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 US financial markets. 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 establish facts that may be of independent interest. For example, I find that a substantial 33% of firm 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, the financial intermediation shock explains around 40% of GDP and 55% 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 a financial shock resembles the behavior of these variables over the business cycle.

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1 Introduction

Is the financial sector an important source of business cycle shocks? My model analysis suggests that the answer is 'yes'. I find that financial sector shocks account for 40% and 55% 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, which may be of independent interest, is a characterization of how important financial markets are for investment. To this end, I analyze the cash flow statements of all the US public non-financial companies included in Compustat. I find that 30% of the capital expenditures of these firms is funded using financial markets. Of this total funding, around 75% is accomplished by issuing debt and equity and 25% by liquidating existing assets. My analysis at quarterly frequencies suggests that the financial system is useful to reconcile imbalances between the realization of positive operating cash flows and capital expenditure commitments. Shocks that originate in the financial system and that can promote or halt the transfer of resources to investing firms can have large effects on capital accumulation and productive activity.

To quantify the effects of such shocks on the business cycle, I then build a dynamic general equilibrium model with financial frictions in which entrepreneurs, like firms in the Compustat dataset, rely on external finance and trading of financial claims to finance their investments. The model builds on Kiyotaki and Moore (2008), henceforth KM, and modifies their theoretical set-up, introducing price and wage rigidities (Smets and Wouters (2003), Christiano, Eichenbaum, and Evans (2005)), and a financial intermediation shock. Entrepreneurs are endowed with random heterogeneous technologies to accumulate physical capital. Entrepreneurs who receive better technologies optimally decide to raise funds from financial markets 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 follow Chari, Christiano, and Eichenbaum (1995), Goodfriend and McCallum (2007) and Cúrdia and Woodford (2010), and 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 fee to cover their costs. I assume that these intermediation costs vary exogenously over time and interpret these disturbances as financial shocks. When the intermediation fees 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 the high-yield corporate bond spread as one of the observables to identify the financial shock. I choose priors for financial parameters so that the model estimation can be consistent with Compustat evidence on corporate investment financing during the same sample period. The estimation results show that approximately 40% of the variance of output and 55% 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 the model to generate both booms and recessions of a plausible magnitude and the right positive comovement 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. 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. 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.

I verify the importance of wage rigidities in the transmission of financial intermediation shocks by re-estimating the model under the assumption of flexible wages and comparing impulse responses and variance decompositions to the benchmark specification with sticky wages. Under flexible wages, aggregate consumption and investment move in opposite directions following a financial intermediation shock. As a consequence, financial disturbances are able to explain only 8% and 39% of output growth and investment growth variance at business cycle frequencies, compared to 40% and 55% in the benchmark sticky-wage case.

From the estimation I am also able 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 constrained entrepreneurs benefit from holding an increasing stock of government bonds that can be liquidated freely to take advantage of future investment opportunities.

My modeling of the financial intermediation wedge is reduced-form, although it is inspired by work from Kurlat (2009) on the macroeconomic amplification effects of adverse selection in trading of financial securities. He builds a theoretical model in which lemons are traded on financial markets alongside assets of good quality (Akerlof (1970)). If savers have only partial information on the quality of claims they buy, they expect to incur portfolio losses that are larger when the share of lemons traded on the market is big. In his set-up, an aggregate shock that raises asset prices, favors sales of good quality assets and reduces the expected losses for savers induced by the purchase of lemons. In particular, Kurlat (2009) shows that this adverse selection friction maps into a model with homogeneous equity claims in which financial transactions are hit by a tax wedge. 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 (2010). Moreover I assume the cost to be time-varying and to be subject to exogenous independent shocks over time.

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 imperfection 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.

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. Secondly, the primary impact of the KM 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. To obtain the right comovement of asset prices and output, I introduce random disturbances in the financial intermediation technology.

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 2. Section 3 describes the features of the model. Section 4 reconciles features of the model with the empirical analysis on Compustat data. Section 5 discusses the estimation strategy, the prior selection on the model parameters and significant moments. Section 6 presents the model estimation results and section 7 concludes.

2 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 characterize what fraction of the total investment carried out by firms within a quarter relies on some form of financial market intermediation.

I can achieve this goal by analyzing 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*$_t$[1], and total investment (or expenditure) on

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

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

physical capital, CAPX_t :[2]

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

In periods when the financing gap assumes positive values, the aggregate of corporations on average generates enough cash from their business operations to cover their physical investments and lend resources to the rest of the economy. On the other hand, when the variable assumes negative values, the firms draw resources from the rest of the economy to cover a fraction of capital expenditures. This variable however is not informative on the degree of dependence of single corporations on financial markets, to the extent that 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.[3]

To avoid this aggregation problem, Chari and Kehoe (2009) analyze annual cash flow data available for corporations in Compustat. In particular, Chari and Kehoe (2009) compute a firm-level measure of financing gap as the difference between operating cash flow, CF^O_t, and capital expenditures, CAPX_t in each 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.

To obtain similar statistics on the degree of financial dependence of corporations, I here follow a slightly different methodology than Chari and Kehoe (2009). Compustat contains cash flow statement data both at annual and at quarterly frequency for the universe of publicly traded North American companies. Quarterly data on cash flow statements are available in Compustat starting from 1984, while a consistent break-down of quarterly cash flows in their components is available since 1989. I exclude Canadian firms from the analysis and concentrate on companies based in the U.S.The aggregate of U.S. Compustat corporations account for an average of 76% of U.S. corporate investment, around 50% of aggregate fixed investment and 35% of aggregate investment, as reported in the Flow of Funds tables at quarterly frequency, from 1989Q1 to 2010:Q1.[4]

I focus on Compustat quarterly cash flow data to quantify the extent of short-term cash-flow imbalances of the companies that are not visible at the annual frequency. I then assume that

[2]Non-financial corporate fixed investment represent the largest component of gross private domestic investment in U.S. data, accounting on average for 50% of the quarterly flow along a sample that ranges between 1989:Q1 and 2010:Q1. Other components of gross private domestic investment are non-corporate non-residential investment (21%), residential investment (27%) and changes in inventories (2%).

[3]The average level of the financing gap as a share of total capital expenditures for U.S. corporations amounts to 8% across a sample period that goes from 1952 to 2010. Only an average of 8% of physical corporate investment was funded by drawing resources from outside of the corporate sector, according to Flow of Funds data.

[4]AFGS 7 and Table 7 in the Appendix compare dynamic properties of level and growth rates of aggregate investment, I_t, aggregate corporate capital expenditure from the Flow of Funds table, FoF CAPX_t, with capital expenditure in Compustat, CAPX_t. I find that Capital Expenditure growth in Compustat correlates well with aggregate Capital Expenditure growth from the Flow of Funds table for Corporations, despite showing a more pronounced volatility.

dividends paid out to equity holders are treated as a unavoidable commitment for firms, similarly to interest on debt. Finally, I recognize that firms' negative financing gap may reflect the realization of negative cash flows within a quarter, $\mathrm{CF}^O_{e,t} < 0$, rather than a deficit caused by large capital expenditures. Negative operating cash flows reveal that some firms access financial markets to fund their working capital needs.

I therefore base my analysis on the sample period that goes from 1989Q1 to 2010Q4 and find that firms rely on financial markets to cover around 30% of their total capital expenditures.

I start my analysis from the observation that for a generic firm e, within a period t, the variation of liquid assets on its balance sheet ($\Delta\ \mathrm{CASH}_{e,t}$) 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 ($\mathrm{CF}^I_{e,t}$):

$$\Delta CASH_{e,t} = CF^O_{e,t} - \left(CF^D_{e,t} + CF^E_{e,t}\right) - CF^I_{e,t} \tag{2}$$

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 find the firm-level equivalent of the Flow of Funds definition of the financing gap in (1) as:

$$\left(CF^O_{e,t} - CAPX_{e,t}\right) = CF^D_{e,t} + \left(DIV_{e,t} + CF^{EO}_{e,t}\right) + \left(NFI_{e,t} + \Delta CASH_{e,t}\right).$$

If operating cash flows, $\mathrm{CF}^O_{e,t}$, are higher than capital expenditures $\mathrm{CAPX}_{e,t}$, then firm e reports a financing surplus: it is able to self-finance its investment in physical capital and to use the extra resources to pay dividends, $\mathrm{DIV}_{e,t}$, buy back shares or pay back its debt obligations ($\mathrm{CF}^E_{e,t}+\mathrm{CF}^D_{e,t} > 0$). Alternatively, the firm can use its surplus to increase the stock of financial assets on its balance sheet or its cash reserves ($\mathrm{NFI}_{e,t} + \Delta\mathrm{CASH}_{e,t} > 0$).

If instead ($\mathrm{CF}^O_{e,t} - \mathrm{CAPX}_{e,t}$) is negative, the firm shows a negative financing gap that can be funded by relying on external investors to subscribe new debt or equity securities ($\mathrm{CF}^E_{i,t} + \mathrm{CF}^D_{i,t} < 0$), by liquidating assets ($\mathrm{NFI}_{i,t} < 0$) or depleting deposits and cash-reserves ($\Delta\mathrm{CASH}_{i,t} < 0$).

$$\underbrace{\left(CF^O_{e,t} - CAPX_{e,t}\right)}_{\text{Financing Gap}} = \underbrace{\left(CF^D_{e,t} + CF^{EO}_{e,t} + \mathrm{DIV}_{\mathrm{e,t}}\right)}_{\text{External Sources}} + \underbrace{\left(NFI_{e,t} + \Delta CASH_{e,t}\right)}_{\text{Portfolio Liquidations}}. \tag{3}$$

To be consistent with the definition of financing gap from the Flow of Funds tables in 1 and with the empirical observation from the finance literature that firms tend to smooth out their dividends payouts over time and treat them as a form of unavoidable remuneration to their shareholders (Lintner (1956), Fama and Babiak (1968), Leary and Michaely (2008)), I redefine the financing gap by subtracting dividends from the operating cash flows on the left-hand side of (3). As a result, the financing gap definition that I adopt becomes:

$$FG_{e,t} = \underbrace{\left(CF^{O}_{e,t} - \mathrm{DIV_{e,t}} - CAPX_{e,t}\right)}_{\text{Financing Gap Net of Dividends}} = \underbrace{\left(CF^{D}_{e,t} + CF^{EO}_{e,t}\right)}_{\text{External Sources}} - \underbrace{\left(NFI_{e,t} + \Delta CASH_{e,t}\right)}_{\text{Portfolio Liquidations}}. \tag{4}$$

In each quarter, I compute the amount in (4) 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:

$$FG^{TOT}_{t} = \sum\nolimits_{e} |FG_{e,t}| \, \mathbf{1}\left\{FG_{e,t} < 0\right\}. \tag{5}$$

I also recognize that a fraction of those firms that report a negative financing gap in each quarter do so because they post negative operating cash flows. Firms that report $\mathrm{CF}^{O}_{e,t} < 0$ access financial markets to fund part of their operating expenses. 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 needs that arise in connection to the accumulation of physical capital only. Consequently, I subtract the amount of negative cash-flows reported in every period, WK_t, from the total financing gap in (5) and define the quarterly Financing Gap Share, FGS_t, as the ratio of the financing gap related to physical investment just described and the total capital expenditure across all firms:

$$FGS_t = \frac{FG^{TOT}_{t} - WK_t}{CAPX_t} = \frac{FG^{TOT}_{t} - \sum_e \left|CF^{O}_{e,t}\right| \mathbf{1}\left\{FG_{e,t} < 0,\ CF^{O}_{e,t} < 0\right\}}{\sum_e CAPX_{e,t}} \tag{6}$$

Table 1 in the Appendix shows that from 1989Q1 and 2010Q1, the average of the financing gap share, FGS_t, amounts to 30,67% of total investment, with a standard deviation of 5.7%:

$$\overline{FGS} = \sum\nolimits_{t} \frac{FGS_t}{T} = 30.63\%$$

The share of capital expenditures that relies on financial intermediation is substantial. This result suggests that shocks that can affect financial markets' ability to transfer new resources to firms in need can potentially have a large impact on capital accumulation.

In the same table I report what fraction of the total financing gap defined in (5) arises due to working capital needs and is excluded from the definition of the Financing Gap Share in (6). I define this ratio as the average over time of the contribution of negative operating cash flows, $\mathrm{CF}^{O}_{e,t}$, to the total financing gap, FG^{TOT}_{t}, in (5):

$$\overline{WKS} = \frac{1}{T} \sum_t \frac{WK_t}{FG^{TOT}_{t}} = 41.01\%$$

and find that around 40% 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 19% of the total financing gap in (5).

