) and secondary markets (sales of old assets with different degrees of liquidity) as sources of funds for capital expenditures and assess their relative importance at a quarterly level.

For this purpose, I analyze cash flow data of U.S. firms. The Flow of Funds table for corporations (table F.102) reports a measure of financial dependence of the corporate sector on transfer of resources from other actors in the economy (e.g. households) defined as the Financing Gap. This variable is computed as the difference between internal funds generated by business operations in the U.S. for the aggregate of firms, US Internal Funds_t,[3] and total investment (or expenditure) on physical capital, CAPX_t :[4]

$$\text{Financing Gap}_t = \text{FG}_t = \text{US Internal Funds}_t - \text{CAPX}_t. \tag{1}$$

In a given quarter FG_t is positive when the aggregate of U.S. corporations generate cash flows from their business operations large enough to cover their capital expenditures and lend resources to the rest of the economy. On the other hand, in a quarter when FG_t is negative, the firms draw resources from the rest of the economy to finance a fraction of their capital expenditures. This aggregate measure however is not informative of the degree of dependence of single corporations on financial markets. Firms in deficit are aggregated with firms in surplus and positive values for the aggregate financing gap can coexist with corporations with large deficits at the micro-level.[5]

To avoid this aggregation problem and obtain a more accurate statistics on the degree of financial dependence of corporations, I build on work from Chari and Kehoe (2009) and rely on micro evidence from Compustat.[6] Compustat contains cash flow statement data both at annual and at quarterly frequency for the universe of publicly traded North American companies. Quarterly data are available from 1984, while a consistent break-down into their components is available since 1989.

I concentrate on the sample period that goes from 1989Q1 to 2010Q4. I focus on companies based in the U.S. excluding Canadian corporations from the analysis.[7] I focus on Compustat quarterly

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[3]U.S. internal funds in a given quarter t are computed as corporate profits net of taxes, dividend payments and capital depreciation:

$$\text{US Internal Funds}_t = \text{Profits}_t - \text{Tax}_t - \text{Dividends}_t + \text{K Depreciation}_t$$

[4]Data in the Flow of Funds tables reveal that non-financial corporate fixed investment is the largest component of gross private domestic investment in the U.S. accounting for an average of 50% of the quarterly flow along the period 1989:Q1 to 2010:Q1. Other components of gross private domestic investment are non-corporate non-residential investment (21%), residential investment (27%) and changes in inventories (2%).

[5]In Flow of Funds data from 1952 to 2010 the average share of the Financing Gap out of total capital expenditures for U.S. corporations amounts to 8%.

[6]Chari and Kehoe (2009) compute a firm-level measure of the annual financing gap for all Compustat firms as the difference between operating cash flow, CF^O_t, and capital expenditures, CAPX_t reported in each calendar year. They then sum the financing gaps over those firms that do not produce cash flows large enough to cover their investment ($\text{CF}^O_t - \text{CAPX}_t < 0$). Finally, they take the ratio of the absolute value of this sum and the total capital expenditure for all the firms and report that from 1971 to 2009, an average of 16% of total corporate investment was funded using financial markets.

[7]Capital expenditures for the aggregate of U.S. Compustat corporations account for an average of 76% of quarterly Flow of Funds U.S. corporate investment, around 50% of aggregate fixed investment and 35% of aggregate investment from 1989Q1 to 2010:Q1. Figure 1 and Table 1 in the appendix compare dynamic properties of level and growth rates of capital expenditures in Compustat, CAPX_t with those of aggregate investment, I_t and aggregate corporate capital expenditures from the Flow of Funds table, FoF CAPX_t. I find that Capital Expenditures growth in Compustat correlates well with aggregate Capital Expenditures growth from the Flow of Funds table for Corporations, despite

cash flow data to quantify the extent of short-term cash-flow imbalances of the companies that are not visible at annual frequencies. I start my analysis from the basic cash flow equality for a generic firm e, within a quarter t:

$$\Delta CASH_{e,t} = CF^{O}_{e,t} - \left(CF^{D}_{e,t} + CF^{E}_{e,t}\right) - CF^{I}_{e,t} \tag{2}$$

that states that the variation of liquid assets on the balance sheet of the firm (Δ $\mathrm{CASH}_{e,t}$) has to equal the difference between the operating cash flow generated by its business operations ($\mathrm{CF}^{O}_{e,t}$) and net cash receipts delivered to debt and equity holders ($\mathrm{CF}^{D}_{e,t}$ + $\mathrm{CF}^{E}_{e,t}$), reduced by the amount of cash used within the period to carry out net financial or physical investments ($\mathrm{CF}^{I}_{e,t}$): I redefine investment cash flow, $\mathrm{CF}^{I}_{e,t} = \mathrm{CAPX}_{e,t} + \mathrm{NFI}_{e,t}$, as the sum of capital expenditures, $\mathrm{CAPX}_{e,t}$, and net financial investment, $\mathrm{NFI}_{e,t}$. Similarly, I decompose the cash flow to equity holders, $\mathrm{CF}^{E}_{e,t} = \mathrm{DIV}_{e,t} + \mathrm{CF}^{EO}_{e,t}$, into dividends ($\mathrm{DIV}_{e,t}$) and other equity net flows ($\mathrm{CF}^{EO}_{e,t}$), so that I can construct the firm-level equivalent of the Flow of Funds definition of the financing gap in (1) as:[8]

$$FG_{e,t} = \underbrace{\left(CF^{O}_{e,t} - \mathrm{DIV_{e,t}} - CAPX_{e,t}\right)}_{\text{Financing Gap Net of Dividends}} = \underbrace{\left(CF^{D}_{e,t} + CF^{EO}_{e,t}\right)}_{\text{External Sources}} - \underbrace{\left(NFI_{e,t} + \Delta CASH_{e,t}\right)}_{\text{Portfolio Liquidations}}. \tag{3}$$

If $\mathrm{FG}_{e,t} > 0$, then firm e reports a financing surplus in period t: it is able to self-finance its investment in physical capital and its dividend pay-outs, $\mathrm{DIV}_{e,t}$, and can use the additional resources to buy back shares and/or pay back its debt obligations ($\mathrm{CF}^{EO}_{e,t}$ + $\mathrm{CF}^{D}_{e,t} > 0$). In addition, the firm could use its surplus to increase the stock of financial assets on its balance sheet and/or its cash reserves ($\mathrm{NFI}_{e,t}$ + Δ $\mathrm{CASH}_{e,t} > 0$).

If instead $\mathrm{FG}_{e,t} < 0$, the negative financing gap in period t can be funded by relying on external investors to subscribe new debt and/or equity securities ($\mathrm{CF}^{EO}_{e,t}$ + $\mathrm{CF}^{D}_{e,t} < 0$), by liquidating assets ($\mathrm{NFI}_{e,t} < 0$) and/or depleting deposits and cash-reserves ($\Delta\mathrm{CASH}_{e,t} < 0$).

In each quarter, I compute $\mathrm{FG}_{e,t}$ for all firms in the dataset and identify those that show a negative financing gap. I then add the absolute value of these deficits across the firms, to find a measure of the total financing gap in each quarter t for the aggregate of Compustat firms:

$$FG^{TOT}_{t} = \sum\nolimits_{e} |FG_{e,t}|\, \mathbf{1}\left\{FG_{e,t} < 0\right\}. \tag{4}$$

I also recognize that a fraction of firms that report a negative financing gap do so because they occasionally post negative quarterly operating cash flows: firms that report $\mathrm{CF}^{O}_{e,t} < 0$ access financial intermediaries and markets in general to fund part of their operating expenses (i.e. their working

showing a more pronounced volatility.

[8]Subtracting dividends from the operating cash flows allows me to be consistent with the definition of financing gap from the Flow of Funds tables in 1. Moreover evidence from the corporate finance literature points out that firms treat dividends as a form of committed remuneration to their shareholders and as such not at their complete disposal (Lintner (1956), Fama and Babiak (1968), Leary and Michaely (2011)).

capital needs). Despite the relevance that working capital financing may have in conditioning production decisions and in driving the demand for financial intermediation of firms, I choose to abstract from it and to concentrate on financial dependence that arises in connection to the accumulation of physical capital only. Consequently, I subtract the absolute value of aggregate negative cash-flows reported in every period, WK_t, from the total financing gap in (4) and define the quarterly Financing Gap Share, FGS_t, as the ratio of the financing gap related to physical investment and the total capital expenditure across all firms:

$$FGS_t = \frac{FG_t^{TOT} - |WK_t|}{CAPX_t} = \frac{FG_t^{TOT} - \sum_e \left|CF_{e,t}^O\right| \mathbf{1}\left\{FG_{e,t} < 0,\ CF_{e,t}^O < 0\right\}}{\sum_e CAPX_{e,t}} \tag{5}$$

Table 2 in the appendix shows that from 1989Q1 and 2010Q1, the average of the financing gap share, FGS_t, amounts to 35.45% of total investment, with a standard deviation of 4.74%:[9]

$$\overline{FGS} = \sum\nolimits_t \frac{FGS_t}{T} = 35.45\%$$

The share of capital expenditures that relies on funding from either primary or secondary markets is substantial. Persistent shocks to the operating conditions on financial markets can disrupt the accumulation of aggregate capital and potentially affect the dynamics of output growth and be a source of business cycle fluctuations.

Figure 3 shows the evolution of the seasonally adjusted Financing Gap Share defined in (5) (black solid line in panel A) and its trend (black solid line in panel B) along the sample period 1989Q1 and 2010Q1.[10]

Panel B shows that reliance of capital expenditures on financial markets features increasing trends along the two economic expansions of the 1990s and in the 2000s. Moreover all three recessions start with a sudden drop in the Financing Gap Share and loosely mark the beginning of prolonged periods of decline in the variable that last well into the initial phase of following economic expansion. The right-hand side of equation 3 suggests how corporations fund their Financing Gap. I use data in

[9] In the same table I report what fraction of the total financing gap defined in (4) arises due to working capital needs and is excluded from the definition of the Financing Gap Share in (5). I define this ratio as the average over time of the contribution of negative operating cash flows, $\mathrm{CF}_{e,t}^O$, to the total financing gap, FG_t^{TOT},in (4):

$$\overline{WKS} = \frac{1}{T}\sum_t \frac{WK_t}{FG_t^{TOT}} = 32.05\%$$

and find that around 32% of firms' total financial dependence is connected to funding operating expenses.

Moreover, I report the Financing Gap Share statistics computed over annual and quarterly data using Chari and Kehoe (2009)'s definition of financing gap in (3). By direct comparison of their methodology with mine, I can compute and report the share of total financing gap that arises by treating dividends as an unavoidable commitment rather than disposable resources. I find that dividend payouts amount to around 26% of the total financing gap in (4).

[10] Figure 5 reports the same results for all North American Compustat companies and compares it with an interpolated version of the annual series from Chari and Kehoe (2009) (red dashed line) and with a series computed using their methodology on quarterly data (blue dashed line). The three series are highly correlated, but the average level of the quarterly data is larger, signaling an important role for the financial sector in funding firms' short-term financial needs. All series are seasonally adjusted using the additive X12 Census model on Compustat quarterly data.

Compustat to determine what fraction of the Financing Gap is funded using resources coming from equity and/or debt holders, $\mathrm{CF}^{EO}_{e,t}$ and $\mathrm{CF}^{D}_{e,t}$, and what fraction is instead financed by liquidation of assets on firms' balance sheets and/or depletion of cash reserves, $\mathrm{NFI}_{e,t}+\Delta\mathrm{CASH}_{e,t}$. In each quarter t, debt and equity intakes account for a fraction, DES_t, of the total financing gap defined in equation 3:

$$DES_t = \frac{\sum_e (CF^D_{e,t} + CF^{EO}_{e,t})\mathbf{1}\left\{FG_{e,t} < 0\right\}}{FG^{TOT}_t} \tag{6}$$

On average, along the sample period debt and equity fund 75.67% of the total financing gap (standard deviation 22.45%):

$$\frac{1}{T}\sum_t DES_t = \frac{1}{T}\sum_t \frac{\sum_e (CF^D_{e,t} + CF^{EO}_{e,t})\mathbf{1}\left\{FG_{e,t} < 0\right\}}{FG^{TOT}_t} = 75.67\%$$

while the remaining 24.43% is covered by portfolio liquidations and changes in cash reserves, as summarized in table 2.[11]

Figure 6 plots the share of the total financing gap that is covered by portfolio liquidations and variation in cash reserves, LIQS_t, with $\mathrm{LIQS}_t = 1 - \mathrm{DES}_t$:

$$LIQS_t = 1 - DES_t = \frac{\sum_e (NFI_{e,t} + \Delta CASH_{e,t})\mathbf{1}\left\{FG_{e,t} < 0\right\}}{FG^{TOT}_t} \tag{7}$$

The graph suggests that the relative importance of asset liquidations versus debt and equity intakes is increasing in recessions. Recessions seem to be characterized mostly by a reduced inflow of external sources of finance per unit of investment undertaken (figure 6) and a shift towards asset liquidation for the aggregate of U.S. corporations.

The data in figure 6 shows some important features. Positive realizations of the series represent quarters when firms liquidate assets or deplete cash reserves. Negative realizations instead represent episodes in which firms are able to borrow from the market not only to cover their financing gap, but also to acquire new financial assets on secondary markets. This phenomenon is particularly pronounced before the burst of the dotcom bubble at the end of the 90s, when the share of corporate mergers and acquisitions had risen to 15% of US GDP in 1999 alone, compared to an average of 4% during the 1980s, (Weston and Weaver (2004)). Another important characteristic of the data series is the difference in the relevance of portfolio liquidations in the 2000s, compared to the 1990s. The average fraction of financing gap covered through asset liquidations is lower along the expansion of the 1990s (average contribution amounts to 19.74% of Financing Gap from 1991 to 2001), and higher in the boom of the 2000s (34.27% from 2002 to 2008).

[11] Variantions in cash reserves amount alone to 20.74% of the total financial gap.

2 The Model

In this section I describe a model that can capture the features of firms' investment financing in the Compustat quarterly data. In the model described in this section entrepreneurs: 1) produce enough resources on aggregate to fund total investment, 2) singularly issue and trade financial claims through a competitive banking sector, to raise funds to finance their capital expenditures and, 3) trade and hold liquid assets as precautionary savings against idiosyncratic investment opportunity, in line with firm-level data in Compustat.

The economy described below consists of a unit measure of entrepreneurs and a unit measure of households, perfectly competitive financial intermediaries (banks),competitive producers of a homogeneous consumption good, intermediate goods producers who act in regime of imperfect competition, capital producers who transform final goods into ready-to-install capital goods, households that supply differentiated labor inputs combined in homogeneous work hours by employment agencies. The government is composed of a monetary authority and a fiscal authority.

2.1 Entrepreneurs

Entrepreneurs are indexed by e. They own the capital stock of the economy, K_t. In each period they receive an idiosyncratic technological shock to install new capital. After observing their technology level, they can decide to increase their capital stock if they receive a good technology draw. To increase their investment capacity and take advantage of their technology, they can borrow resources by issuing and selling equity claims ($\mathrm{N}_{e,t}$) on their physical assets ($\mathrm{K}_{e,t}$) to financial intermediaries. Alternatively, if their technology is inefficient, they can decide to forgo investment opportunities that are not remunerative and instead lend resources to more efficient entrepreneurs in exchange for the rate of return on the new capital produced. Entrepreneurs can also accumulate liquid assets in the form of government bonds ($\mathrm{B}_{e,t}$).