Figure 3 shows the evolution of the seasonally adjusted Financing Gap Share defined in (6) (black solid line in panel A) and its trend (black solid line in panel B) along the sample period 1989Q1 and 2010Q1. Figure 4 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 dashes line) and with a series computed using their methodology on quarterly data (blue dashed line). The three series are highly correlated, but the average of the quarterly data is, as expected, larger.[5]

What are the cyclical properties of the Financing Gap Share series in figure 4? Reliance on financial markets seems to be growing along periods of economic expansion, especially during the boom of the '90s and in the 2000s. All three recessions in the sample start with a sudden, but limited, drop in the financing gap share, followed by a sudden rise. The dynamics of the series along recessions appear to be driven by large drops in capital expenditures, the denominator of equation (6), rather than by falls in the financing gap at the numerator. During periods of economic contraction, investment seems to drop by more than the amount of resources that firms obtain through external credit and liquidation of assets on their portfolio.

The right-hand-side of equation (4) suggests breaking down the negative financing gaps into the sources of funds that help fund it. In particular, the information available in Compustat allows me to determine what fraction of the financing gap is covered by transfers from equity and debt holders, $\mathrm{CF}^{EO}_{e,t}$ and $\mathrm{CF}^{D}_{e,t}$, and what fraction is instead funded by liquidation of assets on firms' balance sheets or depletion of cash reserves, $\mathrm{NFI}_{e,t}+\Delta\mathrm{CASH}_{e,t}$. In each period t, debt and equity intakes account for a fraction, DES_t, of the total financing gap:

$$DES_t = \frac{\sum_e (CF^D_{e,t} + CF^{EO}_{e,t}) \mathbf{1}\{FG_{e,t} < 0\}}{FG^{TOT}_t} \tag{7}$$

On average, along the sample period debt and equity fund 75.63% of the total financing gap (standard deviation 23.74%):

$$\frac{1}{T}\sum_t DES_t = \frac{1}{T}\sum_t \frac{\sum_e (CF^D_{e,t} + CF^{EO}_{e,t}) \mathbf{1}\{FG_{e,t} < 0\}}{FG^{TOT}_t} = 75.63\%$$

[5] All series are seasonally adjusted using the X11 Census procedure on Compustat quarterly data.

while the remaining 24.37% is covered by portfolio liquidations and changes in cash reserves.

Figure 5 plots the share of the total financing gap that is covered by portfolio liquidations and variation in cash reserves, i.e. the complement to 1 of DES_t:

$$LIQS_t = 1 - DES_t = \frac{\sum_e (NFI_{e,t} + \Delta CASH_{e,t}) \mathbf{1}\{FG_{e,t} < 0\}}{FG_t^{TOT}} \tag{8}$$

The graph suggests that the relative importance of asset liquidations versus debt and equity intakes is increasing in recessions. Assets illiquidity can be a concern for firms investment capabilities. Recessions, however, seem to be characterized mostly by a reduced inflow of external finance per unit of investment undertaken (figure 5).

The data in figure 5 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 feature of the data is the difference in the importance that portfolio liquidations acquire in the 2000s, compared to their relative weight in the 90s. Asset liquidations as a sources of financing seem relatively less important in the first half of the sample (average contribution amounts to 19.74% of financing gap), while they receive considerably more weight in the second half (34.27%).

3 The Model

In this section I describe a model that can capture the features of firms' investment financing in the Compustat quarterly data in which entrepreneurs:

1. produce enough resources on aggregate to finance investment, consistently with evidence from the Flow of Funds tables;
2. singularly issue and trade financial claims to raise funds, and
3. trade and hold liquid assets as precautionary savings against idiosyncratic investment opportunity, in line with firm-level data in Compustat;

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

Entrepreneurs own the capital stock of the economy and rent it to the intermediate producers in exchange for a competitive return. Each entrepreneur can decide to increase his capital stock by buying capital goods and installing new capital. Entrepreneurs, however, possess different installation technologies. These technologies are randomly assigned over the population of entrepreneurs in every period and can be thought of as investment opportunities with different degrees of efficiency. If financial markets are perfect, entrepreneurs who possess the best technologies are able to borrow indefinitely from less efficient entrepreneurs. The most efficient entrepreneurs are able to write and sell financial claims on their capital stock and sell them to others, offering a higher rate of return than any other investment technology.

In the model I propose, financial markets are not perfect. Limits are imposed on the ability of entrepreneurs to raise external sources of financing. As in KM, entrepreneurs can only write a limited number of equity claims on the new investment that they want to undertake (external finance constraint). They also can sell only a limited quantity of financial assets to build new capital using their new technology (asset liquidity or resaleability constraint). In addition, banks are in charge of transferring savings from those entrepreneurs with worse technologies to the more efficient ones. In the spirit of Kurlat (2009), Chari, Christiano, and Eichenbaum (1995) and Cúrdia and Woodford (2010), I introduce a reduced-form cost of intermediation between the two subsets of agents. Intermediation costs are time varying and subject to shocks.[6]

Households are composed of workers who supply differentiated labor on a monopolistic market, for the production of the final good. Employment agencies aggregate the differentiated labor into homogeneous work hours and supply them to the intermediate producers.

Government finances a stream of exogenous public expenditures and fiscal transfers to the households by levying distortionary taxes on labor income and on the rate of return on capital and by issuing one-period risk-less government bonds. The monetary authority sets the level of the risk-free rate.

3.1 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 claims on their physical assets to financial intermediaries. Alternatively, if their

[6]Intuitively, these costs can be interpreted as necessary to overcome asymmetric information among potential sellers and potential buyers on the quality of financial claims. See section 3.2 for more details.

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. At the beginning of the period, then, 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, $N^{others}_{e,t-1}$ and interest bearing government bond holdings, $R^B_{t-1}B_{e,t-1}$ 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 $N^{sold}_{e,t-1}$:

A	L
$Q_t K_{e,t-1}$	$Q_t N^{sold}_{e,t-1}$
$Q_t N^{others}_{e,t-1}$	
$R^B_{t-1}B_{e,t-1}$	Net Worth

Assuming that each unit of equity represents one unit of homogeneous capital, so that the two assets share the same expected stream of returns, $\left\{R^K_{t+i}\right\}$ 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:

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

Entrepreneur e maximizes his life-time utility of consumption:

$$\max E_t \sum_{s=0}^{\infty} \beta^s b_{t+s} \log(C_{e,t+s}) \tag{9}$$

subject to a flow of funds constraint:

$$\begin{aligned} &P_t C_{e,t+s} + P^K_{t+s} i_{e,t+s} + Q^B_{t+s}\Delta N^+_{e,t+s} - Q^A_{t+s}\Delta N^-_{e,t+s} + P_{t+s}B_{e,t+s} = \\ &\left(1-\tau^k\right) R^K_{t+s}N_{e,t+s-1} + R^B_{t+s-1}B_{e,t+s-1} \end{aligned} \tag{10}$$

where P_t is the price of the consumption good, P^k_t is the price of capital goods charged by capital producers, Q^B_t is the nominal price at which he can buy equity claims, Q^A_t the one at which he can sell claims, R^k_t and R^B_t are respectively the nominal rate of return on capital and on risk-free government bonds, B_t and liquidity and τ^k is the marginal tax rate on capital income.

The entrepreneur receives after-tax income from his assets at the beginning of the period (the right-hand side of (11)) 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^K_t from capital goods producers. The entrepreneur can also purchase equity claims $\Delta N^+_{e,t}$ at price Q^B_t from banks and government bonds at price P_t from the fiscal authority. Some entrepreneurs may find convenient to sell equity claims $\Delta N^-_{e,t}$ at a price Q^A_t to banks. For now I am assuming that $Q^A_t \leq Q^B_t$, so that no arbitrage opportunity exists for entrepreneurs on the financial market for equity. This will be derived as an equilibrium result when discussing the role of financial intermediaries in section 3.2.

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 $A_{e,t} \sim U\left[A^{low}, A^{high}\right]$. 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:

$$N_{e,t+s} = A_{e,t+s}i_{e,t+s} + \Delta N^{+}_{e,t+s} - \Delta N^{-}_{e,t+s} + (1-\delta) N_{e,t+s-1}. \tag{11}$$

As in KM, the sale of financial claims is constrained exogenously as in KM. Entrepreneurs who decide to purchase and install capital goods can write claims on a fraction $\theta A_{e,t}i_{e,t}$ of their new capital stock and sell it on the market. Similarly, entrepreneurs with good technologies will find it optimal to sell old equity units to finance the installation of new ones:

$$\Delta N^{-}_{e,t+s} \leq \theta A_{e,t+s}i_{e,t+s} + \phi (1-\delta) N_{e,s+t-1}. \tag{12}$$

where the units of equity sold in each period cannot exceed the sum of the external finance limit, $\theta A_{e,t+s}i_{e,t+s}$, and the maximum amount of reselable equity, $\phi (1-\delta) N_{e,s+t-1}$.

Note finally that entrepreneurs' discount factor in (9), $\beta^s b_t$, is subject to an intertemporal preference exogenous shock that follows the AR(1) process:

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

where $\varepsilon^b_t \sim iidN\left(0, \sigma^2_b\right)$.

The maximization problem (9), subject to (11), (11) and (12) and complemented with the non-negativity constraints:

$$\begin{aligned} i_{e,t+s} &\geq 0 \\ \Delta N^{+}_{e,t+s} &\geq 0 \\ \Delta N^{-}_{e,t+s} &\geq 0 \\ B_{e,t+s} &\geq 0 \end{aligned} \tag{13}$$

can be solved at time $t+s$ for the optimal levels of:

$$\left\{C_{e,t+s}, i_{e,t+s}, \Delta N^{+}_{e,t+s}, \Delta N^{-}_{e,t+s}, N_{e,t+s}, B_{e,t+s}\right\}$$

given a set of prices and rates of return:

$$\left\{P_t, P_t^K, Q_{t+s}^B, Q_{t+s}^A, R_{t+s}^K, R_{t+s}^B\right\}$$

a draw of the installation technology $A_{e,t+s}$, a given portfolio of assets $\{N_{e,t+s-1}, B_{e,t+s-1}\}$ 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,$\left\{R_{t+i}^K\right\}$ for $i = \{0, ..., \infty\}$. Entrepreneurs will then always treat them as perfect substitutes. Following Kurlat (2009), I posit the existence of a solution in which a fraction $\chi_{s,t}$ of entrepreneurs decide to sell claims up to their constraint (12) to borrow resources and use their good technology to install new capital goods. I call these agents *Sellers*. Another portion $\chi_{k,t}$ prefer to take advantage of their technology of intermediate quality without buying or selling claims (*Keepers*). The remaining lot is composed of entrepreneurs with poor technology draws who prefer to buy financial claims from the banks (*Buyers*) to installing capital in their backyard.

At the beginning of the period, an entrepreneur observes prices of financial claims, $Q_{t+s}^B \geq Q_{t+s}^A$, 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, Q_t^A and Q_t^B (fig. 1). Depending on his random technology draw, it can be that an entrepreneur becomes a Seller and optimally decides to buy capital goods at price P_t^K and install them by means of his technology A_t^e, while selling claims on the financial markets 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 buy claims on other entrepreneurs' capital stock paying Q_t^B for each financial claim.

Entrepreneurs will be partitioned into three subsets: *Sellers*, *Keepers* and *Buyers*.

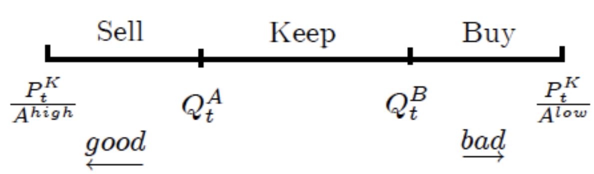

Figure 1: Distribution of Investment Technologies across Entrepreneurs

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

In this case, the 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, as well as 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 borrows the largest amount possible from other entrepreneurs:

$$\Delta N_{s,t}^- = \theta A_{s,t} i_{s,t} + \phi \left(1-\delta\right) N_{s,t-1} \tag{14}$$

and avoids buying assets from the market:

$$\Delta N_{s,t}^+ = 0 \tag{15}$$

I can also shows that, in analogy with KM, in steady state entrepreneurs with a good technology will use up their returns on liquid assets but will not accumulate new ones. I solve the model assuming that the economy does not depart from this allocation and that:

$$B_{s,t} = 0. \tag{16}$$

Substituting (14), (15) and (16) into (11), Sellers' budget constraint in real terms becomes:

$$C_{s,t} + \tilde{q}_{s,t}^A N_{s,t} = \left(1-\tau^k\right) r_t^K N_{s,t-1} + r_t^B B_{s,t-1} + \left[q_t^A \phi + \tilde{q}_{s,t}^A \left(1-\phi\right)\right] \left(1-\delta\right) N_{s,t-1} \tag{17}$$

with:

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

where the right-hand-side of (17) is the net worth of a generic seller, s. Finally, given the distribution of technologies, $\mathrm{A}_{e,t}$, across entrepreneurs, I can compute the measure of sellers in the economy as:

$$\chi_{s,t} = \Pr\left\{\frac{p_t^k}{A_{e,t}} \leq q_t^A\right\}$$

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

The relative price of a unit of installed capital, $\frac{P_t^k}{A_{k,t}}$, is higher than what the market maker pays for each equity claim sold or issued, Q_t^A, but lower than the price at which entrepreneurs can acquire new equity from others, Q_t^B. As a result, the entrepreneurs will not draw resources from financial markets by issuing new claims or selling 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 (11) in real terms becomes:

$$C_{e,t}+\frac{P_t^K}{A_{k,t+s}}N_{k,t}=\left(1-\tau^k\right)R_t^K N_{k,t-1}+R_t^B B_{k,t-1}+\frac{P_t^K}{A_{k,t}}\left(1-\delta\right)N_{k,t-1} \tag{18}$$

Knowing the distribution of technologies $\mathrm{A}_{e,t}$, I can find the measure of keepers in the economy as:

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

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

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 but will acquire financial claims at their market price Q_t^B. Buyers can accumulate government bonds, $B_{b,t}$, in non-arbitrage with equity claims, to self-insure and overcome their future borrowing and liquidity constraints on equity sales in the event that a good technology draw arrives in the next few periods. Their budget constraint in real terms will then become:

$$C_{b,t}+q_t^B N_{b,t}+B_{b,t}=\left(1-\tau^k\right)r_t^K N_{b,t-1}+r_{t+s}^B B_{b,t-1}+q_t^B\left(1-\delta\right)N_{b,t-1} \tag{19}$$

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 (17), (18), (19) now display the net worth of each kind of entrepreneur on their right-hand side. By properties of the log-utility function that characterizes this group of agents, optimal consumption at each point in time can be obtained as a fixed fraction $(1-\beta b_t)$ of the entrepreneur's net worth. Appendix A characterizes the optimal bundle of consumption, investment and asset holding for all three types of entrepreneurs.