At the beginning of the period a snapshot of each entrepreneur's balance sheet will include his capital stock, $K_{e,t-1}$, the equity claims on other entrepreneurs' capital stock, $N_{e,t-1}^{others}$ and interest bearing government bond holdings, $R_{t-1}^{B}B_{e,t-1}$ on the assets side. On the liability side, entrepreneurs sell claims on their capital stock to others, so that part of their $K_{e,t-1}$ is backed by $N_{e,t-1}^{sold}$:

A	L
$Q_tK_{e,t-1}$	$Q_tN_{e,t-1}^{sold}$
$Q_tN_{e,t-1}^{others}$	
$R_{t-1}^{B}B_{e,t-1}$	Net Worth

Assuming that each unit of equity in the economy, N_t, represents one unit of homogeneous capital, K_t, so that the two assets share the same expected stream of returns, $\left\{R_{t+i}^{K}\right\}$ for $i = \{0, ..., \infty\}$, it is possible to define a unique state variable that describes the *net* amount of capital ownership claims held by entrepreneur e:

$$N_{e,t} = K_{e,t} + N_{e,t}^{others} - N_{e,t}^{sold}$$

Entrepreneur e maximizes his life-time utility of consumption:

$$\max E_t \sum_{s=0}^{\infty} \beta^s b_{t+s} \log(C_{e,t+s}) \tag{8}$$

subject to a flow of funds constraint:

$$\begin{aligned} &P_t C_{e,t+s} + P_{t+s}^K i_{e,t+s} + Q_{t+s}^B \Delta N_{e,t+s}^{+} - Q_{t+s}^A \Delta N_{e,t+s}^{-} + P_{t+s} B_{e,t+s} = \\ &\left(1-\tau^k\right) R_{t+s}^K N_{e,t+s-1} + R_{t+s-1}^B B_{e,t+s-1} \end{aligned} \tag{9}$$

The entrepreneur receives after-tax income from his assets at the beginning of the period (the right-hand side of (9)) and uses it to purchase consumption goods, C_t, at price P_t from final goods producers or capital goods $i_{e,t}$, at price P_t^K from capital goods producers. The entrepreneur can also purchase equity claims $\Delta N_{e,t}^{+}$ at price Q_t^B from banks and government bonds at price P_t from the fiscal authority. Some entrepreneurs may decide to sell equity claims $\Delta N_{e,t}^{-}$ at a price Q_t^A to banks.[12]

An entrepreneur can increase his equity stock by purchasing and installing capital goods $i_{e,t}$ by means of the technology $A_{e,t}$, where $A_{e,t} \sim U\left[A^{low}, A^{high}\right]$.[13] He can also increase his assets by purchasing new equity claims from financial markets $\Delta N_{e,t}^{+}$, or decrease them by selling equity claims, $\Delta N_{e,t}^{-}$. The law of motion of the equity stock for entrepreneur e will be:

$$N_{e,t+s} = A_{e,t+s} i_{e,t+s} + \Delta N_{e,t+s}^{+} - \Delta N_{e,t+s}^{-} + (1-\delta) N_{e,t+s-1}. \tag{10}$$

Entrepreneurs are constrained in the amount of financial claims that they can issue and sell on the market, as in KM. Those who decide to purchase and install capital goods can write claims just on a fraction $\theta A_{e,t} i_{e,t}$ of their new capital stock and sell it to banks to raise external financing. Similarly, entrepreneurs with good technologies can only sell a share $\phi(1-\delta) N_{e,s+t-1}$ of old equity units to finance the installation of new ones.[14] Equity sales, $\Delta N_{e,t+s}^{-}$ will then have to satisfy the constraint:

$$\Delta N_{e,t+s}^{-} \leq \theta A_{e,t+s} i_{e,t+s} + \phi(1-\delta) N_{e,s+t-1}. \tag{11}$$

[12] For now I am assuming that $Q_t^A \leq Q_t^B$, so that no arbitrage opportunity exists for entrepreneurs on the equity market. This will be derived as an equilibrium result when discussing the role of financial intermediaries in section 2.2.

[13] Assuming that idiosyncratic technologies are uniformly distributed helps with aggregation of optimality conditions across entrepreneurs.

[14] KM suggest that constraints on new equity issuances, θ, may arise when investment requires a (non-collateralizable) effort of the entrepreneurs to be put in place, as in Hart and Moore (1994). Similarly constraints on the ability to resell old assets, ϕ, can be justified assuming a certain degree of specificity of installed capital, or to the presence of reallocation costs (Eisfeldt and Rampini (2006)).

so they do not exceed the sum of the external finance limit, $\theta A_{e,t+s} i_{e,t+s}$, and the maximum amount of resalable equity, $\phi\left(1-\delta\right) N_{e,s+t-1}$.

Note finally that entrepreneurs' discount factor in (8), $\beta^s b_t$, is subject to an intertemporal preference exogenous shock that follows the AR(1) process:

$$\log b_t = \rho_b \log b_{t-1} + \varepsilon_t^b$$

where $\varepsilon_t^b \sim$ i.i.d. $\mathrm{N}\big(0, \sigma_b^2\big)$.

To sum up, entrepreneurs maximize (8), subject to (9), (10) and (11) and under the non-negativity constraints:

$$i_{e,t+s} \geq 0, \ \ \Delta N_{e,t+s}^{+} \geq 0, \ \ \Delta N_{e,t+s}^{-} \geq 0, \ \ B_{e,t+s} \geq \ \ 0 \tag{12}$$

The problem can be solved at time $t+s$ for the optimal levels of: $\{\mathrm{C}_{e,t+s}$, $\mathrm{i}_{e,t+s}$, Δ $\mathrm{N}_{e,t+s}^{+}$, Δ $\mathrm{N}_{e,t+s}^{-}$, $\mathrm{N}_{e,t+s}$, $\mathrm{B}_{e,t+s}\}$, given a set of prices and rates of return: $\{\mathrm{P}_t$, P_t^K, Q_{t+s}^B, Q_{t+s}^A, R_{t+s}^K, $\mathrm{R}_{t+s}^B\}$, a draw of the installation technology $\mathrm{A}_{e,t+s}$, a portfolio of assets $N_{e,t+s-1}$,$\mathrm{B}_{e,t+s-1}$ at the start of the period and a realization of the aggregate shocks.

New capital and old equity units share the same resale and purchase prices, Q_t^A and Q_t^B, and return profile in the future,$\mathrm{R}_{t+i}^K\}$ for i $= \{0, ..., \infty\}$. Entrepreneurs will then always treat them as perfect substitutes. Following Kurlat (2010), at the beginning of the period an entrepreneur observes the price at which he can sell financial claims to a bank, Q_{t+s}^A, the one at which he can buy financial claims from the bank Q_{t+s}^B, and the level of his installation technology, A_t^e. Entrepreneurs compare their own relative price of capital goods, $\frac{P_t^K}{A_t^e}$, with the resale and purchase prices of equity claims, $\mathrm{Q}_t^A \leq \mathrm{Q}_t^B$ (fig. 7). Depending on his random technology draw, an entrepreneur can becomes a Seller and optimally decide to buy capital goods at price P_t^K and install them by means of his technology A_t^e, while selling claims to financial intermediaries at price Q_t^A. Alternatively, he can become a Keeper and install capital goods using his own technology and income, or become a Buyer, forgoing installation of capital goods and buying claims on the capital stock of other entrepreneurs paying Q_t^B for each financial claim.

Figure 7 shows the partition into the three subsets: *Sellers*, *Keepers* and *Buyers*, depending on the random draw of installation technology for the period. In particular:

- SELLERS (index $e = s$): $\frac{P_t^K}{A_{s,t}} \leq Q_t^A$

Sellers can take advantage of good technology draws. Their relative price of a unit of installed capital, $\frac{P_t^K}{A_{i,t}}$, is lower than the real price at which the entrepreneur can issue new equity claims or sell old ones, Q_t^A, and lower than the price at which he can buy financial claims on other people's capital stock, Q_t^B. The entrepreneur can then profit from building new physical assets at a relative price $\frac{P_t^K}{A_{i,t}}$ and selling equity claims to the financial intermediaries at price Q_t^A. The optimal decision then implies that the entrepreneur sells the intermediaries the highest amount of equity claims possible, from 11:

$$\Delta N^{-}_{s,t} = \theta A_{s,t} i_{s,t} + \phi\left(1-\delta\right) N_{s,t-1} \tag{13}$$

and avoids buying assets from the market, so that $\Delta N^{+}_{s,t} = 0$ In analogy with KM, in steady state entrepreneurs with a good technology will cash their returns on liquid assets but will not accumulate new ones, $B_t = 0$,. I solve the model assuming that the economy does not depart from this allocation. Substituting (13), as well as $\Delta N^{+}_{s,t} = 0$ and $B_t = 0$ into (9), Sellers' real budget constraint becomes

$$C_{s,t} + \tilde{q}^{A}_{s,t} N_{s,t} = \left(1-\tau^{K}\right) r^{K}_{t} N_{s,t-1} + r^{B}_{t} B_{s,t-1} + \left[q^{A}_{t}\phi + \tilde{q}^{A}_{s,t}\left(1-\phi\right)\right]\left(1-\delta\right) N_{s,t-1} \tag{14}$$

with:

$$\tilde{q}^{A}_{s,t} \quad = \quad \frac{\frac{p^{K}_{t}}{A_{s,t}} - \theta q^{A}_{t}}{1-\theta}$$

and real asset prices and rates of return defined as $\mathrm{q}^{A}_{t} = \mathrm{Q}^{A}_{t}/\mathrm{P}_t$, $\mathrm{p}^{K}_{t} = \mathrm{P}^{K}_{t}/\mathrm{P}_t$, $\mathrm{r}^{K}_{t} = \mathrm{R}^{K}_{t}/\mathrm{P}_t$ and $\mathrm{r}^{B}_{t} = \mathrm{R}^{B}_{t}/\mathrm{P}_t$. The right-hand-side of (14) is the net worth of a generic seller, s. Finally, given the distribution of technologies, $\mathrm{A}_{e,t}$, across entrepreneurs, the measure of sellers in the economy is:

$$\chi_{s,t} = \Pr\left\{\frac{P^{K}_{t}}{A_{e,t}} \leq Q^{A}_{t}\right\}$$

- KEEPERS (index $e = k$): $Q^{A}_{t} \leq \frac{P^{K}_{t}}{A_{k,t}} \leq Q^{B}_{t}$

The relative price of a unit of installed capital, $\frac{P^{k}_{t}}{A_{k,t}}$, is higher than what the market maker pays for each equity claim sold or issued, Q^{A}_{t}, but lower than the price at which entrepreneurs can acquire new equity from others, Q^{B}_{t}. As a result, these entrepreneurs will not issue new claims nor sell their assets:

$$\Delta N^{-}_{k,t} = 0$$

nor will they buy financial assets:

$$\Delta N^{+}_{k,t} = 0, \quad B_{k,t} = 0$$

so that their budget constraint (9) in real terms becomes:

$$C_{e,t} + \frac{p^{K}_{t}}{A_{k,t+s}} N_{k,t} = \left(1-\tau^{K}\right) r^{K}_{t} N_{k,t-1} + r^{B}_{t} B_{k,t-1} + \frac{p^{K}_{t}}{A_{k,t}}\left(1-\delta\right) N_{k,t-1} \tag{15}$$

The measure of keepers in the economy is:

$$\chi_{k,t} = \Pr\left\{ Q_t^A \leq \frac{P_t^k}{A_{e,t}} \leq Q_t^B \right\}$$

- BUYERS (index $e = b$): $\frac{P_t^K}{A_{b,t}} \geq Q_t^B$

Buyers receive poor investment technology draws. The relative price of a unit of installed capital, $\frac{P_t^K}{A_{s,t}}$, is higher than both the market price of equity Q_t^B and of the amount obtained from market makers for each units of equity sold or issued, Q_t^A. These entrepreneurs will decide not to install new physical capital. They will instead acquire financial claims at their market price Q_t^B. Similarly to KM, Buyers will accumulate government bonds, $B_{b,t}$ in non-arbitrage with equity claims. They acquire these liquid assets to self-insure against the arrival of good technology draws in the future, so to overcome their binding borrowing and liquidity constraints. Their budget constraint in real terms will then become:

$$C_{b,t} + q_t^B N_{b,t} + B_{b,t} = \left(1 - \tau^K\right) r_t^K N_{b,t-1} + r_{t+s}^B B_{b,t-1} + q_t^B (1 - \delta) N_{b,t-1} \tag{16}$$

where:

$$q_t^B = \frac{Q_t^B}{P_t}$$

Finally, the fraction of buyers in the economy will be:

$$\chi_{b,t} = \Pr\left\{ \frac{P_t^K}{A_{b,t}} \geq Q_t^B \right\} = 1 - \chi_{s,t} - \chi_{k,t}$$

The three budget constraints (14), (15), (16) now display entrepreneurs' net worth on their right-hand side. By properties of the log-utility function, optimal consumption in period t is a fixed fraction $(1 - \beta b_t)$ of the entrepreneur's net worth. [15]

2.2 Financial Intermediaries

Financial intermediaries (or banks) manage the transfer of resources between Sellers and Buyers of financial claims.

In each period, a multitude of intermediaries indexed by i compete to acquire equity claims, $\Delta N_{i,t}^-$, at price Q_t^A and sell the quantity $\Delta N_{i,t}^+$ to Buyers at a price Q_t^B. To do this, they bear

[15] An on-line technical appendix presents the complete set of optimality conditions of the entrepreneurs' problem, under the assumption that the installation technology $A_{e,t}$ follows a Uniform distribution $U\left[A^{lo}, A^{hi}\right]$. This assumptions allows me to derive a closed form aggregate expression for the optimal amount of investment carried out by sellers. The same appendix contains the derivation of the set of equilibrium conditions of the model and the complete definition of the equilibrium for the model economy. The appendix will be soon available at: https://sites.google.com/site/ajelloandrea/.

an intermediation cost equal to $\tau_t Q_t^A$ for each financial claim they process. Banks maximize their nominal profits:

$$\Pi_t^{II} = Q_t^B \Delta N_{i,t}^{+} - \left(1 + \tau_t^q\right) Q_t^A \Delta N_{i,t}^{-} \tag{17}$$

subject to the constraint that the number of claims they buy is the same as the one they sell:

$$\Delta N_{i,t}^{+} = \Delta N_{i,t}^{-}. \tag{18}$$

Perfect competition among intermediaries implies that profits are maximized when:

$$q_t^B = \left(1 + \tau_t^q\right) q_t^A.$$

The real 'bid' price, $q_t^B = \frac{Q_t^B}{P_t}$, offered to buyers, is equal to the 'ask' price, $q_t^A = \frac{Q_t^A}{P_t}$, augmented by an intermediation cost (or spread), τ_t^q.

Sellers and Buyers share the incidence of the intermediation cost. An increase in the cost reduces the expected return on savings to the Buyers. At the same time, it lowers the amount of resources that are transferred to investing entrepreneurs for each unit of equity sold. The price of equity claims sold by investing entrepreneurs, q_t^A, falls and their cost of borrowing rises. The immediate result of the negative shock on τ_t^q is that investment drops with potential effects on output and consumption dynamics, discussed at length in section 4.

In the literature, see Chari, Christiano, and Eichenbaum (1995), Goodfriend and McCallum (2007) and Cúrdia and Woodford (2010b) introduce wedges similar to the one proposed here to model financial market imperfections and the evolution of credit spreads. Work by Kurlat (2010) shows that an adverse selection friction in a model with lemon and non-lemon assets is isomorphic to a model with homogeneous equity claims in which financial transactions are hit by a tax wedge, as discussed in this paper. In his formulation, the wedge is a reduced form representation of the share of lemon claims over total claims traded on the market.[16]

In Kurlat's model, this wedge evolves endogenously and depends positively on the share of lemons traded in every period and the proceeds from the tax are rebated to the government. The wedge generates a spread between the expected cost of borrowing perceived by Sellers and the expected

[16] In a set-up with heterogeneous equity claims, some assets are of good quality while others can be lemons and Sellers can possess private information on the quality of their assets and on the their future payoffs. Buyer cannot distinguish the two before a transaction with a Seller is finalized. Kurlat (2010) follows Akerlof (1970) and shows that, in a dynamic general equilibrium model similar in flavor to KM, sales of good quality assets is pro-cyclical and respond to aggregate shocks. After a persistent negative productivity shock, for example, current and future returns on capital decrease, aggregate savings are reduced and the price of financial assets plummets. This induces entrepreneurs who wish to finance their investment opportunities to hold onto their good quality assets, waiting for better opportunities in the future. Lemons are worthless and sellers always have an incentive to place them on the market at any price. After a negative technology shock the, the composition of asset quality on financial market worsens and this increases the adverse selection problem: the higher probability of purchasing a lemon asset on the market will drive buyers demand for financial claims even lower, generating an amplification effect on the drop of the asset price and on the value of net worth of entrepreneurs in the economy.

return on savings perceived by Buyers.

In my model, I assume that this tax wedge maps into a cost that financial intermediaries bear for each unit of financial claims that they transfer from Sellers to Buyers. The total amount of resources that banks spend to purchase a unit of financial claims from Sellers is then equal to $(1+\tau_t^q)\, q_t^A$. To evaluate the role of financial disturbances as potential drivers of business cycles that are orthogonal to other sources of business fluctuation, I assume that the intermediation costs τ_t follow an exogenous process of the kind:

$$\log(1+\tau_t^q) = (1-\rho_\tau)\log(1+\tau^q) + \rho_\tau \log\left(1+\tau_{t-1}^q\right) + \varepsilon_t^\tau$$

where $\varepsilon_t^\tau \sim N\left(0, \sigma_\tau^2\right)$.

2.3 Final Good Producers

At each time t, competitive firms operate to produce a homogeneous consumption good, Y_t, as a combination of differentiated intermediate good, $\mathrm{Y}_t(i)$, through the technology:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{1+\lambda_{p,t}}}\, di\right]^{1+\lambda_{p,t}} \tag{19}$$

where $\lambda_{p,t}$ is the degree of substitutability between the differentiated inputs. The log of $\lambda_{p,t}$ follows an ARMA(1,1) exogenous process:

$$\log(1+\lambda_{p,t}) = \left(1-\rho_p\right)\log(1+\lambda_p) + \rho_p \log(1+\lambda_{p,t-1}) + \varepsilon_t^p + \theta_p \varepsilon_{t-1}^p \tag{20}$$

with $\varepsilon_t^p \sim N\left(0, \sigma_{\lambda_p}^2\right)$, as in Smets and Wouters (2005).

Standard profit maximization of the final good producers and their zero profit condition determine the price of the final good, P_t, as a CES aggregator of the prices of the intermediate goods, $P_t(i)$:

$$P_t = \left[\int_0^1 P_t(i)^{\frac{1}{\lambda_{p,t}}}\, di\right]^{\lambda_{p,t}}$$

and the demand for intermediate good i as:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t \tag{21}$$

2.4 Intermediate Goods Producers

Firms in regime of monopoly use capital and labor inputs, $K_{t-1}(i)$ and $L_t(i)$, to produce differentiated intermediate goods, $Y_t(i)$, using the following technology:

$$Y_t(i) = \max\left\{A_t^{1-\alpha} K_{t-1}(i)^{\alpha} L_t(i)^{1-\alpha} - A_t F; 0\right\} \tag{22}$$

A_t represents non-stationary labor-augmenting technological progress. The growth rate of A_t follows an exogenous AR(1) process:

$$\log\left(\frac{A_t}{A_{t-1}}\right) = \log(z_t) = (1-\rho_z)\log(\gamma) + \rho_z \log(z_{t-1}) + \varepsilon_t^z \tag{23}$$

where γ is the steady-state growth rate of output in the economy and $\varepsilon_t^z \sim N(0, \sigma_z)$. Finally, $A_t F$ is a fixed cost indexed by A_t that equalizes average profits across the measure of firms to zero in steady state (Rotemberg and Woodford (1995) and Christiano, Eichenbaum, and Evans (2005)).

Firms employ homogeneous labor inputs, $L_t(i)$, from households at a nominal wage rate W_t and rent the capital stock, $K_{t-1}(i)$, from entrepreneurs at a competitive rate R_t^K . Firms minimize their costs and maximize their monopolistic profits, knowing that in period t they will only be able to re-optimize their prices with probability $1-\xi_p$. The remaining fraction of firms that do not re-optimize, ξ_p, are assumed to update their prices according to the indexation rule:

$$P_t(i) = P_{t-1}(i)\,\pi_{t-1}^{\iota_p}\pi^{1-\iota_p}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross rate of inflation and π is its steady state value (Calvo (1983)).

Those firms who can choose their price level will then set $P_t(i)$ optimally by maximizing the present discounted value of their flow of profits:

$$E_t \sum_{s=0}^{\infty} \xi_p^s \beta^s \Lambda_{t+s}^w \left\{ \left[P_t(i) \left(\prod_{j=0}^{s} \pi_{t-1+j}^{\iota_p} \pi^{1-\iota_p} \right) \right] Y_{t+s}(i) - \left[W_t L_t(i) + R_t^k K_t(i) \right] \right\} \tag{24}$$

subject to the demand function for good $Y(i)$, (21), and to the production function (22).Households own shares of the intermediate firms: current and future profits (24) are evaluated according to the marginal utility of a representative household, Λ_t^w.

2.5 Capital Goods Producers

Capital goods producers operate in regime of perfect competition and on a national market. Producers purchase consumption goods from the final goods market, Y_t^I at a price P_t, transforms them into investment goods, I_t, by means of a linear technology:

$$I_t = Y_t^I.$$

Producers then have access to a capital production technology to produce i_t units of capital goods for an amount I_t of investment goods:

$$i_t = \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right] I_t$$

where $S(\cdot)$ is a convex function in $\frac{I_t}{I_{t-1}}$, with $S = 0$ and $S' = 0$ and $S'' > 0$ in steady state (Christiano, Eichenbaum, and Evans (2005)). Producers sell capital goods to the entrepreneurs on a competitive market at a price P_t^k. In every period they choose the optimal amount of inputs, I_t as to maximize their profits:

$$\max_{I_{t+s}} E_t \sum_{s=0}^{\infty} \beta^s E_{t+s} \left\{ \Lambda_{t+s}^w \left[P_{t+s}^k i_{t+s} - P_{t+s} I_{t+s} \right] \right\} \tag{25}$$

s.t.

$$i_{t+s} = \left[1 - S\left(\frac{I_{t+s}}{I_{t+s-1}}\right)\right] I_{t+s}. \tag{26}$$

I assume that the households own stocks in the capital producers, so that the stream of their future profits is weighted by their marginal utility of consumption, Λ_{t+s}^w. Free entry on the capital goods producing sector requires profits to be zero in equilibrium, so that the value of capital goods sold in every period t across all capital producers has to be equal to the nominal value of aggregate investment:

$$P_t^k i_t = P_t I_t$$

2.6 Employment Agencies

The economy is populated by a unit measure of households, indexed by w, who consume and supply a differentiated labor force to employment agencies. A large number of such agencies combines the differentiated labor into a homogeneous labor input L_t, by means of the Dixit-Stiglitz technology:

$$L_t = \left[\int_0^1 L_{w,t}{}^{\frac{1}{1+\lambda_{w,t}}} dw \right]^{1+\lambda_{w,t}}$$

where $\lambda_{w,t}$ is the degree of substitutability of specialized labor inputs, $L_{w,t}$ and the desired mark-up of the wage over the marginal disutility of labor required by the specialized household. I assume that the mark-up evolves according to an exogenous ARMA(1,1) process:

$$\log(1 + \lambda_{w,t}) = (1 - \rho_w) \log(1 + \lambda_w) + \rho_w \log(1 + \lambda_{w,t-1}) + \varepsilon_t^w + \theta_p \varepsilon_{t-1}^w \tag{27}$$

with $\varepsilon_t^w \sim N\left(0, \sigma^2_{\lambda_w}\right)$.

Agencies hire specialized labor, $L_{w,t}$ at monopolistic wages, $W_{w,t}$, and provide homogeneous work hours, L_t, to the intermediate producers, in exchange for a nominal wage, W_t. Similarly to the good production technology, profit maximization delivers a conditional demand for labor input for each employment agency equal to:

$$L_{w,t} = \left(\frac{W_{w,t}}{W_t}\right)^{-\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t$$

The nominal wage paid by the intermediate firms to the employment agencies is an aggregate of the different specialized salaries $W_{w,t}$:

$$W_t = \left[\int_0^1 W_{w,t}^{\frac{1}{\lambda_{w,t}}} dz\right]^{\lambda_{w,t}}$$

2.7 Households

Households maximize their lifetime utility of consumption, $\mathrm{C}_{w,t}$:

$$\sum_{s=0}^{\infty} \beta^s \left[\log\left(C_{w,t+s} - hC_{w,t+s-1}\right) - \omega \frac{{L_{w,t+s}}^{1+v}}{1+v}\right] \tag{28}$$

subject to their nominal budget constraint:

$$P_t C_{w,t} + Q_t^B \Delta N_{w,t}^{+} - Q_t^A \Delta N_{w,t}^{-} + B_{w,t} = (1-\tau^L) W_{w,t} L_{w,t} + R_t^K N_{w,t-1} + R_{t-1}^B B_{w,t-1} + T_t + Q_{w,t} + \Pi_t \tag{29}$$

and to limited participation constraints on financial markets: $\mathrm{B}_{w,t} = 0$, $\Delta N_{w,t}^{+} = 0$ and $\Delta N_{w,t}^{-} = 0$. Workers do not borrow or accumulate assets in equilibrium.[17] As a result, in a generic time t nominal consumption $P_t C_{w,t}$ is financed by labor earnings, $W_{w,t} L_{w,t}$, net of distortionary taxes $\tau^L W_{w,t} L_{w,t}$ and lump-sum transfers, T_t, and profits earned from ownership of intermediate firms, banks and

[17] Kiyotaki and Moore (2008) derive this as an equilibrium result of their model that holds as long as, in a liquidity-constrained dynamic equilibrium, the expected rate of return on financial assets is lower than the intertemporal rate of substitutions of households. The fact that all households do not save in equilibrium and cannot borrow on financial markets is a rather extreme implication, in a model economy in which labor inputs traditionally receive around 60% of total output as remuneration. Empirical work on life-cycle consumption dynamics does suggest that a significant 20% share of people in the US economy live hand-to-mouth existences (Gourinchas and Parker (2002), Hurst and Willen (2007)). In practice it is possible to allow for a certain degree of savings at the household level, by introducing idiosyncratic shocks and borrowing constraints, similar to the random investment opportunities that occur along entrepreneurs' life cycle. Random health expenses (Kiyotaki and Moore (2005)) or unexpected taxation shocks (Woodford (1990)) could in practice create an incentive in favor of households' precautionary saving behavior. Alternatively it is possible to introduce aggregate savings at the households' level by allowing them to trade separately on long-term government bonds, at yields higher than the risk-free rate. This form of bond market segmentation would introduce a simple term structure of government bond yields whose upward slope is sustained by entrepreneur's demand for liquid short-term bonds. To keep the model tractable, in this paper I choose to restrict households' ability to trade resources on the intertemporal margin.

capital producers, Π_t. The budget constraint of the household becomes:

$$P_t C_{w,t} = \left(1-\tau^L\right) W_{w,t} L_{w,t} + T_t + Q_{w,t} + \Pi_t$$

In every period only a fraction $(1-\xi_w)$ of workers re-optimizes the nominal wage. To make aggregation simple, I assume that workers are able to insure themselves against negative realizations of their labor income that occur in each period t, by trading claims $Q_{w,t}$ with other workers before they are called to re-optimize $W_{w,t}$.

The wage is set monopolistically by each household as in Erceg, Henderson, and Levin (2000): a fraction $(1-\xi_w)$ of workers supplies labor monopolistically and sets $W_{w,t}$ by maximizing:

$$E_t \sum_{s=0}^{\infty} \xi_w^{t+s} \beta^{t+s} \left\{ -\frac{\omega}{1+\nu} {L_{w,t+s}}^{1+\nu} \right\}$$

subject to the labor demand of the employment agencies:

$$L_{w,t+s} = \left(\frac{W_{w,t}}{W_t}\right)^{-\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} L_t$$

The remaining fraction ξ_w is assumed to index their wages $W_{w,t}$ in every period according to a rule:

$$W_{w,t} = W_{w,t-1} \left(\pi_{t-1} e^{z_{t-1}}\right)^{\iota_w} \left(\pi e^{\gamma}\right)^{1-\iota_w}$$

that describe their evolution as a geometric average of past and steady state values of inflation and labor productivity.

2.8 Monetary Authority

The central bank sets the level of the nominal interest rate, R_t^B, according to a Taylor-type rule of the kind:

$$\frac{R_t^B}{R^B} = \left(\frac{R_{t-1}^B}{R^B}\right)^{\rho_R} \left[\left(\frac{\bar{\pi}_t}{\pi}\right)^{\phi_\pi}\right]^{1-\rho_R} \left(\frac{\Delta \overline{X}_{t-s}}{\gamma}\right)^{\phi_Y} \eta_{mp,t} \tag{30}$$

where the nominal risk free rate depends on its lagged realization and responds to deviations of a 4-period trailing inflation index $\bar{\pi}_t = \sum_{s=0}^{3} \frac{\pi_{t-s}}{4}$ from steady state inflation, π, as well as to the deviations of the average growth rate of GDP, $X_t = C_t + I_t + G_t$, in the previous year $\Delta \overline{X}_{t-s} = \sum_{s=0}^{3} \frac{\log X_{t-s} - \log X_{t-s-1}}{4}$ from its steady state value γ. Moreover, $\eta_{mp,t}$ represents an i.i.d. monetary policy shock:

$$\log \eta_{mp,t} = \varepsilon_{mp,t}$$

where $\varepsilon_{mp,t}$ is i.i.d. $N\left(0, \sigma_{mp}^2\right)$.

2.9 Fiscal Authority

The fiscal authority issues debt, B_t and collects distortionary taxes on labor income and capital rents, $\tau^k R_t^k K_{t-1}$ and $\tau^l W_t L_t$ to finance a stream of public expenditures, G_t, lump-sum transfers to households, T_t, and interest payments on the stock of debt that has come to maturity, $R_{t-1}^B B_{t-1}$:

$$B_t + \tau^k R_t^k K_{t-1} + \tau^l W_t L_t = R_{t-1}^B B_{t-1} + G_t + T_t.$$

Following the DSGE empirical literature, the share of government spending over total output follows an exogenous process:

$$G_t = \left(1 - \frac{1}{g_t}\right) Y_t$$

where:

$$\log g_t = (1 - \rho^g)\, g_{ss} + \rho^g \log g_{t-1} + \varepsilon_t^g$$

and $\varepsilon_t^g \sim$ i.i.d.N$\big(0, \sigma^{g2}\big)$.

My model requires an empirically plausible description of the dynamics of the supply of liquid assets that originates from the public authority. I then follow Leeper, Plante, and Traum (2010) in their empirical work on the dynamics of fiscal financing in a DSGE model of the US economy.[18] To obtain a fiscal rule that resembles the one in the de-trended model in Leeper, Plante, and Traum (2010) as closely as possible, I assume the share of transfers over total output, T_t/Y_t, to depart from its steady state value, ToY, in response to deviations of the average growth rate of output in the past quarter from the stable growth path as well as to deviations of the debt to output ratio $\frac{B_t}{Y_t}$ from a specific target, BoY:[19]

$$\frac{T_t/Y_t}{ToY} = \left(\frac{\Delta Y_t}{\gamma}\right)^{-\varphi_Y} \left(\frac{B_t/Y_t}{BoY}\right)^{-\varphi_B}$$

Transfers then increase when output growth falls below its steady state value. On the other hand, transfers fall when B_t/Y_t increases over its steady state level, as to keep the stock of public debt stationary.

Notice also that the description of the public provision of liquid assets in the form of government bonds assumes a key role in this model. Fiscal policy is non-Ricardian (as in Woodford (1990)): different agents accumulate government bonds than those who bear the burden of taxation. Workers do not save, so that they are not able to smooth out the impact of their fiscal contribution and entitlements along time. Entrepreneurs, on the other hand, do not save for tax-smoothing purposes. They instead accumulate government bonds to self-insure against the arrival of good investments in the future and overcome their borrowing and liquidity constraints described in section 2.1.

[18] Differently from Leeper, Plante, and Traum (2010), I do not allow for taxation on final consumption and do not include correlation among the stochastic components of the fiscal rules.

[19] The latter feature insures that fiscal policy is passive, so that it does not conflict with the central bank's Taylor rule in the determination of a unique stable path for the growth rate of the price level (Woodford (2003)).

2.10 Aggregation, Market Clearing and Model Solution

Aggregation across entrepreneurs is made easy by the log-preferences assumption and by the independence of the realizations of installation technology idiosyncratic shocks, $A_{e,t}$, with the amount of capital and financial assets that agents enter the period with, $\mathrm{N}_{e,t-1}$ and $\mathrm{B}_{e,t-1}$. Log-utility implies linearity of their consumption, investment and portfolio decisions with respect to the state variables, N_{t-1} and B_{t-1}. Summing over the individual flow of funds constraints, output at time t, Y_t, is absorbed by consumption of sellers (S), keepers (K), buyers (B) and workers (W), by investment and government spending and financial intermediation costs:

$$\begin{aligned} Y_t &= \int_S C_{s,t} f(A_{e,t}) ds + \int_K C_{k,t} f(A_{e,t}) dk + \int_B C_{b,t} f(A_{e,t}) db + C_t^W + I_t + G_t + \tau_t q_t^A \Delta N_t \\ &= C_t + I_t + G_t + \tau_t q_t^A \Delta N_t \end{aligned}$$

where GDP is instead defined as:

$$X_t = C_t + I_t + G_t$$

To solve the model, I first rewrite its equilibrium conditions in stationary terms, rescaling such variables as output and GDP, Y_t, X_t, consumption, C_t, investment, I_t, capital and equity, K_t and N_t and real wages, $\frac{W_t}{P_t}$, that inherit the unit root of the total factor productivity stochastic process, A_t. I then compute the steady state of the model in terms of stationary variables and find a log-linear approximation of the equilibrium conditions around it. I then solve the system of rational expectation equations to obtain the model's state-space representation.

3 Estimation

In this section I describe the estimation of the model in section 2 on U.S. data using Bayesian methods. I start with a description of the data and of the choice of prior distributions for the model parameters and for certain moments, based on previous work in the DSGE estimation literature and on the micro-data evidence from Compustat reported in section 1. I here discuss the estimates and the features of the impulse response functions to the financial intermediation shock, the model fit and the variance decomposition of the observables in the fundamental shocks implied by the estimation. I finally present the historical decomposition of the observables into the smoothed fundamental shocks and perform some counterfactual exercises on the last 3 years of GDP growth to identify the driving forces of the Great Recession.