3.2 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 compete to acquire equity claims from Sellers, $\Delta N_{i,t}^-$, at price Q_t^A and sell the same quantity $\Delta N_{s,t}^+=\Delta N_{s,t}^+$ to Buyers at a price Q_t^B. To do this, they bear an intermediation cost equal to $\tau_t Q_t^A$ for each financial claim they process. Their nominal profits are then:

$$\Pi_t^{II} = Q_t^B \Delta N_{i,t}^+ - \left(1 + \tau_t^q\right) Q_t^A \Delta N_{i,t}^- \tag{20}$$

where units sold and bought represent the same number of units of capital so that:

$$\Delta N_{i,t}^+ = \Delta N_{i,t}^-. \tag{21}$$

Perfect competition among intermediaries implies that their profits are equal to zero in equilibrium so that:

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

The 'bid' price, Q_t^B, offered to buyers, is equal to the 'ask' price, Q_t^A, augmented by the spread, τ_t^q.

I assume that the intermediation costs τ_t follow an exogenous process of the kind:

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

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

A shock that increases the intermediation cost, reduces the expected return on savings to the Buyers by raising Q_t^B. 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 6.

How can we rationalize this reduced-form description of financial intermediation? In a different model, with heterogeneous equity claims, Sellers can be assumed to possess private information on the quality of their assets and on the their future payoffs. Some assets are of good quality while others can be lemons and a Buyer cannot distinguish the two before a transaction with a Seller is finalized. Kurlat (2009) 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. 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 those 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. In particular, Kurlat (2009) shows that an adverse selection friction in his model with lemon and non-lemon assets is equivalent to a model with homogeneous equity claims like mine, in which financial transactions are hit by a tax wedge. In his formulation, the tax wedge is a reduced form representation of the share of lemon claims over total claims traded on the market. In Kurlat's formulation, this tax 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 introduces a spread between the expected cost of borrowing perceived by Sellers and the expected 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 the economic cycle that are orthogonal to other sources of business fluctuation, I assume that the cost wedge, τ_t^q, evolves exogenously over time, following an AR(1) process hit by a series of *iid* shocks.

3.3 Final Good Producers

At each time t, competitive firms operate to produce a homogenous consumption good as a combination of differentiated intermediate goods. These products are aggregated in the final good sector according to a standard Dixit-Stiglitz technology of the kind:

$$Y_t = \left[\int_0^1 Y_t\,(i)^{\frac{1}{1+\lambda_{p,t}}}\,di\right]^{1+\lambda_{p,t}} \tag{22}$$

where Y_t is a homogenous consumption good, $Y_t\,(i)$ are the inputs supplied by the intermediate goods' sector and $\lambda_{p,t}$ is the degree of substitutability between the differentiated inputs. The log of $\lambda_{p,t}$ follows an ARMA(1,1) exogenous process:

$$\log\left(1+\lambda_{p,t}\right) = \left(1-\rho_p\right)\log\left(1+\lambda_p\right) + \rho_p\log\left(1+\lambda_{p,t-1}\right) + \varepsilon_t^p + \theta_p\varepsilon_{t-1}^p \tag{23}$$

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

Firms purchase intermediate goods $Y_t\,(i)$ from their monopolistic producers at prices $P_t\,(i)$ and sell the homogeneous final good Y_t at price P_t. Standard profit maximization of the final good producers and their zero profit condition allow me to write 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:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t \tag{24}$$

3.4 Intermediate Goods Producers

Firms in regime of monopoly produce differentiated intermediate goods using the following production technology:

$$Y_t(i) = \max\left\{A_t^{1-\alpha} K_{t-1}(i)^{\alpha} L_t(i)^{1-\alpha} - A_t F; 0\right\} \tag{25}$$

where $K_{t-1}(i)$ and $L_t(i)$ are capital and labor inputs for firm i. A_t represents non-stationary labor-augmenting technological progress. The growth rate of A_t follows an exogenous AR(1) process:

$$\log\left(\frac{A_t}{A_{t-1}}\right) = \log(z_t) = (1-\rho_z)\log(\gamma) + \rho_z \log(z_{t-1}) + \varepsilon_t^z \tag{26}$$

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 is chosen to make average profits across the measure of firms equal to zero in steady state (Rotemberg and Woodford (1993) and Christiano, Eichenbaum, and Evans (2005)).

These intermediate firms minimize their costs and employ homogenous 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 maximize their monopolistic profits, knowing that at each point in time 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)). This means that a fraction ξ_p of intermediate firms will set their prices as a geometric average of past and steady-state inflation.

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:

$$E_t \sum_{s=0}^{\infty} \xi_p^s \beta^s \Lambda_{t+s}^w \left\{\left[P_t(i)\left(\prod_{j=0}^{s} \pi_{t-1+j}^{\iota_p} \pi^{1-\iota_p}\right)\right] Y_{t+s}(i) - \left[W_t L_t(i) + R_t^k K_t(i)\right]\right\} \tag{27}$$

subject to the demand function for good $Y(i)$, (24), and to the production function (25). Households own shares of the intermediate firms: current and future profits (27) are evaluated according to the marginal utility of a representative household, Λ_t^w.

Capital good 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 will choose the optimal amount of inputs, I_t as to maximize their profits:

$$\max_{I_{t+s}} E_t \sum_{s=0}^{\infty} \beta^s E_{t+s} \left\{\Lambda_{t+s}^w \left[P_{t+s}^k i_{t+s} - P_{t+s} I_{t+s}\right]\right\} \tag{28}$$

s.t.

$$i_{t+s} = \left[1 - S\left(\frac{I_{t+s}}{I_{t+s-1}}\right)\right] I_{t+s}. \tag{29}$$

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}^e .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:

$$P_t^k i_t = P_t I_t$$

3.5 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 homogenous 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:

$$\log\left(1+\lambda_{w,t}\right)=\left(1-\rho_w\right)\log\left(1+\lambda_w\right)+\rho_w\log\left(1+\lambda_{w,t-1}\right)+\varepsilon_t^w+\theta_p\varepsilon_{t-1}^w \tag{30}$$

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

Agencies hire specialized labor, $L_{w,t}$ at monopolistic wages, $W_{w,t}$, and provide homogenous 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 equal to:

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

an aggregation of the different $W_{w,t}$, the wage granted to household w in exchange for their specialized labor.

3.6 Households

Households maximize their lifetime utility:

$$\sum_{s=0}^{\infty}\beta^s\left[\log\left(C_{w,t+s}-hC_{w,t+s-1}\right)-\omega\frac{{L_{w,t+s}}^{1+v}}{1+v}\right] \tag{31}$$

subject to their nominal budget constraint:

$$P_tC_{w,t}+Q_t^B\Delta N_{w,t}^{+}-Q_t^A\Delta N_{w,t}^{-}+B_{w,t}=(1-\tau^L)W_{w,t}L_{w,t}+R_t^KN_{w,t-1}+R_{t-1}^BB_{w,t-1}+T_t+Q_{w,t}+\Pi_t \tag{32}$$

and to limited participation constraints on financial markets:

$$\begin{aligned}B_{w,t} &\geq 0\\ \Delta N_{w,t}^{+} &= 0\\ \Delta N_{w,t}^{-} &= 0\end{aligned}$$

Workers do not borrow or accumulate assets in equilibrium.[7] As a result, in a generic time

[7]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

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 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.

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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 (Hurst and Willen (2007), Gourinchas and Parker (2002)). In practice it would be 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. I decided to keep the model tractable and to reflect the evidence availble in aggregate data that shows that the business sector in the US economy is able to produce enough savings to finance its own capital expenditures and does not borrow from other sectors of the economy, including households.

3.7 Monetary Authority

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

$$\frac{R_t^B}{R^B} = \left(\frac{R_{t-1}^B}{R^B}\right)^{\rho_R} \left[\left(\frac{\bar{\pi}_t}{\pi}\right)^{\phi_\pi}\right]^{1-\rho_R} \left(\frac{\Delta\overline{X}_{t-s}}{\gamma}\right)^{\phi_Y} \eta_{mp,t} \tag{33}$$

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 iid monetary policy shock:

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

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

3.8 Fiscal Authority

The government runs a balanced budget in every period. 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 $\varepsilon_t^g \sim iidN\left(0, \sigma^{g2}\right)$.

My model requires an empirically plausible description of the dynamics of the supply of liquid assets that originates from the public authority. To obtain that I follow Leeper, Plante, and Traum (2010) in the empirical work they conduct on the dynamics of fiscal financing in a DSGE model of the US economy.[8] Similarly to their work, I assume that lump-sum transfers to workers, T_t, follow a rule that displays two main features. On one hand, transfers depend on output dynamics and can act as automatic stabilizers along the business cycle. On the other hand fiscal variables respond to

[8]Differently from Leeper et al. (2009), at this stage I do not allow for taxation on final consumption and do not include correlation among the stochastic components of the fiscal rules.

deviations of the debt to GDP ratio, B_t/X_t, from a target level, BoX, and so to keep the stock of debt stationary along time. This 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)). To obtain a fiscal rule that resembles the one in Leeper, Plante, and Traum (2010) de-trended model 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:

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

Transfers then increase when output growth falls below its steady state value. On the other hand, transfers fall when B_t/Y_t increases, 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 their fiscal contribution along time. Entrepreneurs, on the other hand, do not save for tax-smoothing purposes, but accumulate government bonds to self-insure to overcome their borrowing and liquidity constraints on equity sales in the event that a good investment opportunity arrives.

3.9 Aggregation and Market Clearing

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}.[9]

An equilibrium in this economy is defined as a sequence of prices and rates of return

$$\{P_t, P_t^K, Q_t^A, Q_t^B, W_t, R_t^K, R_{t-1}^B\}$$

such that:

- final goods producers choose input $\{K_{t-1}, L_t\}$ and output $\{Y_t\}$ levels to maximize their profits subject the available technology;

[9] Appendix A 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.

- intermediate goods producers set their prices $\{P_t(i)\}$ to maximize their monopolistic profits subject to the demand from final producers (24) and their production function (25);

- capital producers choose the optimal level of input and output $\{Y_t^I, i_t\}$ that maximize their profits (28) under their technological constraint (29);

- entrepreneurs choose optimal consumption, investment, equity sales and purchases as well as asset levels:
$$\left\{C_{e,t}, i_{e,t}, \Delta N_{e,t}^{+}, \Delta N_{e,t}^{-}, N_{e,t}, B_t\right\}$$
that maximize their lifetime utility (9), under their flow of funds constraint (11), and the law of accumulation of equity (11), while satisfying the liquidity constraint (12) and the non-negativity conditions (13);

- Banks maximize their profits (20), to intermediate an amount of equity claims $\Delta N_t^{+} = \Delta N_t^{-}$ between savers and buyers;

- employment agencies maximize their profits by choosing the optimal supply of homogeneous labor, L_t, and their demand for households' specialized labor, $L_{w,t}$;

- households choose consumption, monopolistic wages to maximize their lifetime utility (31) subject to their flow of funds constraint (32);

- Markets clear. 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:
$$X_t = C_t + I_t + G_t$$
Total bond supply, B_t, has to equal to the sum of buyers' individual demands:
$$B_t = \int B_{e,t} f(A_{e,t}) de = B_t^B$$
The equity market clears when the aggregate equity holdings of the (1-$\chi_{s,t}$ - $\chi_{k,t}$) measure of buyers are equal to the sum of their depreciated equity stock, (1- $\chi_{s,t}$ - $\chi_{k,t}$) (1-δ) N_{t-1},

plus the aggregate amount of new and old equity that the $\chi_{s,t}$ measure of sellers can issues, $\theta A_t^S I_t^S + \phi\left(1-\delta\right)\chi_{s,t} N_t$:

$$N_t^B = \theta A_t^S I_t^S + \phi_t\left(1-\delta\right)\chi_{s,t} N_{t-1} + \left(1-\delta\right)\left(1-\chi_{s,t}-\chi_{k,t}\right) N_{t-1}$$

The labor market clears when the amount of hours demanded by intermediate producers equals the total supply of labor from households:

$$\int_0^1 L_t\left(i\right) di = \int_0^1 L_{w,t} dw$$

A technical appendix available online and upon request contains the derivation of the set of equilibrium conditions of the model.[10]

3.10 Model Solution

To solve the model, I first rewrite its equilibrium conditions in stationary terms, rescaling such variables as output, Y_t, consumption, C_t, investment, I_t, capital, K_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.