3.1 Data and Prior Selection

I estimate the model by Bayesian methods on sample that spans from 1989Q1 to 2010Q1. To estimate the model parameters I use the following vector of eight observable time series, obtained from Haver Analytics:

$$\left[\Delta \log X_t,\ \Delta \log I_t,\ \Delta \log C_t,\ R_t^B,\ \pi_t,\ Sp_t,\ \log\left(L_t\right),\ \Delta \log \frac{W_t}{P_t}\right].$$

The dataset is composed of the log growth rate of real per-capita GDP, $X_t = C_t + I_t + G_t$, investment, I_t, and aggregate consumption, C_t, the federal funds rate mapped into the model nominal risk-free rate, R_t^B, the GDP price deflator, π_t, the spread of high-yield B-rated corporate bonds from the Merrill Lynch's High Yield Master file versus AAA corporate yields of comparable maturity, Sp_t, the log of per-capita hours worked and the growth rate of real hourly wages, $\frac{W_t}{P_t}$. Notice that I choose the observed spread, Sp_t, to map into the model difference between the borrowing cost of Sellers and the yield on risk-free government bonds, up to a measurement error $\eta_t^{Sp} \sim N\left(0, \sigma^2_{\eta^{Sp}}\right)$:

$$Sp_t = E_t\left[\log\left(\frac{R_{t+1}^K + (1-\delta)\, Q_{t+1}^A}{Q_t^A}\right) - R_t^B\right] + \eta_t^{Sp}$$

The choice of this particular series of spreads uniforms to the literature that finds high-yield spreads to have a significant predictive content for economic activity (Gertler and Lown (1999)). In particular these spreads are the mid-credit-quality-spectrum spreads that Gilchrist, Yankov, and Zakrajsek (2009) find to be good predictors of unemployment and investment dynamics. The measurement error is intended to account for the differences in the federal funds rate and the AAA corporate bond yield, used as reference points to compute the spread in the model and the data respectively. The measurement error is also intended to correct for the imperfect mapping of rates of return on equity in the model onto yields on state-non-contingent bonds in the data.

Estimates for the parameters are obtained by maximizing the posterior distribution of the model (An and Schorfheide (2007)) over the vector of observables. The posterior function combines the model likelihood function with prior distributions imposed on model parameters and on theoretical moments of specific variables of interest.

The choice of the priors for most parameters of the model is rather standard in the literature (Del Negro, Schorfheide, Smets, and Wouters (2007), Justiniano, Primiceri, and Tambalotti (2010)) and is reported in table 3.

A few words are necessary to discuss the priors selection on parameters that influence entrepreneurs' investment financing decisions and the efficiency of financial intermediation in the model. I set a Gamma prior on the steady state quarterly intermediation cost, τ_{ss}^q, with mean equal to 62.5 basis points and standard deviation equal to 15, compatible with an annual intermediation costs of 250 basis points chosen by Cúrdia and Woodford (2010a) to match the median spread between the Federal Reserve Board index of commercial and industrial loan rates and the federal funds rate, over the period 1986-2007. I use my analysis of quarterly Compustat cash flow data to set the prior mean and standard deviation on the steady state level of the financing gap share, FGS.

The aggregate of entrepreneurs in the model can easily represent the universe of corporations in Compustat: they earn operating cash flows from their capital stock and use them to finance new capital expenditures. They also access financial markets to either raise external financing or to liquidate part of their assets.

Starting from the accounting cash flow identity (3) in section 1, I can map its components to the flow of funds constraint of an entrepreneur that is willing to buy and install new capital goods in my model in section 2:

$$\underbrace{PC_{e,t}}_{DIV_{e,t}} + \underbrace{P_t^K i_{e,t}}_{CAPX_{e,t}} - \left[\underbrace{Q_t^A \phi\left(1-\delta\right) N_{e,t-1}}_{NFI_{e,t}} + \underbrace{\left(R_{t-1}^B B_{e,t-1} - B_{e,t}\right)}_{\Delta CASH_{e,t}}\right] - \underbrace{\theta Q_t^A A_{e,t} i_{e,t}}_{\left(CF_{e,t}^D + CF_{e,t}^{EO}\right)} = \underbrace{R_t^K N_{e,t-1}}_{CF_{e,t}^O} \tag{31}$$

The returns on the equity holdings, $\mathrm{R}_t^K N_{e,t-1}$, correspond to the operating cash flows, $\mathrm{CF}_{e,t}^O$. Entrepreneur's nominal consumption, $\mathrm{P}_t\mathrm{C}_{e,t}$, can be identified with dividends paid to equity holders, $\mathrm{DIV}_{e,t}$, and the purchase of new capital goods, $P_t^K i_{e,t}$, with capital expenditures, $\mathrm{CAPX}_{e,t}$. Net financial operations in Compustat, $\mathrm{NFI}_{e,t}$, are mapped into net sales of old equity claims, $Q_t^A \phi\left(1-\delta\right)$ $\mathrm{N}_{e,t-1}$, while variations in the amount of liquidity, $\Delta\mathrm{CASH}_{e,t}$, correspond in the model to net acquisitions of government bonds, $\left(R_{t-1}^B B_{t-1} - B_t\right)$. Finally transfers from debt and equity holders, $\mathrm{CF}_{e,t}^D + \mathrm{CF}_{e,t}^{EO}$, correspond to issuances of equity claims on the new capital goods installed, $\theta Q_t^A A_{e,t} i_{e,t}$.

From (31), it is easy to derive the model equivalent of the Financing Gap Share defined in (5). Entrepreneurs with the best technology to install capital goods (sellers) are willing to borrow resources and to utilize their liquid assets to carry on their investment. The aggregate financing gap over the $\chi_{s,t}$ measure of sellers, S, can be written as:

$$\begin{aligned}
FG_t &= \int_S \left[\underbrace{R_t^K N_{s,t-1}}_{CF_{s,t}^O} - \underbrace{PC_{s,t}}_{DIV_{s,t}} - \underbrace{P_t^K i_{s,t}}_{CAPX_{s,t}}\right] f(A_{s,t}) ds \\
&= \int_S \left[\underbrace{Q_t^A \phi\left(1-\delta\right) N_{s,t-1}}_{NFI_{s,t}} + \underbrace{\left(R_{t-1}^B B_{s,t-1} - B_{s,t}\right)}_{\Delta CASH_{s,t}} - \underbrace{\theta Q_t^A A_{s,t} i_{s,t}}_{\left(CF_{s,t}^D + CF_{s,t}^{EO}\right)}\right] f(A_{s,t}) ds \\
&= Q_t^A \left(\phi\left(1-\delta\right)\chi_{s,t} N_{t-1} + \int_S \theta A_{s,t} i_{s,t} f(A_{s,t}) ds\right) + R_{t-1}^B \chi_{s,t} B_{s,t-1}.
\end{aligned}$$

so that the average financing gap share is equal to the mean ratio of the market value of the resources raised by external finance, $Q_t^A \theta A_{s,t} i_{e,t}$, those raised by liquidation of selling illiquid securities, $Q_t^A \phi (1-\delta) \chi_{s,t} N_{t-1}$, and from the liquid assets that come to maturity, $R_{t-1}^B \chi_{s,t} B_{t-1}$, over aggregate investment, I_t along the sample period:

$$FGS_{ss} = \frac{Q_{ss}^A \left(\phi (1-\delta) \chi_{s,ss} N_{ss} + \int_S \theta A_{s,ss} i_{s,ss} f(A_{s,ss}) ds\right) + R_{ss}^B \chi_{s,ss} B_{ss}}{I_{ss}}.$$

I set a Beta prior on the distribution of FGS_{ss}, with mean equal to 0.35 and standard deviation equal to 0.01.

Similarly, I use Compustat evidence to choose a prior on the steady state share of the financing gap that is covered by portfolio liquidations of equity claims, $\text{Q}_{ss}^A(\phi \text{ (1-}\delta\text{) } \chi_{s,ss} \text{N}_{ss})$, and government bonds, $\text{R}_{ss}^B \ \chi_{s,ss} \ \text{B}_{s,ss}$:

$$LIQS_{SS} = \frac{Q_{ss}^A \left(\phi (1-\delta) \chi_{s,ss} N_{ss}\right) + R_{ss}^B \chi_{s,ss} B_{s,ss}}{FG_{ss}}.$$

I choose a prior the average share of the Financing Gap covered by portfolio liquidations, LIQS_{ss}, to be a Beta distribution with mean equal to .25 and a standard deviation of .10.

I also help the identification of ϕ by calibrating the share of government liquidity held by entrepreneurs over GDP, B_{SS}/Y_t. I choose to calibrate the amount of liquid assets in circulation in the economy by referring to the Flow of funds data on corporate asset levels (table L.102). There, I identify a broad set of government-backed liquid assets held by firms that include Treasuries, Currency, Checking and Saving deposits, Municipal Bonds, and GSE and Agency-backed private bonds. Along the sample considered, corporate holdings of government-backed liquid assets amounts to a share of around 5% of GDP. I therefore fix $BoY = 0.05$. This is clearly and understatement of the extent of the average amount of government-backed liquidity over GDP present in the US economy, where the public debt over GDP alone in the same time frame amounts to an average of around 60%. I make this choice because aggregate Flow of funds data suggest that firms are not the primary holders of government bonds and because the primary goal of this work is to offer a realistic picture of the balance sheet and cash flow statements of US corporations to study the interaction between financial market conditions and investment decisions.

This brings the discussion to the calibration of fiscal parameters that govern the government budget constraint in steady state:

$$B_{ss} + \tau^k R_{ss}^k K_{ss} + \tau^l W_{ss} L_{ss} = R_{ss}^B B_{ss} + \left(1 - \frac{1}{g_{ss}}\right) Y_{ss} + T_{ss} \tag{32}$$

To calibrate the tax rates on capital and labor income, τ^k and τ^l, I rely on work on fiscal policy in DSGE models by Leeper, Plante, and Traum (2010). I calibrate the distortionary tax rate on labor and capital income, τ^l and τ^K, to 23% and 18% respectively. I choose the steady state value for g_{ss} to match the 19% average share of government expenditures over GDP observed during the sample period. Having pinned down the level of government-backed liquidity, the steady state share of lump-sum transfers to households over GDP can be found by solving (32). Transfers dynamics instead govern the aggregate supply of liquid assets in general equilibrium over time by means of the taxation rule:

$$\frac{T_t/Y_t}{T_{ss}/Y_{ss}} = \left(\frac{\Delta \log Y_{t-s}}{\gamma}\right)^{-\varphi_Y} \left(\frac{B_t/Y_t}{BoY}\right)^{-\varphi_B}$$

where I calibrate $\varphi_B = 0.4$ as in Leeper, Plante, and Traum (2010) , a value that makes this fiscal rule passive by reducing transfers when the share of government debt over GDP deviates from its steady state value. This locks the economy on a stable equilibrium path for the growth rate of the price level, with no conflict with the monetary authority's Taylor-type rule (Woodford (2003)). I fix the elasticity of transfers to deviation of output growth from it steady state, $\varphi_Y = 0.13$, at the value that Leeper, Plante, and Traum (2010)'s estimate for transfers reactions to output deviations from steady state in a stationary model. Notice that the transfers policy is countercyclical (when output growth is low, transfers to households are higher).

A few more choices of priors require a brief discussion. In particular, the parameters governing the distribution of idiosyncratic technology of entrepreneurs $A_{e,t} \sim U\left[A^{lo}, A^{hi}\right]$. I set priors on A^{low} and on the difference $d = A^{high} - A^{low}$, so that combined with prior mean values for the financial parameters, I can approximately match the steady state share of Sellers in the model with the average share of Compustat firms that rely on financial markets in every quarter, 45%. Finally, I calibrate the quarterly rate of capital depreciation to 0.025, a standard value in the RBC and DSGE literature.

The model is buffeted by i.i.d. random innovations:

$$\left[\varepsilon_t^z, \varepsilon_t^{mp}, \varepsilon_t^g, \varepsilon_t^p, \varepsilon_t^w, \varepsilon_t^{\tau_q}, \varepsilon_t^b\right]$$

that respectively hit seven exogenous processes: the growth rate of total factor productivity, z_t, deviations from he Taylor rule $\eta_{mp,t}$, the share of government spending over GDP, g_t, the price and wage mark-ups, $\lambda_t^p$and λ_t^w, the financial intermediation wedge, τ_t^q and the discount factor, b_t.

To conclude, the priors on the persistence parameters for the exogenous processes are all Beta distributions. All have mean equal to 0.6 and standard deviation 0.2, except for the persistence of the neutral technology process, ρ_z. The monetary policy shock is assumed to be i.i.d., because the Taylor rule already allows for autocorrelation in the determination of the risk-free rate. The priors on the standard deviations of the innovations expressed in percentage deviations are inverse Gammas with mean 0.5 and standard deviation equal to 1, excluding the shock to the monetary policy rule, ε_t^{mp}, to the price and wage mark-ups, ε_t^p and ε_t^w, and to the discount factor, where the prior has a mean of 0.10 and a standard deviation of 1. I set a prior on the standard deviation of the measurement error on the spread that wants to be conservative with a mean of 15 basis points and a standard deviation of 5.

I complement this set of calibrated parameters and exogenous priors, with prior information on the second moments of the observed variables computed over a pre-sample that spans from 1954Q3 to 1988Q4. Pre-sample data is available for all the series, excluding the spread, Sp_t. In particular, I follow Christiano, Trabandt, and Walentin (2010) and set prior distributions on the variance of the observable variables using the asymptotic Normal distribution of their GMM estimator computed over the pre-sample. This allows me to help the identification of the highly-parametrized model and to help the estimation procedure to identify regions of the parameter space that can generate business cycle fluctuations of plausible magnitude. Table 5 reports the mean and standard deviations of the moment priors.

4 Results

This section reports the results of the Bayesian estimation of the model parameters, devolving particular attention to the coefficients that govern the financial structure of the model. I then discuss the model fit and describe the impulse responses of key variables to a financial intermediation shock. I present the variance decomposition of the observable variables and their historical decomposition during the Great Recession. I conclude the section with evidence that wage rigidities are the key element that allows the financial intermediation shock to play a fundamental role in driving the business cycle in the past 20 years of data.

4.1 Parameter Estimates

Table 3 reports the median and 90% confidence intervals for the set of model parameters, while table 6 reports the same quantiles for model-implied moments of the key financial variables introduced in section 1 and compares them with their empirical counterparts. I compute the confidence interval by running a Markov chain Monte Carlo exploration of the posterior distribution.

Estimates of conventional parameters such as those governing price and wage rigidities, the investment adjustment cost friction as well as the degree of persistence and magnitudes of traditional shocks are in line with previous findings in the literature. The estimated steady state annualized spread, $400\tau_q$, ranges between 1 and 36 basis points, despite its prior distribution mean matching a quarterly risk spread equal to 250 basis points (Cúrdia and Woodford (2010b)). The estimation favors steady state equilibria in which financial intermediation costs are low and attributes the observed cyclical fluctuations in the spread to large realizations of the financial shock (see 7 where the model-implied volatility of the spread is higher than in the data).

Table 6 shows that the estimated steady state value of the financing gap share assumes values that are consistent with Compustat evidence. The 90% confidence interval for the model-implied moment ranges between [34.9%, 37.8%], compatible with the 35.5% fraction of total investment funded using financial markets found in Compustat data in section 1. The estimated steady state share of the financing gap that is covered by liquidation of assets ranges between [23.6%, .29.6%], compatible with the 24.3% average over the whole sample period available in Compustat.

Finally, the table shows the average over time of the fraction of firms that record a negative Financing Gap in Compustat in each quarter and compares its model equivalent, $\chi_{s,t} = \Pr\{FG_{e,t} \leq 0\}$. The model estimation does not match this moment perfectly, although the 90% confidence interval ($[58.6\%, 63.4\%]$) contains values that are far from the sample realization observed in Compustat (49%).

4.2 Model Fit

Table 7 reports confidence intervals for the standard deviations of the variables relative to output volatility and compares them to the sample data standard deviations. The table also includes the standard deviations implied by the endogenous priors on the second moments of the observables introduced in section 3.1.

The model is able to match the absolute volatility of investment, as well as the standard deviation of the risk-free-rate observed in the data. The estimation also delivers standard deviations that are compatible with pre-sample evidence for inflation and hours worked and tries to balance the differences in the volatility of the growth rate of real wages across the two periods. The model however comes short when trying to match the standard deviations of output and consumption. As discussed in section 2.7, workers in the model earn and consume a large fraction of total GDP, with no access to financial market that can help smooth out the effect of aggregate shocks on labor earnings over time. The increased volatility in households' consumption translates in higher volatility of total output and prevents the model from delivering a successful matching of the relative volatility of the observables (Table 7).

Table 8 reports the autocorrelation coefficients of order one of the observable variables, compared to their data counterparts. The model is able to reproduce significant positive autocorrelations for all the observables, except for consumption growth. The model matches the autocorrelations coefficients for the nominal interest rate, the spread, the level of hours worked and for the rate of growth of real wages (computed excluding the last recession, see note in table 8) at a 90% confidence level. It fails to generate a sufficient level of persistence for output, investment and consumption, while it overstates the autocorrelation of inflation.

4.3 Impulse Responses to a Financial Intermediation Shock

Figure 8 reports the impulse responses to a one-standard-deviation financial shock, evaluated at the estimated parameter mode.

The plots are intuitive and show a recession of plausible magnitude, in which the negative response of output, consumption and investment on impact is significant at a 90% confidence level.

When the financial intermediation cost rises, the spread between the cost of raising external resources of entrepreneurs and the risk free rate rises by 150 basis points on an annual basis. Investment drops by 2% on impact, while consumption growth is reduced by 0.2%. Accordingly, the growth rate of output falls by 0.5%.