4 Reconciling the Model with the Compustat Cash Flow Analysis

To proceed with the estimation of the model and make use of the micro evidence in section 2, I first discuss how I can map some of the moments of the model to their empirical counterparts from the analysis on Compustat data. Entrepreneurs can be considered as firms who earn operating cash flows from their business operations and use it to finance new capital expenditures.

Starting from the accounting cash flow identity introduced in section 2:

$$DIV_{e,t} + CAPX_{e,t} - \left(NFI_{e,t} + \Delta CASH_{e,t}\right) + \left(CF_{e,t}^D + CF_{e,t}^{EO}\right) = CF_{e,t}^O \tag{34}$$

I can map its components to the flow of funds constraint of an entrepreneur that is willing to buy

[10] The appendix is available at https://sites.google.com/site/andreaajello/

and install new capital goods in my model in section 3:

$$\underbrace{PC_{e,t}}_{DIV_{e,t}}+\underbrace{P_t^K i_{e,t}}_{CAPX_{e,t}}-\left[\underbrace{q_t^A\phi\left(1-\delta\right)N_{e,t-1}}_{NFI_{e,t}}+\underbrace{\left(R_{t-1}^B B_{e,t-1}-B_{e,t}\right)}_{\Delta CASH_{e,t}}\right]-\underbrace{\theta q_t^A A_{e,t}i_{e,t}}_{\left(CF_{e,t}^D+CF_{e,t}^{EO}\right)}=\underbrace{R_t^K N_{e,t-1}}_{CF_{e,t}^O} \tag{35}$$

The returns on the equity stock correspond to the operating cash flows. 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 (35), it is easy to derive the model equivalent of the financing gap share. Entrsepreneurs with the best technology to install capital goods (sellers) are willing to borrow resources and to use up their liquid assets to carry on their investment. Their aggregate financing gap over the $\chi_{s,t}$ measure of sellers can be written as:

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

so that the financing gap share is equal to the 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, $q_t^A\phi\left(1-\delta\right)\chi_{s,t}N_{t-1}$, and from the sale of liquid assets, $R_{t-1}^B\chi_{s,t}B_{t-1}$ over aggregate investment, I_t:

$$FGS_t=\frac{q_t^A\left(\phi\left(1-\delta\right)\chi_{s,t}N_{t-1}+\theta A_{s,t}i_{s,t}\right)+R_{t-1}^B\chi_{s,t}B_{t-1}}{I_t}.$$

and the fraction of the financing gap funded by means of asset liquidations is:

$$LIQS_t=\frac{\left(\phi\left(1-\delta\right)\chi_{s,t}N_{t-1}+R_{t-1}^B\chi_{s,t}B_{t-1}\right)}{FG_{s,t}}.$$

5 Estimation

In this section I describe the estimation of the model in section 3 on U.S. data using Bayesian methods. I start with a description of the data and the prior distributions chosen for the model parameters and for certain moments implied by the model. I then discuss the estimates and the features of the impulse response functions to the financial intermediation shock, the model fit and the variance decomposition implied by the estimated parameters. I conclude discussing the historical decomposition of the fundamental shocks in the model along the sample period considered and perform counterfactual exercises on output dynamics during the last recession.

5.1 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 related to 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 2. 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, $\times\tau^q_{ss}$, 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 (2010) 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. I use a Beta distribution with mean equal to 0.30 and standard deviation equal to 0.05. Similarly, I use Compustat and Flow of funds data evidence to choose a prior on the steady state share of the financing gap that is covered by portfolio liquidations of equity claims, $q^A_{ss}\left(\phi\left(1-\delta\right)\chi_{s,ss}N_{ss}\right)$, and government bonds, $R^B_{ss}\chi_{s,ss}B_{s,ss}$:

$$LIQS_{SS} = \frac{Q^A_{ss}\left(\phi\left(1-\delta\right)\chi_{s,ss}N_{ss}\right) + R^B_{ss}\chi_{s,ss}B_{s,ss}}{FG_{ss}} = 25\%.$$

The prior that I set on portfolio liquidations, $LIQS_{ss}$, is a Beta 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:

$$B_{ss} + \tau^k R^k_{ss}K_{ss} + \tau^l W_{ss}L_{ss} = R^B_{ss}B_{ss} + \left(1 - \frac{1}{g_{ss}}\right)Y_{ss} + T_{ss} \tag{36}$$

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 (36). Transfer 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 Taylor rule (Woodford (2003)). I fix the elasticity of transfer 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 transfer reactions to output deviations from steady state in a stationary model. Notice that the transfer 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 *iid* 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 *iid*, 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 (2009) 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 4 reports the mean and standard deviations of the moment priors.

6 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.

6.1 Parameter Estimates

Table 2 reports the median and 90% confidence intervals for the set of model parameters, while table 5 reports the estimated implied moments of financial variables. I compute the confidence interval by running a Markov chain Monte Carlo exploration of the posterior function.

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 finding in the literature. The estimated steady state quarterly spread ranges between 8 and 21 basis points, despite the prior set around the sample mean of the high-yield spread of 62.5. 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.

Table 5 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 [0.327, 0.375], compatible with the 30.63% fraction of total investment funded using financial markets found in Compustat data in section 2. The estimated steady state share of the financing gap that is covered by liquidation of assets ranges between [37%, .43%], higher than the 25% average over the whole sample period available in Compustat, but largely within the range of plausible values assumed by the variable along the sample (see figure 5).

6.2 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 persistence of the responses reflects the high autocorrelation of the exogenous process for the intermediation cost, τ_t^q. 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 price of equity sold on the market drops by 4% and the implied 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 0.6%.

A remarkable feature of the impulse responses in figure 8 is the fact that a negative financial shock in the model delivers a sizable drop in the price of traded assets. The impulse response to a financial intermediation shock can be compared to the dynamics of the model following a negative liquidity shock as modeled in Kiyotaki and Moore (2008). A sudden drop in the liquidity of financial assets can be engineered by exogenously reducing the share of assets that entrepreneurs can sell in every period, ϕ, as in KM's original set-up. Figure 9 reports the impulse responses for output, investment, consumption and the price of equity to an exogenous drop in ϕ, evaluated at the posterior mode parameter estimates for my model. The graphs show that by restricting the supply of financial claims on the market, a negative liquidity shock results in a rise in their equilibrium price (bottom right panel). This supply effect dominates over the reduction in the demand for financial claims that have suddenly become less liquid. A similar result is documented by Nezafat and Slavík (2009) , who find that in the KM set-up, similar negative shocks to the ability of entrepreneurs to issue new claims and borrow against the new investment (an exogenous drop in θ in the model) also deliver a rise in asset prices.

Most recently, Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) show that, in the KM set-up, significant drops in asset prices can be achieved by the interaction of negative liquidity shocks with a binding zero lower bound on the nominal interest rate and price rigidities. If the zero lower bound binds and prices are sticky, the expected deflation generated by a negative liquidity shock translates into a rise in the real interest rate on government bonds. Since bonds are traded in non-arbitrage with equity claims, then the price of capital has to drop significantly to increase the rate of return on equity and re-establish equilibrium on financial markets. The drop in asset prices in the calibration of their model amplifies the negative real effects of a liquidity shock, giving rise to recessive outcomes comparable in size to the Great Depression.

6.3 Model Fit

How well does the model fit the features of the data series used for the estimation? Table 6 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 described in section 5.1.

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 real wages growth across the two periods. The model however comes short when trying to match the standard deviations of output and consumption. As discussed in section 3.6, 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 reflects on total output and does not help achieve successful results in matching the relative volatility of the observables (Table 6).

Table 7 reports the autocorrelation coefficients of order one of the observables, compared to those found in the data. The model is able to reproduce significant positive autocorrelations for all the observables. The model matches the autocorrelations coefficients for output, hours and the spread at a 90% confidence level, but falls short in generating the right magnitude of the same coefficients for investment, consumption inflation and real wages.

6.4 Variance Decomposition

This section quantifies the relative importance of the fundamental shocks in the model in driving business cycle fluctuations. Table 8 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 40% of the unconditional variance of GDP growth and around 55% of the volatility of investment. The shock is also able to explain around 40% of cyclical movements in inflation and 90% of the variance of the nominal risk-free rate, suggesting a high degree of intervention of the monetary authority in response to fluctuations induced by financial disturbances. 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 in the observed spread to the financial shock. This result is in line with the view that traditional aggregate shocks (e.g. innovations in total factor productivity) are not able alone to reproduce sizable time-varying risk premia in models where agents show a low degree of risk-aversion (Mehra and Prescott (1985), Hansen and Jagannathan (1991)).

Column 1 in table 8 shows how the neutral technology shock seems to have limited relevance in explaining aggregate fluctuations. The TFP shock accounts for a share of GDP volatility between 8% and 18%, in contrast with the RBC and Neo-Keynesian DSGE empirical literature where it generally accounts for shares of output volatlity larger than 20%. The exogenous nature of the financial intermediation shock can be identified as one of the reasons that drive this result. Following Kurlat (2009), it is plausible to interpret the financial intermediation wedge as a reduced-form representation of an adverse selection friction, that arises on markets with information asymmetries and trading of heterogeneous assets (see section 3 for more details). Aggregate shocks that increase the marginal product of capital, such as positive TFP shocks, favor trading of good quality assets and ameliorate the adverse selection problem, reducing the intermediation wedge endogenously. This form of interaction and financial amplification of other aggregate shocks is not currently present in the model, but is the subject of my ongoing research efforts.

6.5 Smoothed Shocks and Historical Decomposition of the Last 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 last recession.

Figure 10 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 both 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 11 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 11 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 TP, in line with recent findings by Fernald (2009). 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 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 12 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 12 suggest that the nominal interest rate has been consistently higher than the value implied by the estimated Taylor rule.[11]

6.6 Why is the Financial Shock so 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 comovement 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 comovement 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.

In this section I explore the reason why the posterior maximization favors the financial shock as

[11]Research by Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) suggests that unconventional monetary policy 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 in place. For estimation purposes, I abstract from imposing the zero lower bound on the nominal interest rate.

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.

6.6.1 Comovement 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 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 13 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 2 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.[12]

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

[12] Recently, Del Negro, Eggertsson, Ferrero, and Kiyotaki (2010) have emphasized that KM's model of liquidity shocks can produce positive comovement between consumption and investment when the economy is characterized by a certain degree of nominal rigidities. When the liquidity shock hits, aggregate demand falls but prices now can only adjust slowly. What happens to the real rate of interest? This can be defined approximately as the difference between

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 reoptimize 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 output, and contemporaneously reduces the wage bill, $W_t L_t$. 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 comovement 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.[13]

To confirm this intuition, figure 13 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).[14] 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 also by relying on 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 8 and 9. The estimation of the model under flexible wages shows that the

the nominal interest rate and expected future inflation:

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

If prices are expected to drop and the nominal interest rate cannot be decreased, the real interest rate will rise. The price of capital willl have to drop to re-establish non-arbitrage between government bonds and equity claims. The collapse in asset prices can reduce the value of entrepreneurs' net worth and consequently hurt their level of consumption, together with investment. In their set-up, the feedback of the movement in asset prices on net worth and consumption 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.

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

[14]The estimated parameters and posterior characterization for the model with flexible wages are reported in table 7

importance of the financial intermediation shock in explaining business cycle fluctuations in output and consumption drops significantly with respect to the sticky wages model. The shock is able to explain 8% of GDP growth variance and 40% of aggregate investment growth variance compared to 40% and 55% under sticky wages. This result is in line with the intuition discussed for the impulse responses in figure 13: financial intermediation shocks are not able to generate the right comovement 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. 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 variation in equilibrium mark-ups induced by the other structural shocks (including financial intermediation shocks) in the sticky-wage case.

7 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 40% of output and 55% 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 comovement 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 8% and 40% of output and investment growth volatilities.