A remarkable feature of the impulse responses is that a negative financial shock in the model delivers a large drop in the price of equity, driving it 4% below its steady state level on impact. Hence, the financial intermediation shock generates intuitive and highly volatily cyclical movements in asset prices. This finding contrasts with the rise in equity price that follows a liquidity shock in the original KM model as carefully characterized by Shi (2011). [20]

The high degree of persistence of the impulse responses is attributable partly to the high autocorrelation coefficient of the exogenous process for the intermediation cost, τ_t^q, that tries to match the features of the observed high-yield spread in the data (figure 10). In addition, the slow convergence of the economy to its steady state after a financial intermediation shock is also due to the path followed by equilibrium real wages and aggregate consumption. As discussed in section 2.7, households do not trade on financial markets and consequently are only able to smooth out their consumption through wage re-optimization. Modeling entrepreneurs and workers as members of a single representative household, as in Shi (2011), can eliminate barriers to intertemporal consumption smoothing and allow for a less persistent response of real wages and workers' consumption path. [21]

One additional source of persistence originates from the endogenous effect that a financial shock has on the average investment technology adopted in the economy. A negative financial shock increase the cost of borrowing for the most productive entrepreneurs (with a high level of investment technology). The financial shock also reduces the rate of return to savings on financial assets. This induces some of the less efficient entrepreneurs to start using their capital accumulation technology instead of trading assets on financial markets. Referring to figure 7, higher financial intermediation costs lower the amount of external resources available to the most efficient entrepreneurs and at the same increase the fraction of Keepers, so that as a result the average relative price of investment in the economy goes up. Empirical work by Justiniano, Primiceri, and Tambalotti (2010) shows that investment-specific technology shocks (ISTSs) can account for large fractions of business cycle

[20] Nezafat and Slavík (2009) similarly document that in the KM set-up, a negative shock to entrepreneurs' borrowing capacity (an exogenous drop in θ in the model) also generates a rise in asset prices. Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) also note how in the KM model the interaction of negative liquidity shocks with a binding zero lower bound on the nominal interest rate and the presence of price rigidities can generate significant drops in asset prices and recessions comparable in size to the Great Depression.

[21] It is interesting to note how Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) have adopted both modeling strategies in different versions of their work and that the introduction of a representative household has left their predictions largely unchanged both quantitatively and qualitatively with respect to a model with both entrepreneurs and workers.

variation in output and suggest that these disturbances could originate on financial markets. Kahn and Thomas (2011) also study the effects of credit market shocks on the allocation of capital across firms with heterogeneous productivity. They find that credit shocks are amplified and propagated through large negative endogenous technology shocks, generated by disruptions to the distribution of capital away from the most productive firms. In my model a financial shock is paired endogenously with a negative ISTS.[22]

4.4 Variance Decomposition

This section quantifies the relative importance of the fundamental shocks in the model in driving business cycle fluctuations. Table 9 reports the contribution of each shock to the volatility of the observable variables in periodic cycles that range between 6 to 32 quarters in length, as in Stock and Watson (1999).

The sixth column suggests that the financial intermediation shock is the most important source of business cycle fluctuations, explaining around 35% of the unconditional variance of GDP growth and around 60% of the volatility of investment. The shock is also able to explain around 40% of cyclical movements in inflation and the vast majority of the variance of the nominal risk-free rate. This result suggests an active role of monetary policy through the Taylor rule in response to changes in output and prices induced by financial disturbances.[23]

The financial intermediation wedge, τ_t^q, maps closely to the observed high-yield spread series. The estimation procedure naturally attributes around 100% of cyclical fluctuations of the observed spread to the financial shock. This result is a product of the log-linearization of the model's equilibrium conditions that does not allow pricing of other sources of aggregate risk.[24]

Column 1 in table 9 shows how, according to the model estimates, neutral technology shocks only explain a small fraction of the variance of GDP growth in the last 20 years. The 90% confidence inverval for the share of GDP growth variance explained by TFP shocks ranges from 9% to 20%. This result confirms the conclusions of previous work in the empirical macro literature that attributes the

[22] One more interesting consequence of the interaction of financial shocks with the aggregate investment technology pertains to the dynamics of the price of capital. In my model, with heterogeneous entrepreneurs and an intermediation sector, after a negative financial shock hits the price of traded equity at which banks are willing to buy assets, q_t^A, plunges while the average relative price of investment rises. In a representative agent model the price of capital necessarily coincides with the relative price of investment. The negative co-movement of the price of capital and output induced by ISTSs leads Christiano, Motto, and Rostagno (2010) to prefer financial shocks over ISTSs as important drivers of the business cycle. My model shows that the two sources of aggregate fluctuations can be strictly connected and that in particular ISTSs can have a financial origin.

[23] Christiano, Motto, and Rostagno (2010) find that financial (risk) shocks in a Bernanke, Gertler, and Gilchrist (1999) framework can account for around 20% and 30% of output fluctuations in the U.S. and the Euro Area respectively. Christiano, Trabandt, and Walentin (2011) find that the same shock explains 25% of output growth and 75% of investment growth in a small open economy like Sweden.

[24] The estimation of higher order perturbations of the solution of a model with similar frictions and a high degree of risk aversion could identify different sources of time-varying risk premia in the spreads. I leave this extension for future research.

cause of economic fluctuations in the past 20 years predominantly to demand shocks.[25]

4.5 Smoothed Shocks and Historical Decomposition of the Great Recession

In this section I present the historical contribution of the financial shock to the dynamics of output growth along the sample and run some counterfactual exercises to study the contribution of aggregate shocks to the dynamics of the Great Recession.

Figure 11 provides a time series representation of the evolution of quarterly output growth conditional on the presence of financial shocks alone (red dotted line) and compares it to the observed data series (black solid line). The two lines show remarkably similar features and the financial shock seems to drive output growth variations alone in the boom of the 2000s. The shock is also identified as the main cause of the recessions in 1990-1991, when the junk bond market and the Savings and Loans industry collapsed, as well as in 2008-2010, marked by the upheaval on the subprime mortgage market.

Figure 12 offers a closer look at the contribution of shocks in the model to the evolution of output growth during the last recession. I concentrate on the role of financial shocks, $\varepsilon_t^{\tau_q}$, as well as of the neutral technology shocks, ε_t^z, and the two policy disturbances: the monetary policy shocks, ε_t^{mp}, modeled as random deviations from the Taylor rule, and the government spending shock, ε_t^g. I compute the counterfactual smoothed series for output growth at the posterior mode. This exercise shows how output growth dynamics would have differed from the path observed in the data when excluding the smoothed realizations of each type of shock one at a time.

For example, the top left panel in figure 12 shows what output growth would have been in absence of the financial shock (red dashed line) compared to the data (blue solid line) from 2007Q1 to 2010Q1. The estimation suggests that a series of negative financial shocks raised intermediation costs and slowed down output growth starting in 2007Q3. In absence of the negative financial shocks, the contraction in output growth observed in the data would have been observed only in the second half of 2008 and be limited in magnitude.

A second interesting finding comes from the analysis of the role of innovations to total factor productivity. The top right panel suggests that the past recession was characterized by an increase in TFP, in line with recent findings by Fernald (2009) and Shimer (2010). As evidenced by the red dashed line, in absence of positive technology shocks, output would have contracted by an additional 0.5% at the trough and the recovery would have been slower.

The bottom left panel also suggests that government spending shocks played an important role in reducing the impact on output of the recession. In absence of positive government spending

[25] For estimations on a similar sample period see Christiano, Motto, and Rostagno (2010). In support of a reduced role for technology shocks in recent history, Shimer (2010) finds no evidence in the last 20 years of U.S. data that labor productivity and real wages are procyclical. More specifically, Fernald (2009) reports that TFP has increased during the last recession, in line with the path of smoothed productivity shocks that I obtain from my model. See section 4.5 for more details.

shocks, the red dashed line shows that output would have fallen by an additional 1% at the trough. Public sector deficits are beneficial in the model, as financially constrained entrepreneurs demand government bonds as a form of precautionary savings to insure against the future arrival of investment opportunities, in the spirit of policy experiments in Kiyotaki and Moore (2008) and Guerrieri and Lorenzoni (2011).

On the other hand, the bottom right panel and the smoothed series of monetary policy shocks in figure 13 seem to suggest that, although the reduction in the fed funds rate helped sustain economic growth at the onset of the recession, monetary policy interventions became ineffective and that the zero-lower bound on the nominal interest rate became binding in the second half of 2008. The series of positive monetary policy shocks in figure 13 suggest that the nominal interest rate has been consistently higher than the value implied by the estimated Taylor-type rule.[26]

4.6 Why are Financial Shocks Important?

Any general equilibrium model that aims to identify the role of non-TFP shocks as possible drivers of business cycle fluctuations has to be able to generate the positive co-movement between consumption and investment observed in the data at business cycle frequencies. In an influential article, Barro and King (1984) show how, in a general equilibrium model with flexible prices and wages in the Real Business Cycle tradition, it is hard to detect sources of business cycle fluctuations different from changes in total factor productivity, that can trigger positive co-movement of hours worked, consumption and investment. In fact, any shock that increases the equilibrium quantity of hours worked on impact has to induce a contemporaneous drop in consumption to maintain the equilibrium equality between the marginal product of labor and the marginal rate of substitution between consumption and hours worked (see Justiniano, Primiceri, and Tambalotti (2010) for further details).

In this section I explore the reason why the posterior maximization favors the financial shock as the main driver of business cycle fluctuations. I find that nominal rigidities, and in particular sticky wages are the key element in driving aggregate consumption, investment and hours worked in the same direction on impact after a financial intermediation shock.

4.6.1 Sticky Wages and Positive Co-movement of Investment and Consumption

In this section I discuss the importance of the assumption of nominal and real wage rigidities in generating a recession in which aggregate output, consumption and investment drop simultaneously on impact after the shock. To establish the importance of the frictions, I first discuss the impulse responses in the benchmark model estimated under the assumption that wages are sticky. I then

[26] Research by Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) suggests that unconventional monetary policy (e.g. in the model, public supply of liquid assets, B_t in exchange for illiquid ones, N_t) can play an important role in sustaining economic activity after a negative shock to the liquidity of traded assets, especially when the zero lower bound is binding. For estimation purposes, I abstract from imposing the zero lower bound on the nominal interest rate.

re-estimate the model under flexible wages and compare the impulse responses to the benchmark. I finally analyze the variance decomposition of the model under flexible wages and note how the new assumption significantly reduces the importance of the financial intermediation shock in explaining business cycle fluctuations.

In my model there are two classes of agents: entrepreneurs and households. Entrepreneurs optimize their stream of consumption through time and save by accumulating equity claims as well as government bonds. They do not supply hours worked on the labor market. Households, on the other hand, have no access to financial markets and consume the realization of their income in every period. This feature of the model allows me to intuitively describe the inter-temporal and the intratemporal transmission channels of an intermediation shock, by studying the effects on each of the two sets of agents separately.

Figure 9 shows the impulse responses for aggregate output, investment and consumption growth to a one-standard deviation financial shock, together with the breakdown of aggregate consumption into entrepreneurs' and households' shares, C_t^e and C_t^w respectively. The figure also shows the dynamics of hours worked. The impulse response in the black dashed lines are computed at the posterior mode parameters in table 3 for the benchmark model with price and wage rigidities.

On the intertemporal margin, If the intermediation spread, τ_t^q, rises and intermediation of financial claims becomes more expensive, entrepreneurs with a good investment opportunity perceive an increase in their cost of borrowing: the price of equity claims drops and entrepreneurs can rely on a reduced amount of external resources to install new capital. As a consequence investment, I_t, plunges. On the other side of the financial market, entrepreneurs with inefficient technologies expect lower real returns on financial assets and consequently reduce their savings and increase their consumption. On aggregate, investment and savings drop, while consumption of entrepreneurs, C_t^e, rises.[27]

On the intratemporal margin, instead, the model is able to make households' consumption drop

[27] Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) also emphasize that KM's model of liquidity shocks can produce positive co-movement between consumption and investment when the economy features a certain degree of nominal rigidities. The transmission mechanism is similar to one proposed in Christiano, Motto, and Rostagno (2011) and Christiano, Motto, and Rostagno (2010). While in a frictionless RBC model a negative intertemporal shock (e.g. a financial shock) reduces aggregate investment, lowers the real interest rate and drives up consumption, in a Neo-Keynesian model with nominal rigidities, the real interest rate is approximately defined as the difference between the nominal interest rate and expected future inflation:

$$r_t^B \simeq R_t^B - E_t\left(\pi_{t+1}\right)$$

and depends on the monetary authority decisions. If, following the shock, prices are expected to drop and the central bank does not decrease the nominal interest rate enough, the real interest rate can rise. The price of capital has to drop to re-establish non-arbitrage between government bonds and equity claims. At the same time consumption will drop, together with investment. In Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010), the negative shift in asset prices, consumption and entrepreneurial net worth is particularly pronounced when the nominal interest rate hits the zero lower bound: in that case any expected future drop in the price level translates into an increase of the real interest rate of the same magnitude with potential disastrous effects on every component of aggregate output. As I discuss later in this section, in my model the intertemporal transmission channel is not as important in delivering the positive co-movement between consumption and investment as is instead the effect of wage rigidities on the labor market dynamic equilibrium in response to an aggregate demand shock.

on impact thanks to sticky wages. The drop in aggregate demand translates into a downward shift in the demand for labor inputs. If workers cannot re-optimize their wages freely, the decrease in labor demand translates into a large drop in the equilibrium amount of hours worked, L_t. The drop in hours amplifies the negative effect of the shock on aggregate production and GDP, and contemporaneously reduces the wage bill, $\mathrm{W}_t\mathrm{L}_t$. In equilibrium the drop in the wage bill pushes down households' and aggregate consumption, C_t^w and C_t, and generates the right positive co-movement between investment and consumption on impact. The shock has also a secondary effect: the fall in aggregate demand reduces the marginal costs of intermediate monopolists and increases the price mark-up and firms' monopolistic profits. Households own the intermediate firms and the rise in profits levels helps them sustain their consumption after the shock hits. The secondary effect however is not strong enough to dominate the drop in households' consumption generated by the decrease in the aggregate wage bill.[28]

To confirm this intuition, figure 9 also shows the impulse response functions for the same variables at the posterior mode, when the model is re-estimated under the assumption that wages are perfectly flexible (blue solid lines).[29] As in the case of sticky wages, the reduction in labor demand translates into lower equilibrium wages and hours worked. Simultaneously, lower real wages translate into higher mark-ups for the monopolistic firms and the increase in firms' profits. This generates a positive income effect for households that allows them to reduce their labor supply. The equilibrium outcome shows a larger negative adjustment in the wage rate relative to the benchmark sticky wages model, while hours worked drop by a lower amount. Households' wage bill falls, but they are able to keep a smoother consumption profile with respect to the sticky wages case by relying on both a sustained equilibrium level of hours worked and higher profits from the monopolistic firms. As a consequence, the drop in households' consumption is not large enough to drive aggregate consumption down in response to a financial intermediation shock. Consumption and investment move in opposite direction in the short run and the financial shock loses its ability to generate an empirically plausible recession.

This intuition is confirmed by comparing the variance decomposition exercises for the model estimated under the assumption of sticky and flexible wages. I report results for the two cases respectively in tables 9 and 10.[30] The estimation of the model under flexible wages shows that the importance of the financial intermediation shock in explaining business cycle fluctuations in output, investment and consumption growth drops significantly with respect to the sticky wages model. The shock is able to explain 9.5% of GDP growth variance and 49% of aggregate investment growth variance compared to 35% and 60% under sticky wages. The financial shock in the benchmark model is able to explain 7% of business cycle volatility in aggregate consumption, while under flexible wages

[28] The assumption that households own intermediate firms is controversial, but necessary to keep the entrepreneurs' optimal consumption, investment and trading decisions tractable.

[29] The estimated parameters and posterior characterization for the model with flexible wages are reported in table 5.

[30] Parameter estimates or the model with flexible wages are reported in table 4.

it can account for a mere 1%.

This result is in line with the intuition discussed for the impulse responses in figure 9: financial intermediation shocks are not able to generate the right co-movement between investment and consumption and hence meaningful booms and recessions. Consequently, under flexible wages TFP shocks gain importance in explaining business cycle fluctuations as in the traditional RBC literature (from 13% to 30% of GDP growth volatility explained at business cycle frequencies). Similarly, exogenous shocks to wage mark-ups, λ_w, increase their relevance in explaining aggregate cycles. As noted in Justiniano, Primiceri, and Tambalotti (2010), sticky wages drive an endogenous wedge between the real wage and the marginal rate of substitution between consumption and hours worked in the intratemporal Euler equation of the households. Under flexible wages, exogenous shocks to the wage mark-up substitute the endogenous change in equilibrium mark-ups induced by the other structural shocks (including financial intermediation shocks) in the sticky-wage case. As a result, exogenous wage mark-up shocks go from explaining 12% of GDP growth variance under sticky wages to 25% under flexible wages.[31]

5 Conclusions

In this paper I have addressed the question of how important are shocks to the ability of the financial sector in driving the business cycle. The main finding of this research is that the contribution of financial shocks to cyclical fluctuations is very large and accounts for around 35% of output and 60% of investment volatility, when estimated on the last 20 years of US macro data.

To establish this result, I have estimated a dynamic general equilibrium model with nominal rigidities and financial frictions in which entrepreneurs rely on external finance and trading of financial claims to fund their investments. The model features stylized financial intermediaries (banks) that bear a cost to transfer resources from savers to investors.

Shocks to the financial intermediation costs intuitively map into movements of the interest rate spreads and are able to explain the dynamics of the real variables that shaped the last recession, as well as the 1990-1991 downturn and the boom of the 2000s. I find that nominal rigidities play an important role in the transmission of the financial shocks. In particular wage rigidities allow the shock to generate the positive co-movement of investment and consumption that is observed in the data along the business cycles. Assuming flexible wages and re-estimating the model on the same data series along the same sample period delivers very different results: the financial intermediation shock is only able to explain around 9.5% of output growth and 49% of investment growth volatilities.

[31] For further support to the role of wage rigidities in the transmission of intertemporal disturbances see also Justiniano, Primiceri, and Tambalotti (2010) and Furlanetto and Seneca (2010) on investment-specific technology shocks.

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Tables and Figures

Table 1: Compustat and Flow of Funds data on Capital Expenditures and Investment

	V_t		
Moment	$CAPX_t$	FoF $CAPX_t$	FoF I_t
$E[\frac{CAPX_t}{V_t}]$	1	73.11%	35.64%
$E[\Delta \log V_t]$	0.96%	1.03%	0.81%
100 Stdev$[\Delta \log V_t]$	4.9%	2.7%	3.6%
Corr$[\Delta \log V_t, \Delta \log CAPX_t]$	1	0.63	0.30

Variables V_t in columns are: $CAPX_t$: Compustat aggregate Capital Expenditure; FoF $CAPX_t$: Flow of Funds Corporate Capital Expenditure; FoF I_t: Flow of Funds Aggregate Investment. The table reports: $E[\frac{CAPX_t}{V_t}]$: the average fraction of each variable represented by Compustat Capital Expenditure; 100 $E[\Delta \log V_t]$: the average quarterly growth rate of the series along the sample period; 100 Stdev$[\Delta \log V_t]$: the standard deviation of the quarterly growth rate of the series; Corr$[\Delta \log V_t, \Delta \log CAPX_t]$: the correlation of each series with $CAPX_t$.
Source: Compustat and Flow of Funds Tables. Sample Period 1989Q1 - 2010Q1.

Table 2: Compustat Evidence on Corporate Investment Financing

Variable V_t	Mean(V_t)	StdDev(V_t)
FGS_t^1	**35.45%**	**4.74%**
FGS_t - Annual (Chari - Kehoe method)^2	18.74%	5.17%
FGS_t - Quarterly (Chari - Kehoe method)^3	39.12%	6.75%
WKS_t^4	32.05%	4.34%
$DIVS_t^5$	25.87%	7.02%
–		
DES_t = External Finance$_t$ / FG_t^6	75.67%	22.45%
$LIQS_t$ = Portfolio Liquidations$_t$ / FG_t^7	24.33%	22.45%
$CASHS_t = \Delta CASH_t$ / FG_t^8	20.74%	14.49%

Mean and standard deviations of variables across sample Period 1989Q1 - 2010Q1, if not otherwise specified. Source: Compustat.

1. Financing Gap Share of Capital Expenditure defined in equation 5, total of U.S. corporations.
2. Financing Gap Share, Chari and Kehoe's method, total of North American corporations (U.S. and Canada). Sample period: 1971 - 2009.
3. Financing Gap Share, Chari and Kehoe's method, total of North American corporations.
4. Share of Total Financing Gap due to working capital needs. U.S. corporations.
5. Weight of Dividend payouts on Total Financing Gap. U.S. corporations.
6. Share of Financing Gap funded by external sources (debt and/or equity). U.S. corporations.
7. Share of Financing Gap funded by portfolio liquidations. U.S. corporations
8. Share of Financing Gap funded by variations in cash reserves. U.S. corporations

Parameters Estimates - Sticky Wages

Table 3: Calibrated Values, Priors and Posterior Estimates for the Model Parameters

Parameter	Explanation	Prior[1]	Mode	[	5%[2]		95%[2]	]
A^{low}	Entrepreneurs's tech distribution (level)	$N(0.90, .010)$	0.879	[	0.787	–	1.065	]
d	Entrepreneurs's tech distribution (width)	$IG(0.025, 0.05)$	0.023	[	0.019	–	0.033	]
$\left(\beta^{-1}-1\right)\times 100$	Discount factor	*Calibrated*	0.900	[	–	–	–	]
h	Habit	*Calibrated*	0.900	[	–	–	–	]
$\log L_{ss}$	Labor Supply	$N(2, 0.50)$	1.779	[	1.027	–	2.604	]
ν	Inverse Frisch	$G(2, 0.50)$	1.295	[	0.862	–	1.961	]
θ	Borrowing Constraint	$B(0.30, 0.10)$	0.271	[	0.257	–	0.297	]
$\phi \times 100$	Liquidity Constraint	$G(0.50, 0.10)$	0.074	[	0.027	–	0.102	]
BoY	Liquidity over GDP	*Calibrated*	0.025	[	–	–	–	]
φ^B	Fiscal Rule - Debt	*Calibrated*	0.500	[	–	–	–	]
φ^B	Fiscal Rule - Output	*Calibrated*	0.130	[	–	–	–	]
τ^K	Capital Tax Rate	*Calibrated*	0.184	[	–	–	–	]
τ^l	Labor Tax Rate	*Calibrated*	0.223	[	–	–	–	]
α	Share of Capital	$B(0.30, 0.10)$	0.287	[	0.266	–	0.315	]
S	Investment Adj. Costs	$G(2, 0.50)$	1.276	[	0.965	–	2.060	]
λ_p	Price Mark-up	$IG(0.15, 0.05)$	0.061	[	0.047	–	0.079	]
ξ_p	Calvo prices	$B(0.70, 0.10)$	0.799	[	0.722	–	0.835	]
ι_p	Indexation Prices	$B(0.50, 0.15)$	0.125	[	0.058	–	0.236	]
λ_w	Wage Mark-up	$IG(0.15, 0.05)$	0.124	[	0.090	–	0.226	]
ξ_w	Calvo wages	$B(0.70, 0.10)$	0.729	[	0.654	–	0.781	]
ι_w	Indexation Wages	$B(0.50, 0.15)$	0.201	[	0.118	–	0.378	]
ϕ^π	Taylor rule - Inflation	$N(1.7, 0.30)$	1.900	[	1.716	–	2.091	]
ϕ^y	Taylor rule - Output	$N(0.125, 0.05)$	0.269	[	0.2400	–	0.300	]

continued

Parameter	Explanation	Prior[1]	Mode	[	5%[2]		95%[2]	]
ρ^R	Taylor rule - Persistence	$B(0.60, 0.20)$	0.847	[	0.815	–	0.870	]
π_{ss}	SS Inflation	$N(0.50, 0.10)$	0.758	[	0.584	–	0.849	]
γ	SS Output Growth	$N(0.30, 0.05)$	0.326	[	0.254	–	0.395	]
τ_q	SS Spread	$G(0.625, 0.15)$	0.018	[	0.003	–	0.090	]
θ_p	MA(1) Price Mark-up	$B(0.50, 0.10)$	0.820	[	0.653	–	0.853	]
θ_w	MA(1) Wage Mark-up	$B(0.50, 0.10)$	0.660	[	0.416	–	0.751	]
ρ_z	AR(1) TFP shock	$B(0.40, 0.20)$	0.412	[	0.301	–	0.487	]
ρ_g	AR(1) Gov't spending	$B(0.60, 0.20)$	0.982	[	0.960	–	0.991	]
ρ_p	AR(1) Price Mark-up	$B(0.60, 0.20)$	0.933	[	0.880	–	0.968	]
ρ_w	AR(1) Wage Mark-up	$B(0.60, 0.20)$	0.890	[	0.784	–	0.914	]
ρ_{τ_q}	AR(1) Financial Spread	$B(0.60, 0.20)$	0.981	[	0.972	–	0.984	]
ρ_b	AR(1) Intertemporal pref.	$B(0.40, 0.20)$	0.973	[	0.947	–	0.990	]
σ_z	Stdev TFP Shock	$IG(0.50, 1)$	0.482	[	0.431	–	0.515	]
σ_{mp}	Stdev MP Shock	$IG(0.50, 1)$	0.119	[	0.107	–	0.140	]
σ_g	Stdev Gov't Shock	$IG(0.50, 1)$	0.326	[	0.296	–	0.376	]
σ_p	Stdev Pr. Mark-up Shock	$IG(0.50, 1)$	0.151	[	0.127	–	0.187	]
σ_w	Stdev Wage Mark-up Shock	$IG(0.50, 1)$	0.298	[	0.264	–	0.368	]
σ_{τ_q}	Stdev Financial Shock	$IG(0.50, 1)$	4.870	[	4.212	–	5.603	]
σ_b	Stdev Preference Shock	$IG(0.50, 1)$	0.027	[	0.025	–	0.030	]
σ_η	Stdev Meas Error Spread	$IG(0.25, 1)$	0.475	[	0.482	–	0.565	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 N stands for Normal, B Beta, G Gamma and IG Inverse-Gamma1 distribution.
2 Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm.
Acceptance rate 31%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Parameters Estimates - Flexible Wages

Table 4: Calibrated Values, Priors and Posterior Estimates for the Model Parameters

Parameter	Explanation	Prior[1]	Mode	[	5%[2]		95%[2]	]
A^{low}	Entrepreneurs's tech distribution (level)	$N(0.90, .010)$	0.909	[	0.798	–	1.060	]
d	Entrepreneurs's tech distribution (width)	$IG(0.025, 0.05)$	0.023	[	0.018	–	0.028	]
$(\beta^{-1} - 1) \times 100$	Discount factor	*Calibrated*	0.900	[	–	–	–	]
h	Habit	*Calibrated*	0.900	[	–	–	–	]
$\log L_{ss}$	Labor Supply	$N(2, 0.50)$	1.855	[	1.179	–	2.542	]
ν	Inverse Frisch	$G(2, 0.50)$	0.438	[	0.291	–	0.589	]
θ	Borrowing Constraint	$B(0.30, 0.10)$	0.268	[	0.252	–	0.285	]
$\phi \times 100$	Liquidity Constraint	$G(0.50, 0.10)$	0.072	[	0.048	–	0.096	]
BoY	Liquidity over GDP	*Calibrated*	0.025	[	–	–	–	]
φ^B	Fiscal Rule - Debt	*Calibrated*	0.500	[	–	–	–	]
φ^B	Fiscal Rule - Output	*Calibrated*	0.130	[	–	–	–	]
τ^k	Capital Tax Rate	*Calibrated*	0.184	[	–	–	–	]
τ^l	Labor Tax Rate	*Calibrated*	0.223	[	–	–	–	]
α	Share of Capital	$B(0.30, 0.10)$	0.272	[	0.253	–	0.291	]
$S"$	Investment Adj. Costs	$G(2, 0.50)$	2.470	[	1.842	–	3.339	]
λ_p	Price Mark-up	$IG(0.15, 0.05)$	0.053	[	0.042	–	0.066	]
ξ_p	Calvo prices	$B(0.70, 0.10)$	0.603	[	0.533	–	0.659	]
ι_p	Indexation Prices	$B(0.50, 0.15)$	0.109	[	0.049	–	0.247	]
λ_w	Labor Pref	$IG(0.15, 0.05)$	0.161	[	0.098	–	0.261	]
ϕ^π	Taylor rule - Inflation	$N(1.7, 0.30)$	1.764	[	1.582	–	1.914	]
ϕ^y	Taylor rule - Output	$N(0.125, 0.05)$	0.209	[	0.182	–	0.237	]
continued								

Parameter	Explanation	Prior[1]	Mode	[	5%[2]		95%[2]	]
ρ^R	Taylor rule - Persistence	$B(0.60, 0.20)$	0.790	[	0.757	–	0.817	]
π_{ss}	SS Inflation	$N(0.50, 0.10)$	0.786	[	0.685	–	0.884	]
γ	SS Output Growth	$N(0.30, 0.05)$	0.343	[	0.276	–	0.400	]
τ_q	SS Spread	$G(0.625, 0.15)$	0.013	[	0.001	–	0.028	]
θ_p	MA(1) Price Mark-up	$B(0.50, 0.10)$	0.444	[	0.145	–	0.741	]
θ_w	MA(1) Laboor Pref	$B(0.50, 0.10)$	0.297	[	0.171	–	0.406	]
ρ_z	AR(1) TFP shock	$B(0.40, 0.20)$	0.153	[	0.080	–	0.244	]
ρ_g	AR(1) Gov't spending	$B(0.60, 0.20)$	0.983	[	0.963	–	0.992	]
ρ_p	AR(1) Price Mark-up	$B(0.60, 0.20)$	0.981	[	0.970	–	0.988	]
ρ_w	AR(1) Labor Pref	$B(0.60, 0.20)$	0.672	[	0.326	–	0.928	]
ρ_{τ_q}	AR(1) Financial Spread	$B(0.60, 0.20)$	0.981	[	0.975	–	0.986	]
ρ_b	AR(1) Intertemporal pref.	$B(0.40, 0.20)$	0.954	[	0.922	–	0.981	]
σ_z	Stdev TFP Shock	$IG(0.50, 1)$	0.450	[	0.417	–	0.483	]
σ_{mp}	Stdev MP Shock	$IG(0.50, 1)$	0.129	[	0.113	–	0.15	]
σ_g	Stdev Gov't . Shock	$IG(0.50, 1)$	0.320	[	0.287	–	0.362	]
σ_p	Stdev Pr. Mark-up Shock	$IG(0.50, 1)$	0.225	[	0.169	–	0.314	]
σ_w	Stdev Labor Pref Shock	$IG(0.50, 1)$	44.162	[	41.651	–	46.787	]
σ_{τ_q}	Stdev Financial Shock	$IG(0.50, 1)$	4.50	[	3.89	–	5.158	]
σ_b	Stdev Preference Shock	$IG(0.50, 1)$	0.031	[	0.029	–	0.034	]
σ_η	Stdev Meas Error Spread	$IG(0.25, 1)$	0.435	[	0.373	–	0.503	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1. N stands for Normal, B Beta, G Gamma and IG Inverse-Gamma distribution
2. Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm.
Acceptance rate 29%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 5: Priors on Theoretical Moments

Moment	Prior Type	Prior Mean	Prior Std
$\text{Var}(\Delta \log X_t)$	N	1.15	0.18
$\text{Var}(\Delta \log I_t)$	N	16.35	2.63
$\text{Var}(\Delta \log C_t)$	N	0.29	0.04
$\text{Var}(R_t^B)$	N	0.84	0.23
$\text{Var}(\pi_t)$	N	0.43	0.10
$\text{Var}(logL)$	N	10.74	2.36
$\text{Var}(Sp_t)$	-	-	-
$\text{Var}(\Delta \log w_t)$	N	0.20	0.03
$\text{E}[FGS_t]$	B	0.30	0.05
$\text{E}[LIQS_t]$	B	0.25	0.10

Prior distributions on the variances of observables are the Normal asymptotic distributions of the GMM variance estimators, computed on a pre-sample that spans from 1954:Q3 to 1988:Q4. Source: Haver Analytics. Prior distributions on steady state level of financing gap share (FGS_t) and share of portfolio liquidations over total financing gap (PLS_t), centered around Compustat sample averages over a period 1989:Q1 - 2010:Q1. Source: Compustat

Table 6: Compustat Moments - Estimated Model vs. Data

	Data	Model Median	[5%		95%]
$E[FGS_t]$	0.355	0.364	[0.349	–	0.378]
$E[LIQS_t]$	0.243	0.267	[0.236	–	0.296]
$Pr(FG<0)$	0.49	0.610	[0.586	–	0.630]

Estimated steady state level of financing gap share (FGS_t), share of external finance over financing gap (DES_t), share of portfolio liquidations over total financing gap (LIQS_t), share of firms that record negative financing gaps. Model implied moments are compared with data averages. Source: Compustat. Sample period: 1989:Q1 to 2010:Q1). Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 31%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 7: Model Fit : Standard Deviations

Observables	Data	Model				Prior Mean
		Median	5%	-	95%	
Stdev($\Delta \log X_t$)	0.63	0.80	[0.69	-	0.93]	1.07
Stdev($\Delta \log I_t$)	2.58	2.41	[2.03	-	2.84]	4.04
Stdev($\Delta \log C_t$)	0.50	0.68	[0.59	-	0.78]	0.54
Stdev(R_t^B)	0.58	0.72	[0.42	-	1.24]	0.92
Stdev(π_t)	0.27	0.54	[0.40	-	0.77]	0.66
Stdev($\log L_t$)	4.75	2.77	[1.75	-	4.39]	3.28
Stdev(Sp_t)	0.52	1.11	[0.75	-	1.84]	-
Stdev($\Delta \log w_t$)	0.75	0.58	[0.49	-	0.67]	0.45

Standard deviations of observable variables. Model implied vs. Data and implied prior distribution mean from Table 5. Source: Haver Analytics. Sample period: 1989Q1 - 2010Q1. Pre-sample for priors: 1954Q3 - 1988Q4. Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 31%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 8: Model Fit : Autocorrelations of Order 1

Observables	Data	Model			
		Median	5%	-	95%
Corr($\Delta \log X_t, \Delta \log X_{t-1}$)	0.47	0.194	[0.003	-	0.382]
Corr($\Delta \log I_t, \Delta \log I_{t-1}$)	0.60	0.239	[0.050	-	0.412]
Corr($\Delta \log C_t, \Delta \log C_{t-1}$)	0.51	0.140	[-0.050	-	0.326]
Corr(R_t^B, R_{t-1}^B)	0.93	0.956	[0.902	-	0.981]
Corr(π_t, π_{t-1})	0.52	0.782	[0.621	-	0.889]
Corr($\log L_t, \log L_{t-1}$)	0.93	0.927	[0.845	-	0.968]
Corr(Sp_t, Sp_{t-1})	0.81	0.742	[0.455	-	0.899]
Corr($\Delta \log w_t, \Delta \log w_{t-1}$)	0.035*	0.312	[0.112	-	0.492]

Autocorrelation of Order 1 of Observable Variables. Model implied vs. Data Data source: Haver Analytics, Sample period 1989Q1 - 2010Q1. Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 31%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.
* The autocorrelation of real wages computed over a sample that ends in 2007:Q4 and excludes the last recession is 0.15.