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Tables and Figures

Table 1: Compustat Evidence on Corporate Investment Financing

Variable X	Mean(X)	StdDev(X)
FGS[1]	**30.63%**	**5.67%**
FGS - Annual (Chari - Kehoe method)[2]	16.26%	4.53%
FGS - Quarterly (Chari - Kehoe method)[3]	34.83%	5.47%
WKS[4]	41.01%	11.57%
DIVS[5]	19.43%	6.20%
–		
External Finance / FG[6]	75.63%	23.74%
Portfolio Liquidations / FG[7]	24.37%	23.74%

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

1. Financing Gap Share of Capital Expenditure defined in equation 6, total of U.S. firms.
2. Financing Gap Share, Chari and Kehoe's method, total of North American corporations. 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

Parameters Estimates - Sticky Wages

Table 2: 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)	$N(0.90, .010)$	0.878	[	0.760	–	1.025	]
d	Entrepreneurs's tech distribution (width)	$IG(0.025, 0.05)$	0.035	[	0.026	–	0.039	]
$\left(\beta^{-1}-1\right)\times 100$	Discount factor	*Calibrated*	0.900	[	–	–	–	]
h	Habit	*Calibrated*	0.900	[	–	–	–	]
$\log L_{ss}$	Labor Supply	$N(2, 0.50)$	2.564	[	1.615	–	3.211	]
ν	Inverse Frisch	$G(2, 0.50)$	1.447	[	1.072	–	2.130	]
θ	Borrowing Constraint	$B(0.30, 0.10)$	0.238	[	0.218	–	0.254	]
$\phi\times 100$	Liquidity Constraint	$G(0.50, 0.10)$	0.082	[	0.062	–	0.106	]
BoY	Liquidity over GDP	*Calibrated*	0.050	[	–	–	–	]
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	$B(0.30, 0.10)$	0.339	[	0.317	–	0.362	]
S	Investment Adj. Costs	$G(2, 0.50)$	1.212	[	0.895	–	1.940	]
λ_p	Price Mark-up	$IG(0.15, 0.05)$	0.062	[	0.048	–	0.080	]
ξ_p	Calvo prices	$B(0.70, 0.10)$	0.807	[	0.734	–	0.846	]
ι_p	Indexation Prices	$B(0.50, 0.15)$	0.146	[	0.089	–	0.306	]
λ_w	Wage Mark-up	$IG(0.15, 0.05)$	0.129	[	0.087	–	0.201	]
ξ_w	Calvo wages	$B(0.70, 0.10)$	0.735	[	0.664	–	0.779	]
ι_w	Indexation Wages	$B(0.50, 0.15)$	0.164	[	0.090	–	0.235	]
ϕ^{π}	Taylor rule - Inflation	$N(1.7, 0.30)$	2.144	[	1.918	–	2.299	]
ϕ^{y}	Taylor rule - Output	$N(0.125, 0.05)$	0.284	[	0.257	–	0.314	]

Parameter	Explanation	Prior[1]	Mode	[	5%[2]		95%[2]	]
ρ^R	Taylor rule - Persistence	$B(0.60, 0.20)$	0.858	[	0.825	–	0.877	]
π_{ss}	SS Inflation	$N(0.50, 0.10)$	0.592	[	0.548	–	0.742	]
γ	SS Output Growth	$N(0.30, 0.05)$	0.305	[	0.269	–	0.342	]
τ_q	SS Spread	$G(0.625, 0.15)$	0.173	[	0.087	–	0.212	]
θ_p	MA(1) Price Mark-up	$B(0.80, 0.10)$	0.714	[	0.673	–	0.853	]
θ_w	MA(1) Wage Mark-up	$B(0.80, 0.10)$	0.671	[	0.398	–	0.772	]
ρ_z	AR(1) TFP shock	$B(0.40, 0.20)$	0.411	[	0.309	–	0.480	]
ρ_g	AR(1) Gov't spending	$B(0.60, 0.20)$	0.978	[	0.956	–	0.981	]
ρ_p	AR(1) Price Mark-up	$B(0.60, 0.20)$	0.930	[	0.895	–	0.959	]
ρ_w	AR(1) Wage Mark-up	$B(0.60, 0.20)$	0.819	[	0.791	–	0.911	]
ρ_{τ_q}	AR(1) Financial Spread	$B(0.60, 0.20)$	0.977	[	0.966	–	0.981	]
ρ_b	AR(1) Intertemporal pref.	$B(0.40, 0.20)$	0.991	[	0.983	–	0.992	]
σ_z	Stdev TFP Shock	$IG(0.50, 1)$	0.496	[	0.456	–	0.542	]
σ_{mp}	Stdev MP Shock	$IG(0.50, 1)$	0.123	[	0.111	–	0.144	]
σ_g	Stdev Gov't Shock	$IG(0.50, 1)$	0.354	[	0.321	–	0.402	]
σ_p	Stdev Pr. Mark-up Shock	$IG(0.50, 1)$	0.151	[	0.121	–	0.175	]
σ_w	Stdev Wage Mark-up Shock	$IG(0.50, 1)$	0.282	[	0.256	–	0.346	]
σ_{τ_q}	Stdev Financial Shock	$IG(0.50, 1)$	4.431	[	3.981	–	5.388	]
σ_b	Stdev Preference Shock	$IG(0.50, 1)$	0.026	[	0.024	–	0.029	]
σ_η	Stdev Meas Error Spread	$IG(0.25, 1)$	0.525	[	0.472	–	0.657	]

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 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm.
Acceptance rate 23%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Parameters Estimates - Flexible 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)	$N(0.90, .010)$	0.887	[	0.768	–	1.041	]
d	Entrepreneurs's tech distribution (width)	$IG(0.025, 0.05)$	0.03	[	0.024	–	0.037	]
$\left(\beta^{-1} - 1\right) \times 100$	Discount factor	*Calibrated*	0.900	[	–	–	–	]
h	Habit	*Calibrated*	0.900	[	–	–	–	]
$\log L_{ss}$	Labor Supply	$N(2, 0.50)$	2.729	[	2.037	–	3.479	]
ν	Inverse Frisch	$G(2, 0.50)$	0.423	[	{0.301}	–	.524	]
θ	Borrowing Constraint	$B(0.30, 0.10)$	0.251	[	0.233	–	0.269	]
$\phi \times 100$	Liquidity Constraint	$G(0.50, 0.10)$	0.0012	[	0.001	–	0.002	]
BoY	Liquidity over GDP	*Calibrated*	0.050	[	–	–	–	]
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	$B(0.30, 0.10)$	0.300	[	0.283	–	0.32	]
S"	Investment Adj. Costs	$G(2, 0.50)$	2.314	[	1.804	–	2.914	]
λ_p	Price Mark-up	$IG(0.15, 0.05)$	0.054	[	0.044	–	0.067	]
ξ_p	Calvo prices	$B(0.70, 0.10)$	0.637	[	0.590	–	0.687	]
ι_p	Indexation Prices	$B(0.50, 0.15)$	0.10	[	0.063	–	0.133	]
λ_w	Wage Mark-up	$IG(0.15, 0.05)$	0.134	[	0.088	–	0.210	]
ξ_w	Calvo wages	$B(0.70, 0.10)$	0.735	[	0.664	–	0.779	]
ι_w	Indexation Wages	$B(0.50, 0.15)$	0.206	[	0.178	–	0.237	]
ϕ^{π}	Taylor rule - Inflation	$N(1.7, 0.30)$	2.305	[	2.216	–	2.432	]
ϕ^{y}	Taylor rule - Output	$N(0.125, 0.05)$	0.105	[	0.037	–	0.176	]

Parameter	Explanation	Prior[1]	Mode	[	5%[2]		95%[2]	]
ρ^R	Taylor rule - Persistence	$B(0.60, 0.20)$	0.988	[	0.980	–	0.993	]
π_{ss}	SS Inflation	$N(0.50, 0.10)$	0.592	[	0.548	–	0.742	]
γ	SS Output Growth	$N(0.30, 0.05)$	0.305	[	0.269	–	0.342	]
τ_q	SS Spread	$G(0.625, 0.15)$	0.266	[	0.196	–	0.359	]
θ_p	MA(1) Price Mark-up	$B(0.80, 0.10)$	0.554	[	0.399	–	0.755	]
θ_w	MA(1) Wage Mark-up	$B(0.80, 0.10)$	0.671	[	0.257	–	0.501	]
ρ_z	AR(1) TFP shock	$B(0.40, 0.20)$	0.105	[	0.037	–	0.177	]
ρ_g	AR(1) Gov't spending	$B(0.60, 0.20)$	0.988	[	0.980	–	0.993	]
ρ_p	AR(1) Price Mark-up	$B(0.60, 0.20)$	0.978	[	0.966	–	0.986	]
ρ_w	AR(1) Wage Mark-up	$B(0.60, 0.20)$	0.863	[	0.716	–	0.971	]
ρ_{τ_q}	AR(1) Financial Spread	$B(0.60, 0.20)$	0.982	[	0.977	–	0.986	]
ρ_b	AR(1) Intertemporal pref.	$B(0.40, 0.20)$	0.976	[	0.963	–	0.987	]
σ_z	Stdev TFP Shock	$IG(0.50, 1)$	0.464	[	0.431	–	0.497	]
σ_{mp}	Stdev MP Shock	$IG(0.50, 1)$	0.129	[	0.113	–	0.15	]
σ_g	Stdev Gov't . Shock	$IG(0.50, 1)$	0.335	[	0.298	–	0.377	]
σ_p	Stdev Pr. Mark-up Shock	$IG(0.50, 1)$	0.209	[	0.163	–	0.377	]
σ_w	Stdev Labor Pref Shock	$IG(0.50, 1)$	43.677	[	41.237	–	46.139	]
σ_{τ_q}	Stdev Financial Shock	$IG(0.50, 1)$	4.47	[	3.708	–	5.256	]
σ_b	Stdev Preference Shock	$IG(0.50, 1)$	0.032	[	0.03	–	0.035	]
σ_η	Stdev Meas Error Spread	$IG(0.25, 1)$	0.51	[	0.435	–	0.605	]

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 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm.

Acceptance rate 21%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 4: Priors on Theoretical Moments

Moment	Prior Type	Prior Mean	Prior Std
$\mathrm{Var}(\Delta \log X_t)$	N	1.15	0.18
$\mathrm{Var}(\Delta \log I_t)$	N	16.35	2.63
$\mathrm{Var}(\Delta \log C_t)$	N	0.29	0.04
$\mathrm{Var}(R_t^B)$	N	0.84	0.23
$\mathrm{Var}(\pi_t)$	N	0.43	0.10
$\mathrm{Var}(logL)$	N	10.74	2.36
$\mathrm{Var}(Sp_t)$	-	-	-
$\mathrm{Var}(\Delta \log w_t)$	N	0.20	0.03
$\mathrm{E}[FGS_t]$	B	0.30	0.05
$\mathrm{E}[PLS_t]$	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 2088:Q4. Prior distributions on steady state level of financing gap share (FGS) and share of portfolio liquidations over total financing gap (PLS), centered around Compustat sample averages over a period 1989:Q1 - 2010:Q1.

Table 5: Compustat Moments - Estimated Model vs. Data

	Data	Model Median	[	5%		95%	]
$E[FGS_t]$	0.307	0.351	[	0.310	–	0.364	]
$E[DES_t]$	0.75	0.597	[	0.568	–	0.624	]
$E[LIQS_t]$	0.25	0.403	[	0.376	–	0.432	]
$Pr(FG<0)$	0.49	0.567	[	0.546	–	0.594	]

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: 1989q1 to 2010q1). Posterior percentiles from 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 23%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 6: Model Fit : Standard Deviations

Observables	Data	Model				Prior Mean
		Median	5%	-	95%	
Stdev($\Delta \log X_t$)	0.63	0.83	[0.72	-	0.96]	1.07
Stdev($\Delta \log I_t$)	2.58	2.37	[2.01	-	2.79]	4.04
Stdev($\Delta \log C_t$)	0.50	0.69	[0.60	-	0.79]	0.54
Stdev(R_t^B)	0.58	0.74	[0.44	-	0.74]	0.92
Stdev(π_t)	0.27	0.53	[0.39	-	0.74]	0.66
Stdev($\log L_t$)	4.75	2.93	[1.89	-	4.55]	3.28
Stdev(Sp_t)	0.52	1.20	[0.80	-	1.89]	-
Stdev($\Delta \log w_t$)	0.75	0.56	[0.48	-	0.66]	0.45

Standard deviations of observable variables. Model implied vs. Data and Endogenous Prior mean. Source: Haver Analytics. Sample period: 1989Q1 - 2010Q1. Pre-sample for priors: 1954Q3 - 1988Q4. Posterior percentiles from 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 23%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 7: Model Fit : Autocorrelations of Order 1