Table 9: Posterior Variance Decomposition - Sticky wages (benchmark case)

	TFP	MP	Gov't	Price Mark-up	Wage Mark-up	Financial	Preference	Meas. Error
$\Delta \log X_t$	**13.7**	**7.7**	**2.6**	**18.9**	**15.2**	**34.8**	**5.4**	**0.0**
	[8.6 - 20.1]	[4.9 - 11.1]	[1.6 - 4.4]	[13.3 - 25.8]	[8.7 - 24.6]	[25.4 - 45.5]	[4.1 - 7.0]	[0.0 - 0.0]
$\Delta \log I_t$	**5.8**	**3.5**	**0.5**	**19.9**	**4.3**	**60.80**	**4.6**	**0.0**
	[4.1 - 8.1]	[2.5 - 5.6]	[0.4 - 0.9]	[15.1 - 31.1]	[3.1 - 6.0]	[53.1 - 68.4]	[3.1 - 7.1]	[0.0 - 0.0]
$\Delta \log C_t$	**22.7**	**6.7**	**8.95**	**7.0**	**26.7**	**4.7**	**22.0**	**0.0**
	[15.9 - 30.3]	[3.7 - 10.0]	[5.8 - 13.3]	[3.6 - 11.1]	[18.2 - 37.3]	[1.9 - 8.9]	[17.3 - 26.5]	[0.0 - 0.0]
R_t^B	**0.7**	**2.8**	**0.9**	**3.4**	**1.9**	**85.9**	**4.0**	**0.0**
	[0.3 - 1.9]	[2.0 - 3.9]	[0.5 - 1.7]	[2.2 - 5.2]	[0.9 - 3.4]	[88.9 - 90.2]	[2.9 - 5.3]	[0.0 - 0.0]
π_t	**18.1**	**4.8**	**0.3**	**16.0**	**14.0**	**43.6**	**2.6**	**0.0**
	[12.8 - 24.3]	[3.5 - 6.5]	[0.2 - 0.6]	[10.8 - 22.9]	[9.2 - 19.8]	[34.7 - 52.0]	[1.9 - 3.8]	[0.0 - 0.0]
$\log L_t$	**8.0**	**8.4**	**3.5**	**28.5**	**29.3**	**16.1**	**4.1**	**0.0**
	[3.0 - 16.2]	[5.1 - 11.7]	[1.8 - 6.2]	[20.4 - 37.6]	[16.6 - 46.1]	[9.8 - 23.9]	[2.9 - 5.6]	[0.0 - 0.0]
Sp_t	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**99.9**	**0.0**	**0.0**
	[0.0 - 0.0]	[0.0 - 0.0]	[0.0 - 0.1]	[0.0 - 0.1]	[0.0 - 0.0]	[99.8 - 99.9]	[0.0 - 0.0]	[0.0 - 0.20]
$\Delta \log w_t$	**16.7**	**1.9**	**2.7**	**37.1**	**35.1**	**1.8**	**1.8**	**0.0**
	[12.5 - 26.1]	[1.0 - 3.1]	[1.7 - 3.9]	[27.8 - 46.3]	[25.6 - 45.5]	[0.6 - 3.8]	[1.0 - 3.0]	[0.0 - 0.0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Median values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 31%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.
Values are percentages. Rows may not sum up to 100% due to rounding error.
Computed used parameter estimates in table 3.

Table 10: Variance Decomposition of the observables - Flexible wages

	TFP	MP	Gov't	Price Mark-up	Labor Preference	Financial	Preference	Meas. Error
$\Delta \log X_t$	**31.2**	**0.4**	**17.5**	**12.3**	**27.2**	**9.5**	**1.3**	**0.0**
	[27.3 - 35.2]	[0.3 - 0.7]	[14.5 - 21.5]	[9.7 - 15.7]	[23.8 - 30.7]	[7.6 - 12.4]	[1 - 1.9]	[0.0 - 0.0]
$\Delta \log I_t$	**5.1**	**1.0**	**2.1**	**22.4**	**3.0**	**49.1**	**16.7**	**0.0**
	[4.2 - 6.3]	[0.7 - 1.5]	[1.6 - 2.9]	[18.4 - 28.2]	[2.3 - 3.8]	[42.9 - 55.5]	[12.8 - 20.7]	[0.0 - 0.0]
$\Delta \log C_t$	**42.4**	**0.0**	**1.0**	**2.2**	**40.7**	**0.8**	**12.8**	**0.0**
	[38.0 - 46.6]	[0.0 - 0.1]	[0.7 - 1.4]	[1.6 - 3.0]	[36.6 - 44.6]	[0.5 - 1.1]	[10.7 - 15.5]	[0.0 - 0.0]
R_t^B	**0.5**	**4.1**	**2.1**	**3.2**	**1.1**	**82.5**	**6.1**	**0.0**
	[0.4 - 0.8]	[3.1 - 5.6]	[1.5 - 3.1]	[2.5 - 4.3]	[0.7 - 1.7]	[78.9 - 85.7]	[4.7 - 7.8]	[0.0 - 0.0]
π_t	**9.1**	**6.5**	**1.9**	**10.2**	**5.5**	**58.4**	**7.5**	**0.0**
	[7.0 - 12.4]	[5.1 - 8.5]	[1.3 - 2.9]	[7.8 - 13.3]	[4.1 - 7.1]	[51.9 - 65.3]	[6.1 - 9.3]	[0.0 - 0.0]
$\log L_t$	**2.1**	**0.4**	**30.0**	**22.7**	**42.8**	**0.7**	**0.7**	**0.0**
	[1.7 - 2.8]	[0.2 - 0.7]	[25.1 - 365.7]	[17.8 - 28.9]	[37.9 - 48.1]	[0.4 - 1.1]	[0.4 - 1.1]	[0.0 - 0.0]
Sp_t	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**99.9**	**0.0**	**0.0**
	[0.0 - 0.0]	[0.0 - 0.0]	[0.0 - 0.2]	[0.0 - 0.1]	[0.0 - 0.0]	[99.8 - 99.9]	[0.0 - 0.0]	[0.0 - 0.0]
$\Delta \log w_t$	**16.8**	**3.4**	**5.7**	**48.6**	**15.7**	**1.2**	**8.1**	**0.0**
	[13.0 - 21.1]	[2.5 - 4.7]	[4.4 - 7.8]	[43.8 - 53.3]	[13.0 - 18.8]	[0.6 - 2.1]	[6.2 - 10.3]	[0.0 - 0.0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Median values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 29%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.
Values are percentages. Rows may not sum up to 100% due to rounding error.
Computed used parameter estimates in table 4.

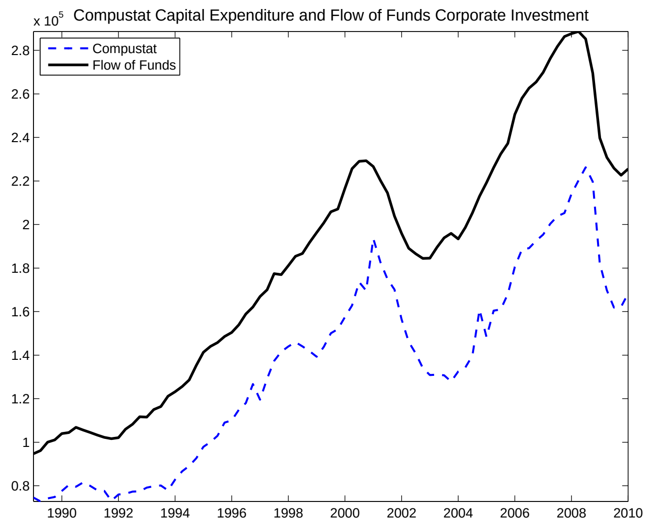

Figure 1: Comparison of Capital Expenditure of Compustat Firms (blue dashed line) and Flow of Funds Corporate Capital Expenditure (black solid line), in millions of dollars. Sources: Compustat and Flow of Funds Table F.102. Sample period 1989Q1 - 2010Q1.

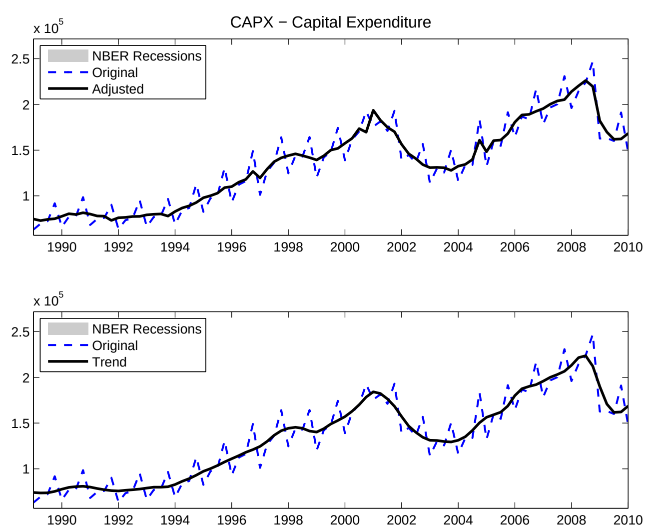

Figure 2: CAPX$_t$: Total Capital Expenditure of U.S. firms in Compustat. Panel A (top) reports the raw data (blue dashed line) against the seasonally-adjusted series (black solid line), in millions of dollars. Panel B shows the raw data (blue dashed line) against the extracted trend (black solid line). Seasonal adjustment and trend extraction performed using the Census X12 procedure. Source: Compustat. Sample period 1989Q1 - 2010Q1.

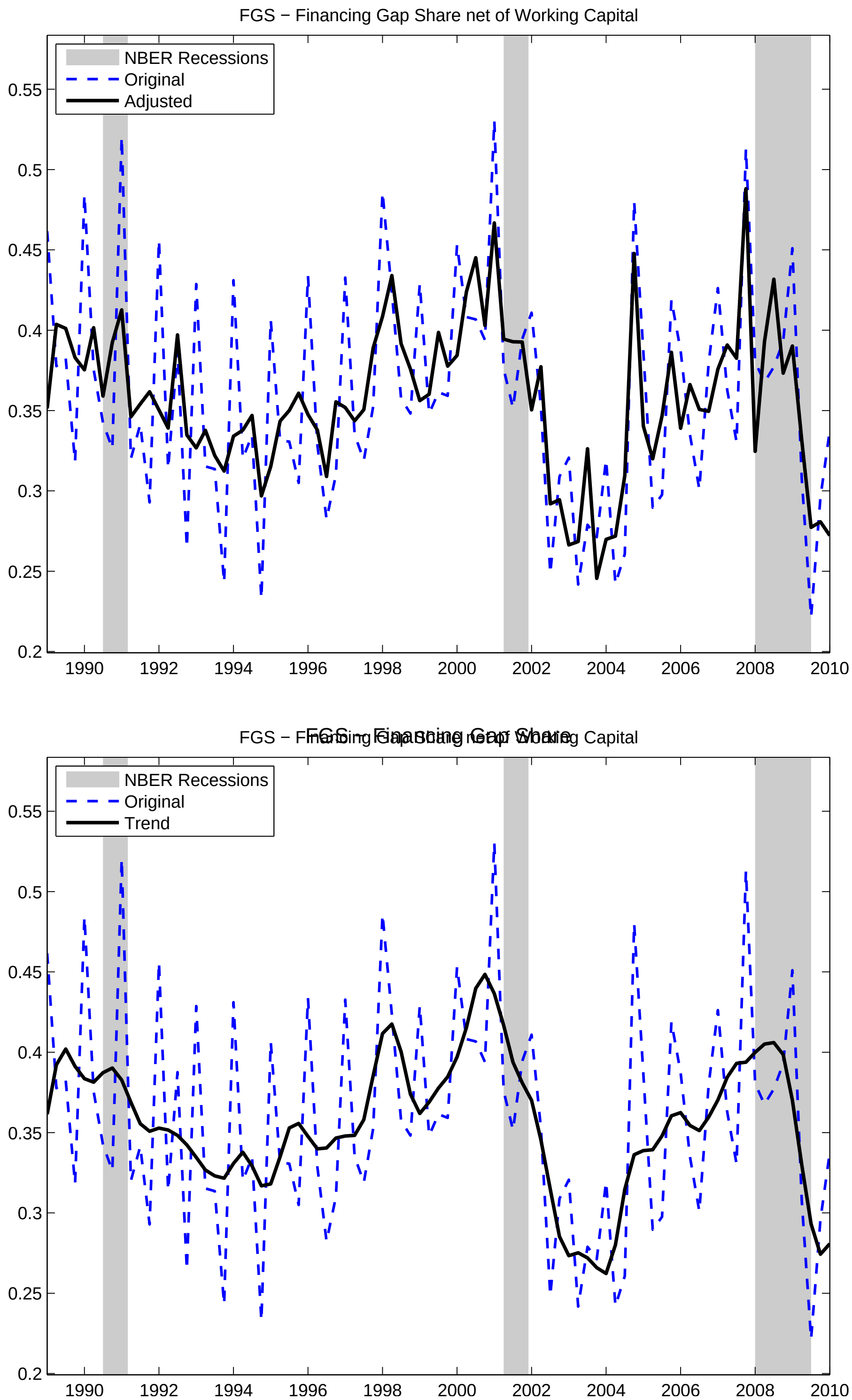

Figure 3: FGS_t: Financing Gap Share. Panel A (top) reports the raw data (blue dashed line) against the seasonally-adjusted series (black solid line). Panel B shows the raw data (blue dashed line) against the extracted trend (black solid line). Seasonal adjustment and trend extraction performed using the Census X12 procedure. Source: Compustat. Sample period 1989Q1 - 2010Q1.

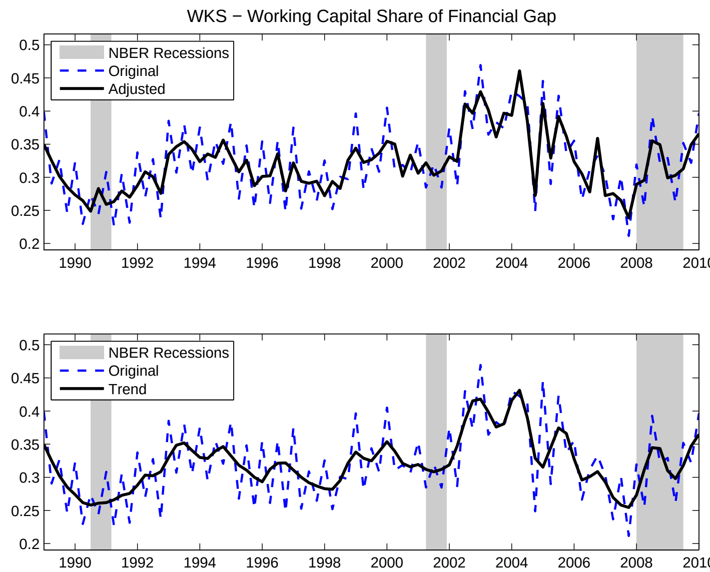

Figure 4: WKS_t: Working capital financing needs as a share of total Financing Gap. Panel A (top) reports the raw data (blue dashed line) against the seasonally-adjusted series (black solid line). Panel B shows the raw data (blue dashed line) against the extracted trend (black solid line). Seasonal adjustment and trend extraction performed using the Census X12 procedure. Source: Compustat. Sample period 1989Q1 - 2010Q1.