Observables	Data	Model			
		Median	5%	-	95%
$\mathrm{Corr}(\Delta \log X_t, \Delta \log X_{t-1})$	0.47	0.32	[0.13	-	0.48]
$\mathrm{Corr}(\Delta \log I_t, \Delta \log I_{t-1})$	0.60	0.23	[0.05	-	0.40]
$\mathrm{Corr}(\Delta \log C_t, \Delta \log C_{t-1})$	0.51	0.32	[0.13	-	0.49]
$\mathrm{Corr}(R^B_t, R^B_{t-1})$	0.93	0.98	[0.94	-	0.99]
$\mathrm{Corr}(\pi_t, \pi_{t-1})$	0.52	0.91	[0.76	-	0.97]
$\mathrm{Corr}(\log L_t, \log L_{t-1})$	0.93	0.96	[0.88	-	0.98]
$\mathrm{Corr}(Sp_t, Sp_{t-1})$	0.81	0.84	[0.57	-	0.95]
$\mathrm{Corr}(\Delta \log w_t, \Delta \log w_{t-1})$	0.035	0.49	[0.28	-	0.64]

Autocorrelation of Order 1 of Observable Variables. Model implied vs. Data Data source: Haver Analytics, Sample period 1989Q1 - 2010Q1. Posterior percentiles from 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 23%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 8: Posterior Variance Decomposition - Sticky wages (benchmark case)

	TFP	MP	Gov't	Price Mark-up	Wage Mark-up	Financial	Preference	Meas. Error
$\Delta \log X_t$	**12.8**	**8.1**	**2.5**	**17.6**	**12.2**	**41.0**	**5.2**	**0.0**
	[7.7 - 18.1]	[5.3 - 11.4]	[1.6 - 4.0]	[12.4 - 23.9]	[6.8 - 19.9]	[29.4 - 51.7]	[4.1 - 6.9]	[0.0 - 0.0]
$\Delta \log I_t$	**6.9**	**4.0**	**0.6**	**22.1**	**4.6**	**56.00**	**5.1**	**0.0**
	[5.1 - 9.9]	[2.7 - 5.6]	[0.4 - 0.9]	[15.1 - 31.1]	[3.3 - 6.3]	[46.6 - 63.6]	[3.6 - 7.7]	[0.0 - 0.0]
$\Delta \log C_t$	**22.1**	**5.9**	**12.0**	**3.7**	**24.0**	**6.6**	**24.7**	**0.0**
	[16.0 - 28.8]	[3.8 - 8.7]	[8.3 - 16.9]	[2.1 - 5.8]	[17.2 - 31.8]	[3.5 - 11.1]	[20.8 - 29.1]	[0.0 - 0.0]
R_t^B	**0.7**	**2.7**	**0.9**	**2.7**	**1.3**	**87.6**	**3.7**	**0.0**
	[0.2 - 1.9]	[2.0 - 3.8]	[0.6 - 1.5]	[1.8 - 3.9]	[0.6 - 2.6]	[84.3 - 90.2]	[2.7 - 5.0]	[0.0 - 0.0]
π_t	**18.5**	**4.4**	**0.2**	**17.8**	**12.6**	**43.1**	**2.6**	**0.0**
	[13.3 - 25.7]	[3.2 - 6.1]	[0.1 - 0.5]	[12.5 - 23.6]	[8.2 - 17.9]	[34.8 - 51.6]	[2.0 - 3.4]	[0.0 - 0.0]
$\log L_t$	**8.6**	**8.7**	**3.1**	**26.8**	**24.0**	**23.4**	**3.8**	**0.0**
	[3.5 - 16.9]	[5.6 - 12.3]	[1.8 - 5.5]	[18.6 - 35.7]	[13.7 - 37.2]	[14.6 - 32.6]	[2.9 - 5.3]	[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]
$\Delta \log w_t$	**16.8**	**1.3**	**2.9**	**34.6**	**40.0**	**1.9**	**1.2**	**0.0**
	[10.4 - 24.5]	[0.6 - 2.2]	[2.0 - 4.4]	[25.2 - 44.9]	[30.3 - 52.4]	[0.7 - 4.3]	[0.7 - 2.1]	[0.0 - 0.0]

Variance Decomposition of the observables. Median values and 90% confidence intervals reported. Posterior percentiles obtained from 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 23%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

Table 9: Variance Decomposition of the observables.

	TFP	**MP**	**Gov't**	**Price Mark-up**	**Wage Mark-up**	**Financial**	**Preference**	**Meas. Error**
$\Delta \log X_t$	**29.7**	**0.6**	**18.8**	**15.1**	**25.4**	**8.2**	**1.8**	**0.0**
	[25.6 - 33.9]	[0.4 - 0.8]	[15.3 - 23.1]	[12.2 - 18.6]	[21.9 - 29.9]	[6.1 - 10.7]	[1.4 - 2.2]	[0.0 - 0.0]
$\Delta \log I_t$	**5.2**	**1.2**	**2.6**	**28.1**	**3.0**	**38.9**	**20.5**	**0.0**
	[4.2 - 6.4]	[0.8 - 1.7]	[1.9 - 3.4]	[23.6 - 32.9]	[2.4 - 3.8]	[32.7 - 45.4]	[16.4 - 25.6]	[0.0 - 0.0]
$\Delta \log C_t$	**39.9**	**0.0**	**1.2**	**2.1**	**38.4**	**0.8**	**17.5**	**0.0**
	[34.9 - 44.7]	[0.0 - 0.1]	[0.8 - 1.7]	[1.5 - 2.9]	[34.1 - 42.8]	[0.6 - 1.1]	[14.6 - 20.7]	[0.0 - 0.0]
R_t^B	**0.4**	**4.2**	**2.1**	**3.1**	**0.8**	**83.6**	**5.6**	**0.0**
	[0.3 - 0.5]	[3.2 - 5.7]	[1.5 - 3.1]	[2.4 - 3.9]	[0.5 - 1.3]	[80.3 - 86.3]	[4.3 - 7.2]	[0.0 - 0.0]
π_t	**8.2**	**7.1**	**1.8**	**11.6**	**4.9**	**59.4**	**6.5**	**0.0**
	[6.2 - 10.9]	[5.4 - 9.4]	[1.2 - 2.6]	[8.9 - 14.9]	[3.9 - 6.2]	[52.9 - 65.8]	[5.2 - 8.2]	[0.0 - 0.0]
$\log L_t$	**2.3**	**0.5**	**30.7**	**25.9**	**38.3**	**1.2**	**0.8**	**0.0**
	[1.8 - 2.8]	[0.3 - 0.8]	[25.7 - 36.4]	[20.4 - 31.7]	[33.0 - 44.2]	[0.7 - 1.8]	[0.6 - 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]
$\Delta \log w_t$	**14.1**	**3.6**	**7.1**	**47.1**	**16.7**	**3.1**	**7.9**	**0.0**
	[11.3 - 17.5]	[2.7 - 4.7]	[5.3 - 9.6]	[42.2 - 51.4]	[14.4 - 19.8]	[1.9 - 4.7]	[6.4 - 9.4]	[0.0 - 0.0]

Variance Decomposition of the observables. Median values and 90% confidence intervals reported. Posterior percentiles obtained from 2 chains of 100,000 draws generated using a Random walk Metropolis algorithm. Acceptance rate 21%. Burning period: initial 20,000 draws. Observations retained: one in every 10 draws.

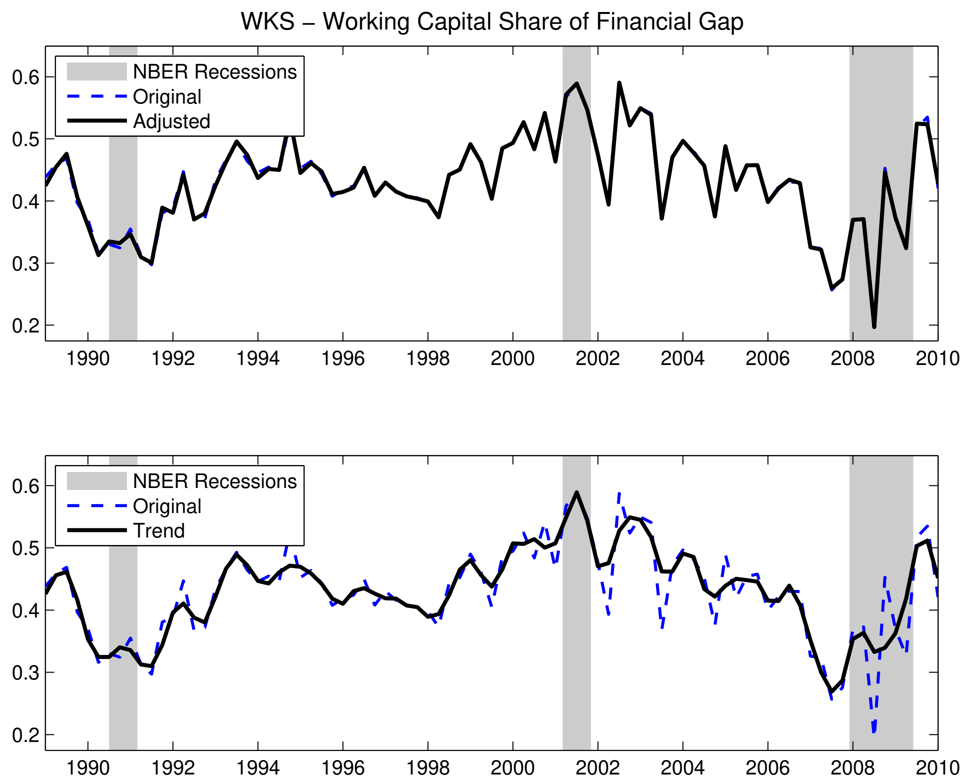
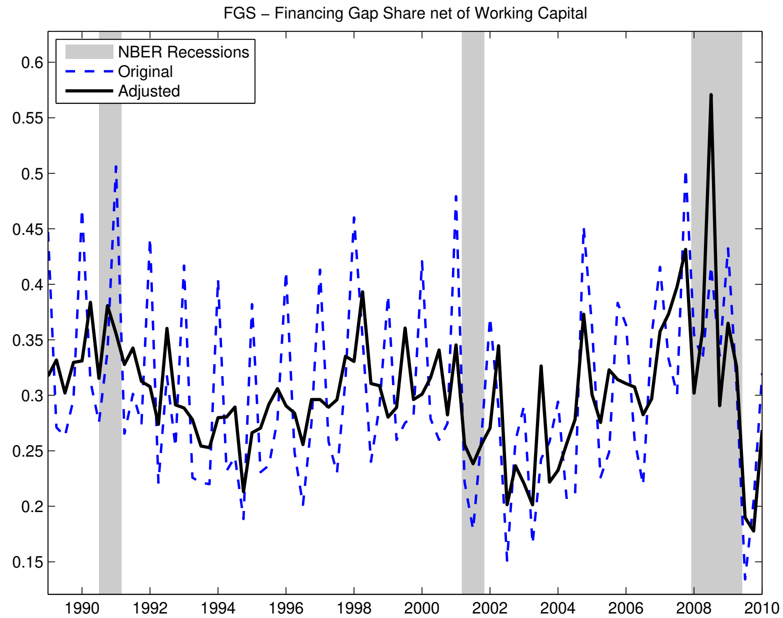


Figure 2: WKS$_t$: Working capital financing needs as a share of total Financing Gap. Source: Compustat. Sample period 1989Q1 - 2010Q1.



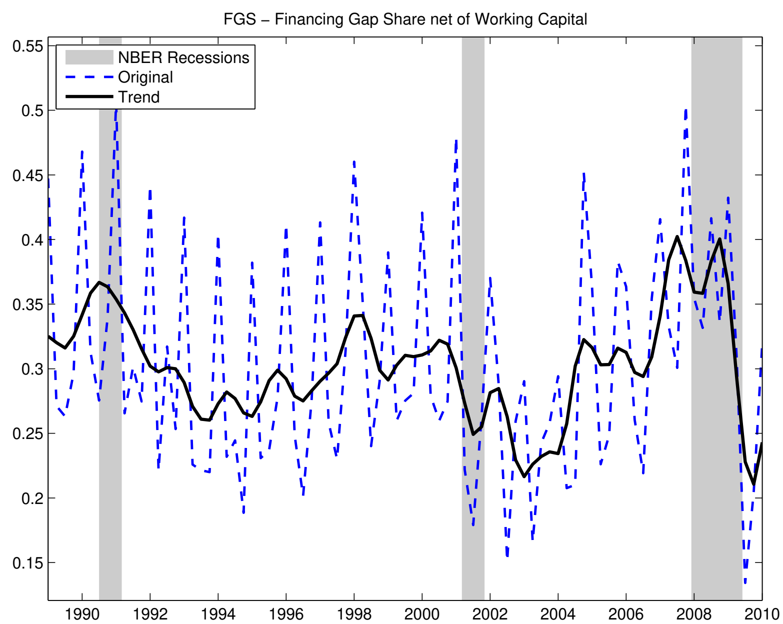


Figure 3: FGS_t: Financing Gap Share. Source: Compustat. Sample period 1989Q1 - 2010Q1.

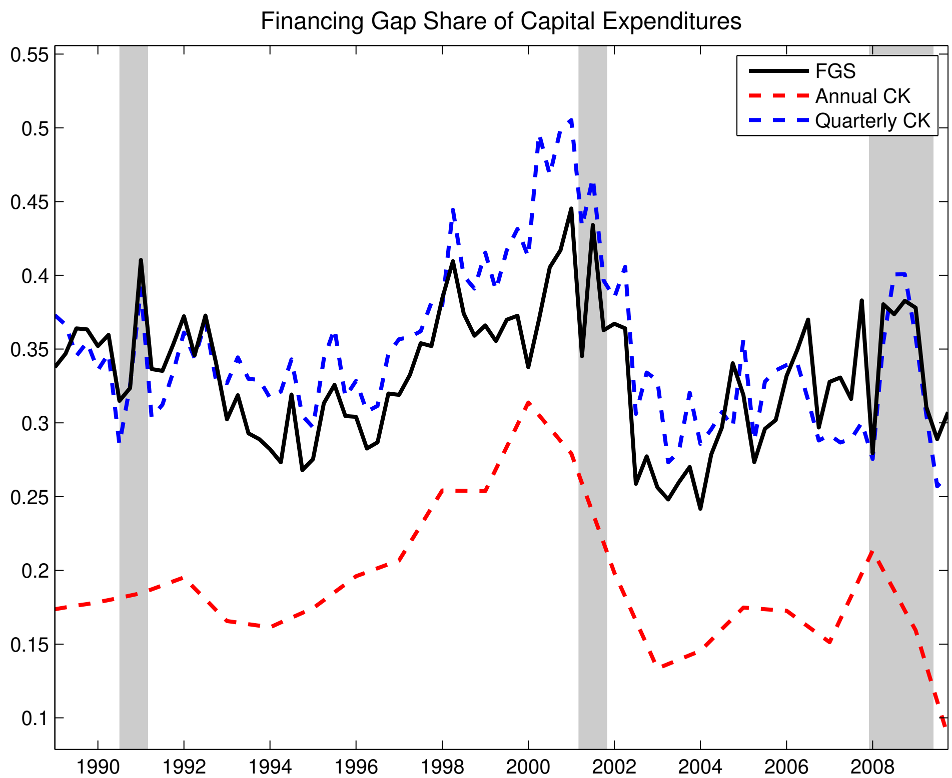


Figure 4: Financing Gap Share, as computed in equation (5) (black solid line). The series is compared to results obtained using Chari and Kehoe (2009)'s methdology applied to annual data (red dashed line) and quarterly data (blue dashed line).

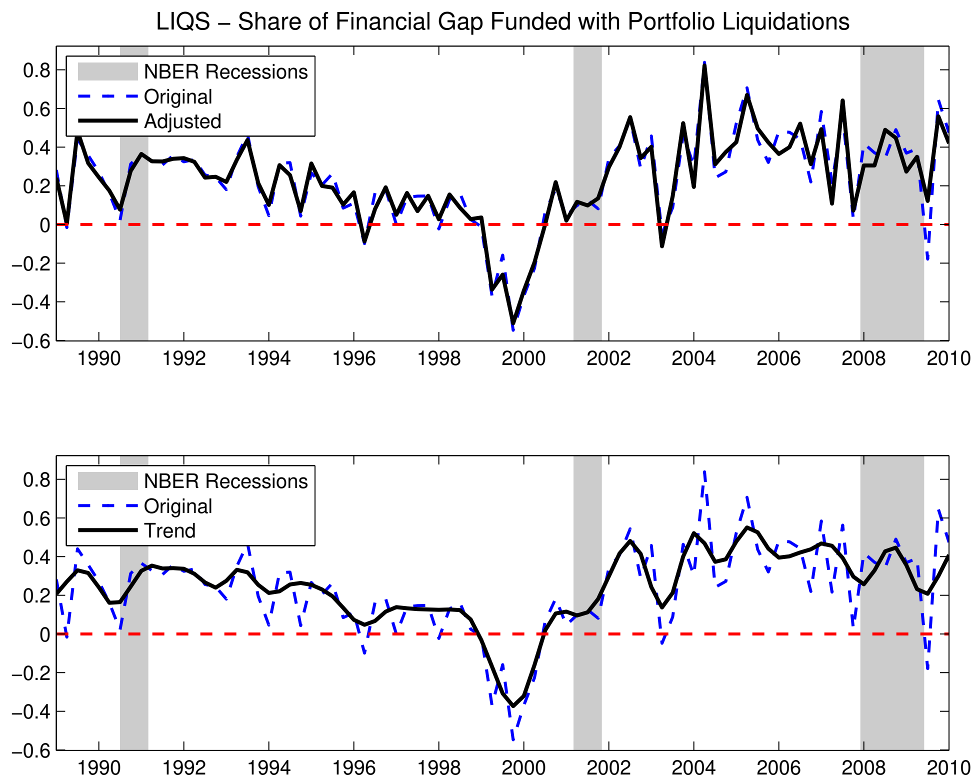


Figure 5: LIQS_t: Share of Financing Gap funded through portfolio liquidations and changes in cash reserves. Source: Compustat. Sample period 1989Q1 - 2010Q1.

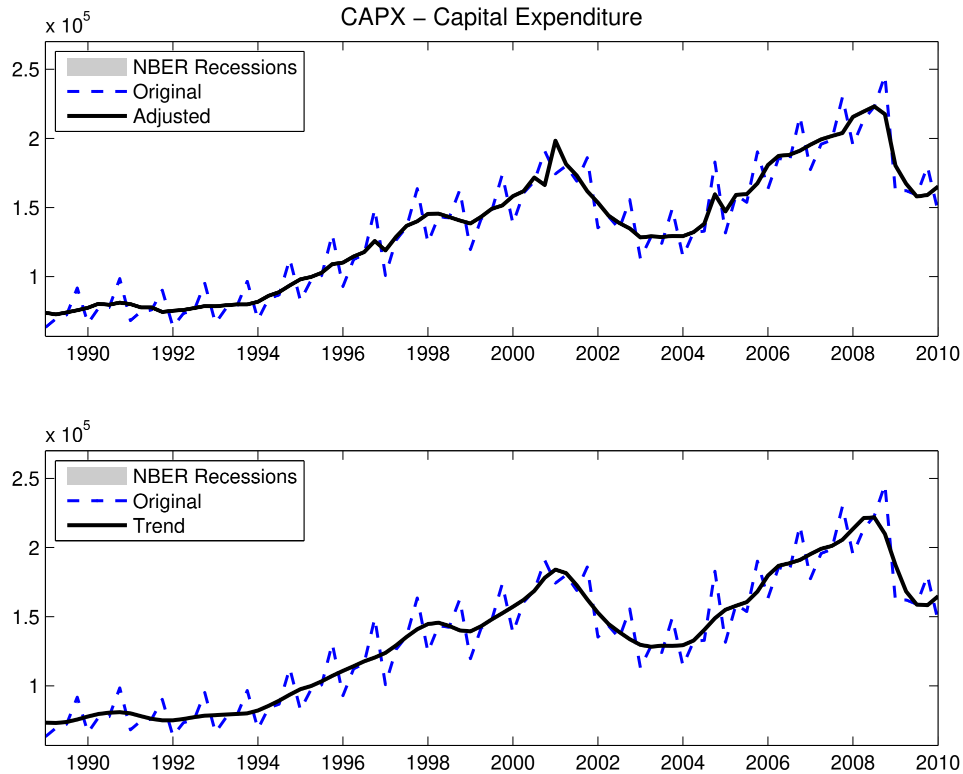


Figure 6: $CAPX_t$: Total Capital Expenditure of U.S. firms in Compustat. Source: Compustat. Sample period 1989Q1 - 2010Q1.

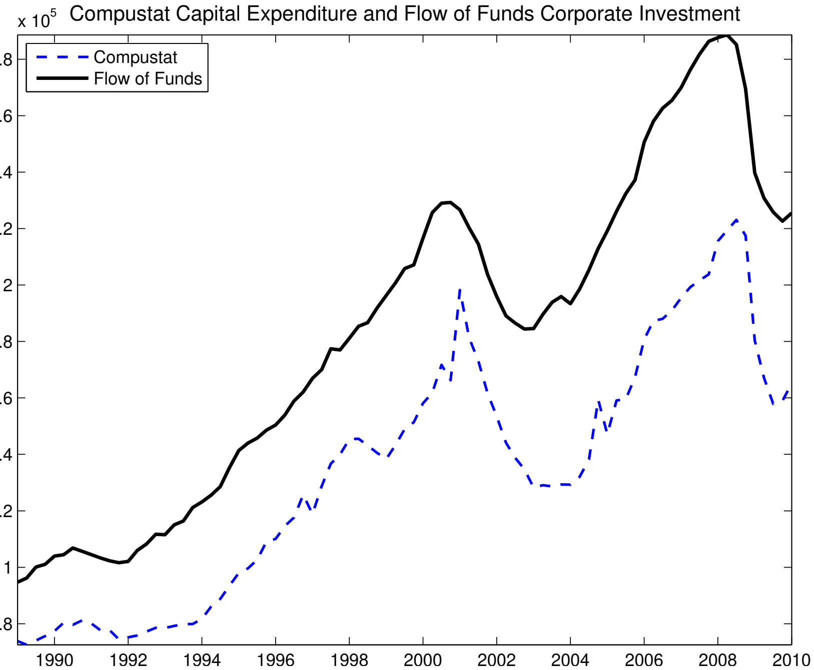


Figure 7: Comparison of Capital Expenditure of Compustat Firms and Flow of Funds Corporate Capital Expenditure. Sources: Compustat and Flow of Funds Table F.102. Sample period 1989Q1 - 2010Q1.

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

Row variables 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: $E[CAPX_t/X_t]$: the average fraction of each variable represented by Compustat Capital Expenditure; 100 $E[X_t]$: the average quarterly growth rate of the series along the sample period; 100 Stdev[$\Delta \log X_t$]: the standard deviation of the quarterly growth rate of the series; Corr[$\Delta \log X_t$, $\Delta \log CAPX_t$]: the correlation of each series with $CAPX_t$.

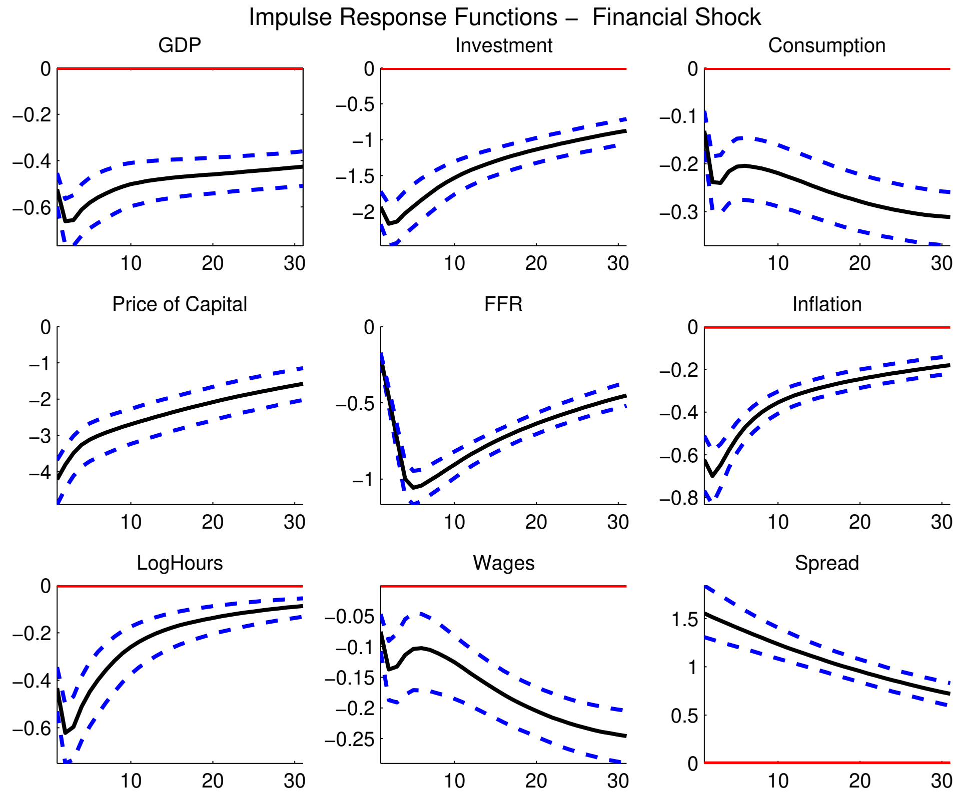


Figure 8: Impulse responses to a one standard deviation financial shock. The dashed lines represent 90 percent posterior probability bands around the posterior median.