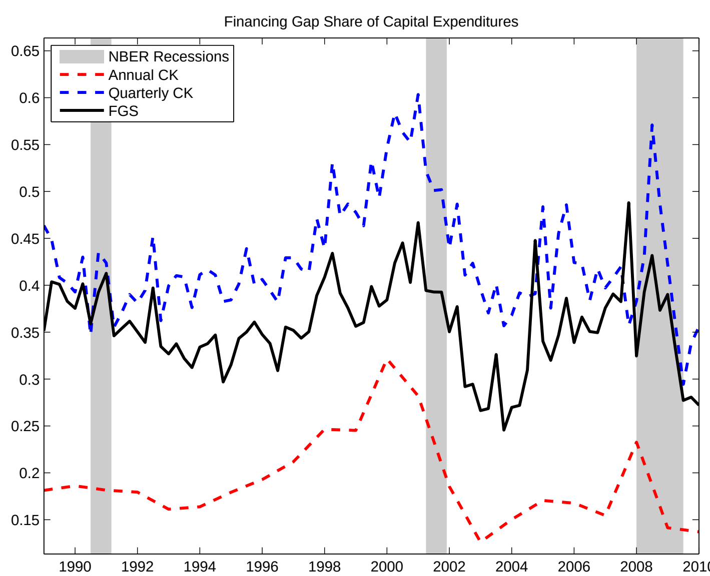

Figure 5: Financing Gap Share, as computed in equation (5) (black solid line) for the aggregate of U.S. and Canadian corporations. The series is compared to results obtained using Chari and Kehoe (2009)'s methdology applied to annual data (red dashed line) and quarterly data (blue dashed line). Source: Compustat. Sample period 1989Q1 - 2010Q1.

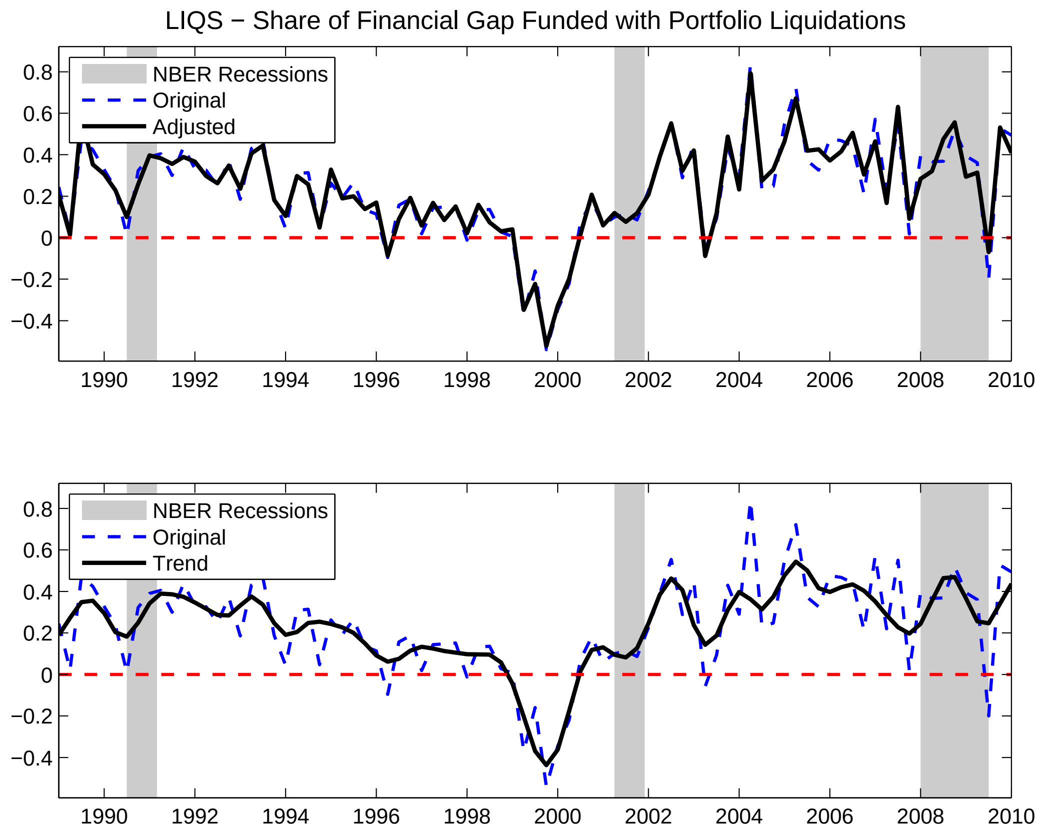

Figure 6: LIQS$_t$: Share of Financing Gap funded through portfolio liquidations and changes in cash reserves. Panel A (top) reports the raw data (blue dashed line) against the seasonally-adjusted series (black solid line). Panel B shows the raw data (blue dashed line) against the extracted trend (black solid line). Seasonal adjustment and trend extraction performed using the Census X12 procedure. Source: Compustat. Sample period 1989Q1 - 2010Q1.

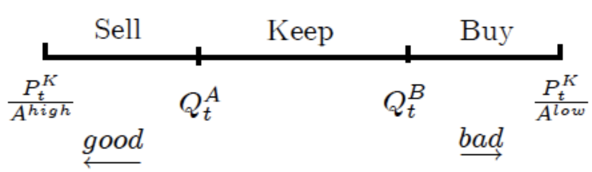

Figure 7: Distribution of Relative Price of Investment Technologies across Entrepreneurs

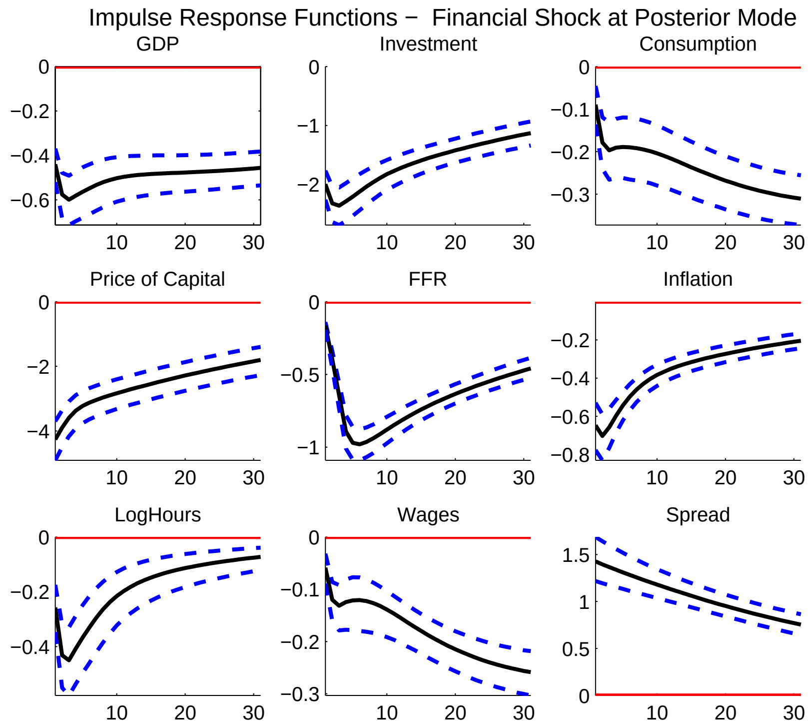

Figure 8: Impulse responses to a one standard deviation financial shock. The dashed lines represent 90 percent posterior probability bands around the posterior median.

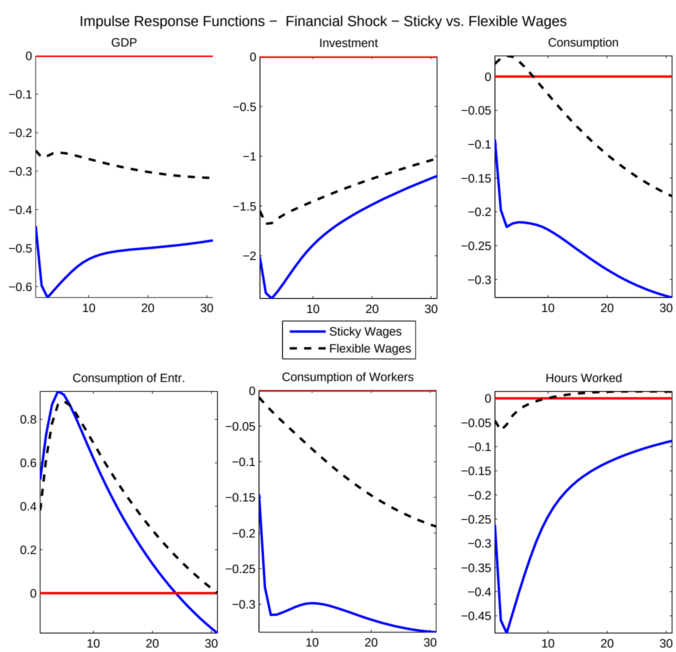

Figure 9: Impulse response functions to a one standard deviation financial shock. Comparison between sticky wages (black dashed line) and flexible wages (blue solid line). Impulse responses are computed at the posterior modes.

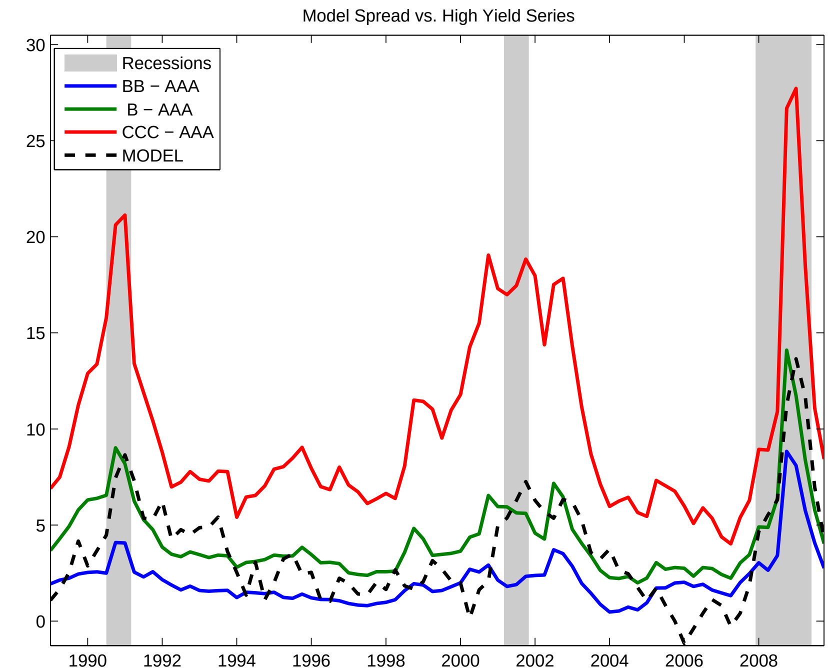

Figure 10: Corporate Bond Spreads - Data vs. Model, in percentage points. Source for Spread data: Haver Analytics. Sample period 1989Q1 - 2010Q1.

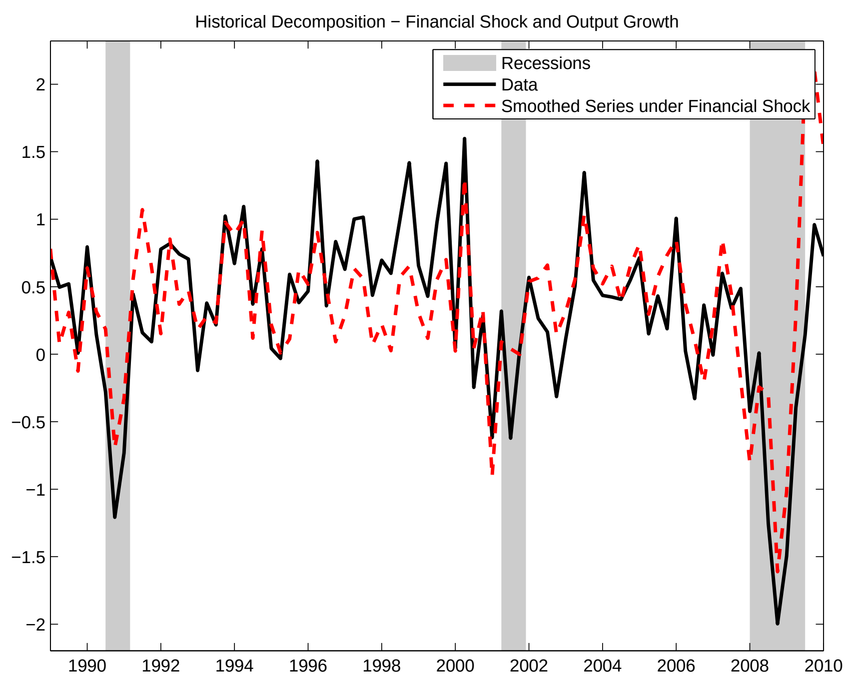

Figure 11: Quarterly output growth in the data (black solid line) and in the model (red dahsed line) with only financial shocks. Source for GDP data: Haver Analytics. Sample period 1989Q1 - 2010Q1.

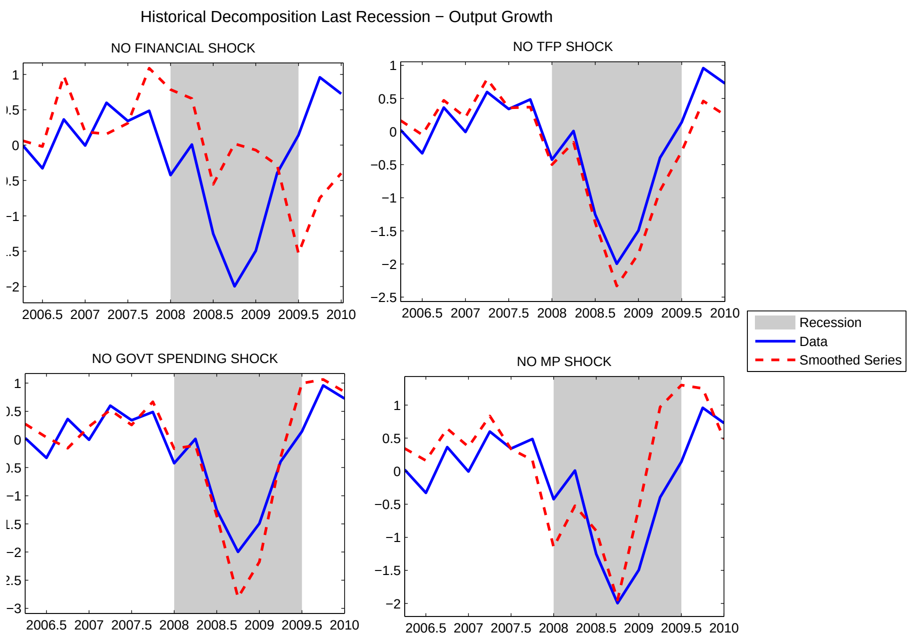

Figure 12: Quarterly GDP growth in the data (blue lines) compared to Kalman-smoothed series from benchmark model estimates (red dashed lines), excluding financial shocks (top-left), TFP shocks (top-right panel), government spending shocks (bottom-left panel) and monetary policy shocks (bottom-right panel). Source for GDP data: Haver Analytics.

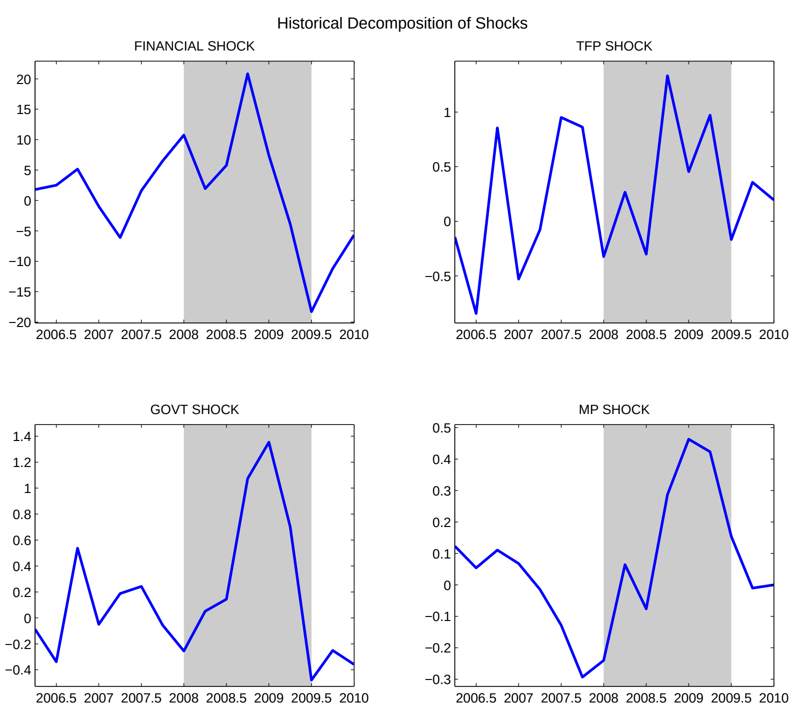

Figure 13: Historical decomposition of last recession into smoothed shocks: financial shocks (top-left panel), TFP shocks (top-right panel), government spending shocks (bottom-left panel) and monetary policy shocks (bottom-right panel).