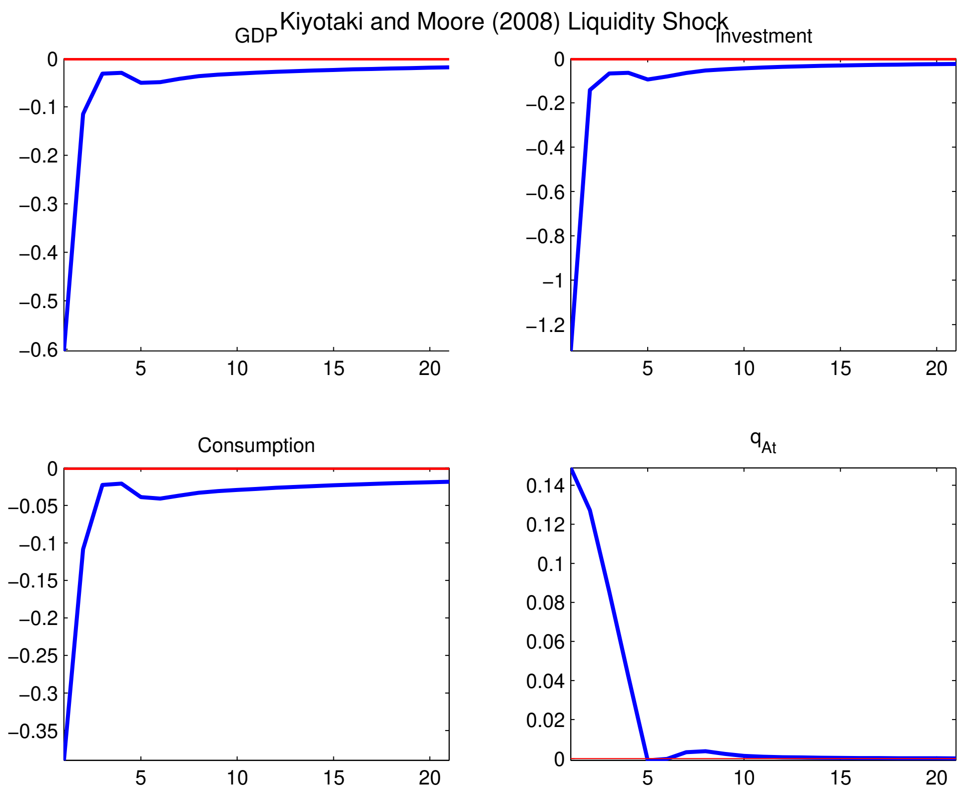


Figure 9: Impulse responses to an exogenous liquidity shock à la Kiyotaki and Moore (2008).

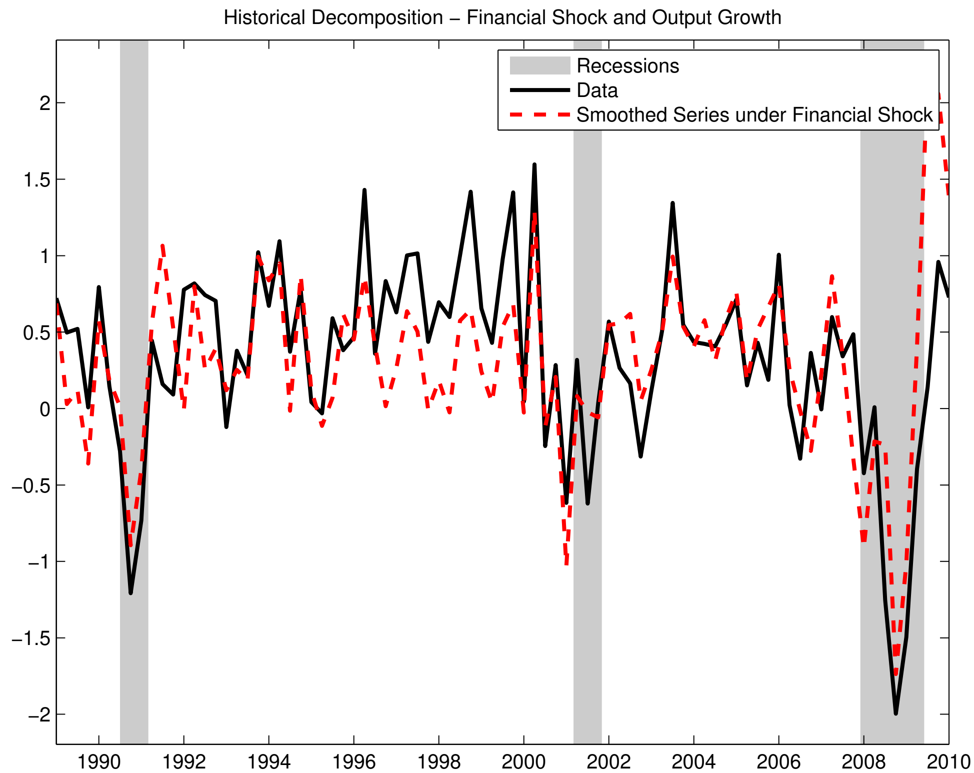


Figure 10: Quarterly output growth in the data (black solid line) and in the model (red dahsed line) with only financial shocks.

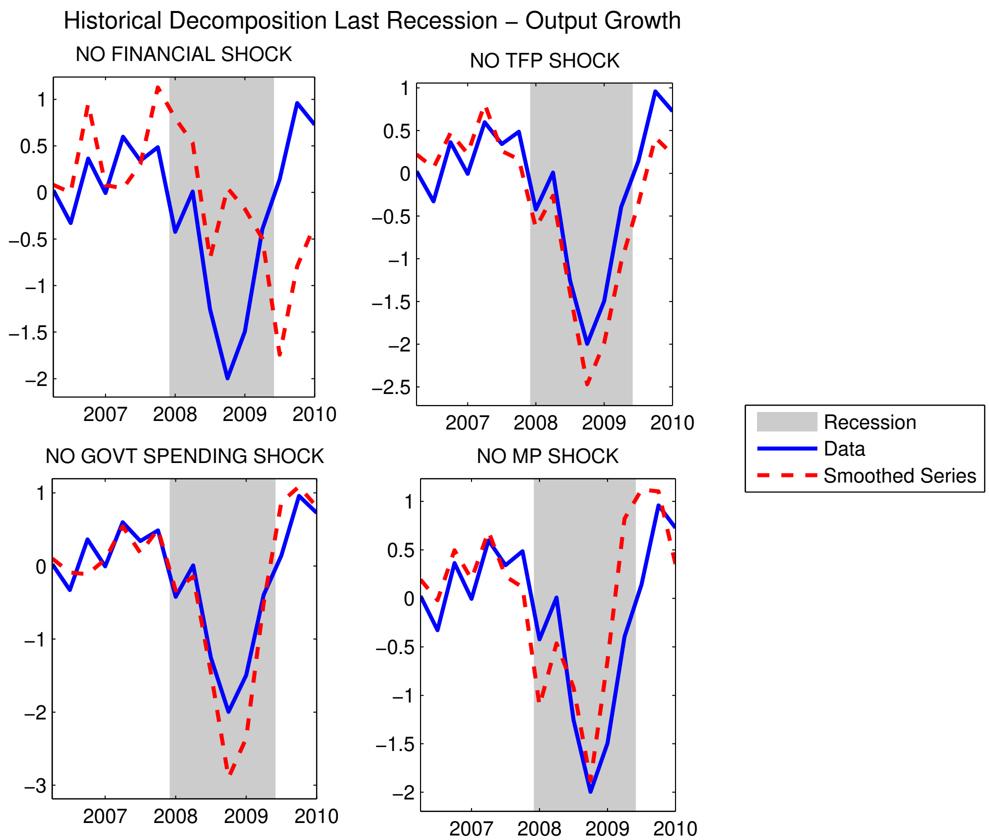


Figure 11: Quarterly output growth in the data (blue lines) and in the model (red dashed lines) without financial shocks (top-left), TFP shocks (top-right panel), government spending shocks (bottom-left panel) and monetary policy shocks (bottom-right panel).

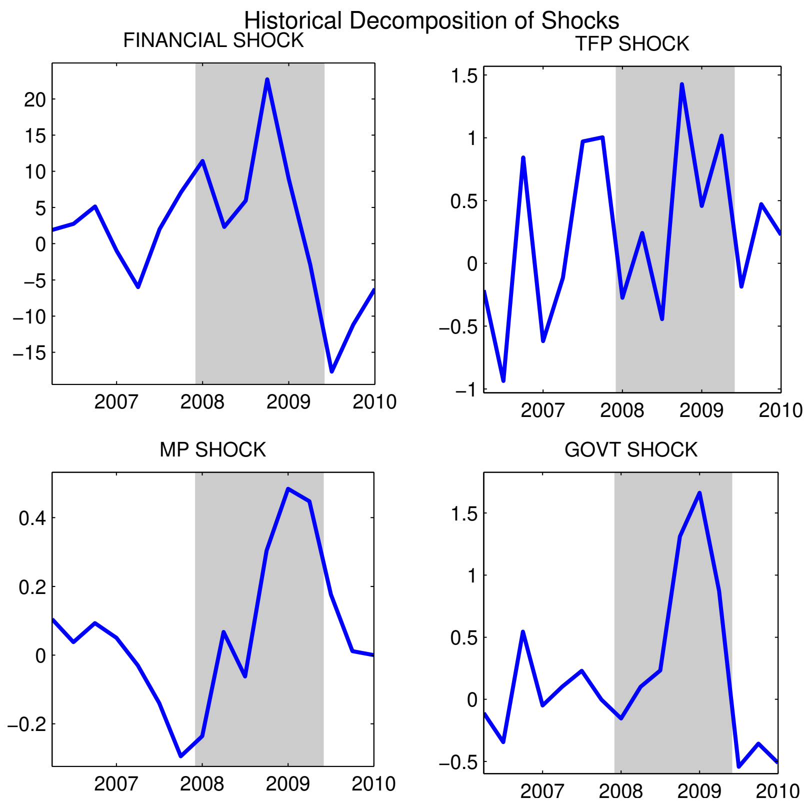


Figure 12: Historical decomposition of last recession into: financial shocks (top-left panel), TFP shocks (top-right panel), government spending shocks (bottom-left panel) and monetary policy shocks (bottom-right panel).

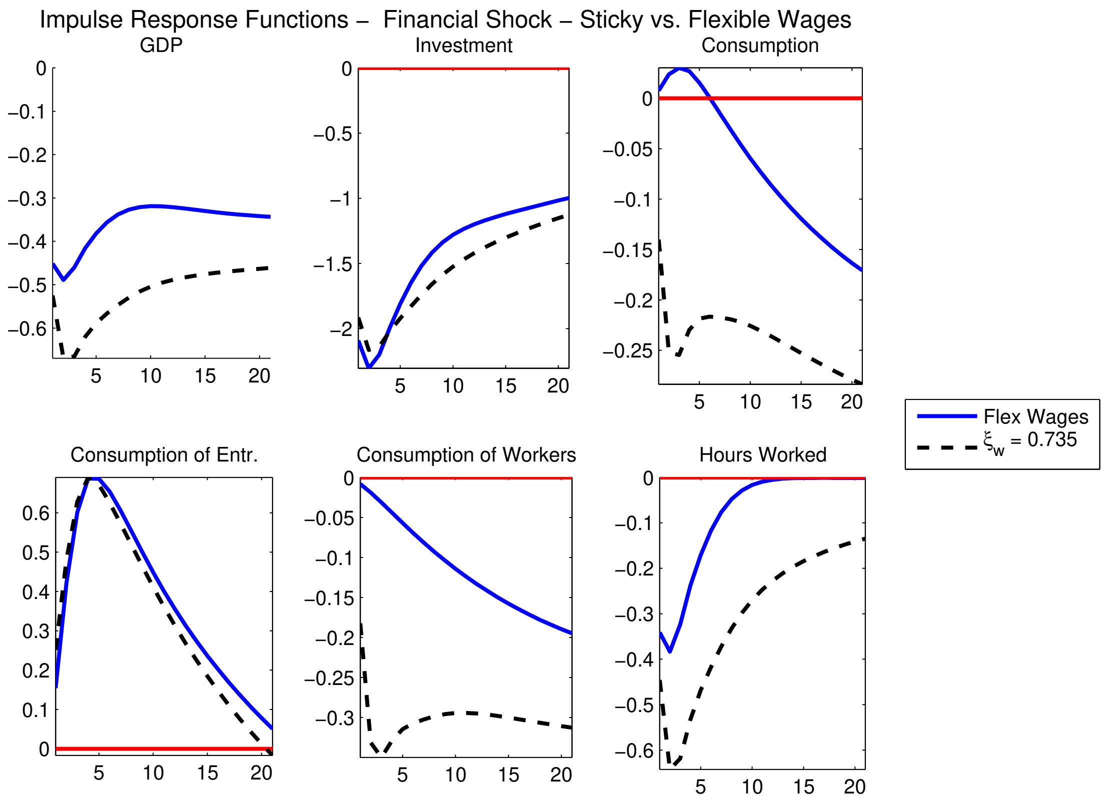


Figure 13: Impulse response functions to a one standard deviation financial shock. Comparison between sticky wages (black dashed line) and flexible wages (blue solid line). Impulse responses are computed at the posterior modes.