Online Appendix

for "Financial Intermediation, Investment Dynamics, and Business Cycle Fluctuations", by Andrea Ajello

This online appendix provides supplementary material for "Financial Intermediation, Investment Dynamics and Business Cycle Fluctuations" by Andrea Ajello, published on the American Economic Review.

Section A compares Flow of Funds and Compustat corporate cash flow data, while section B maps Compustat's financing gap into the model. Section C describes the data used for the estimation. Section D compares financial intermediation shocks and liquidity shocks. Section E reports the model equilibrium conditions. Section F simulates the economy to replicate features of the Great Recession under a binding effective lower bound for the nominal federal funds rate. Section G presents a version of the model with constant aggregate investment technology, while section H studies the accuracy of the log-linearized model solution. Section I presents a version of the model with constant shares of buyers, keeper and sellers. Section J describes an estimated version of the model with shocks to the dispersion of investment technologies. Section K concludes the online appendix with additional robustness estimates and figures.

A Flow of Funds and Compustat Corporate Cash Flow Data

Figure 28 and Table 5 compare dynamic properties of level and growth rates of capital expenditures in Compustat, $CAPX_t$ with those of aggregate corporate capital expenditures from the Flow of Funds table, $FoF\ CAPX_t$ and of aggregate investment, I_t. Capital expenditures for the aggregate of U.S. Compustat corporations account for around 60% of quarterly Flow of Funds U.S. corporate capital expenditure and 32% of aggregate investment from 1989:Q1 to 2008:Q2.

I find that capital expenditures growth in Compustat correlates well with aggregate capital expenditures growth from the Flow of Funds table for corporations (F.102). The two series show similar averages and standard deviations of their annual trailing growth rates. The Compustat series in the graph was seasonally adjusted using the Census X12 procedure.

The same Flow of Funds table for corporations (F.102) reports a measure of financial dependence of the whole 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 United States for the aggregate of firms, U.S. Internal Funds_t, U.S. internal funds in a given quarter t are computed as corporate profits net of taxes, dividend payments and capital depreciation:

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

and total investment (or expenditure) on fixed capital, $CAPX_t$:

$$\text{Financing Gap}_t = FG_t = \text{U.S. Internal Funds}_t - CAPX_t. \tag{35}$$

In a given quarter FG_t is positive when the aggregate of U.S. corporations generate cash flows from their business operations large enough to cover their capital expenditures and lend resources to the rest of the economy. On the other hand, in a quarter when FG_t is negative, the firms draw resources from the rest of the economy to finance a fraction of their capital expenditures. This aggregate measure, however, is not informative of the degree of dependence of single corporations on financial markets. Firms in deficit are aggregated with firms in surplus and positive values for the aggregate financing gap can coexist with corporations with large deficits at the micro-level. In Flow of Funds data from 1952 to 2008, the average share of the financing gap out of total capital expenditures for U.S. corporations amounts to +8%, showing that the corporate sector has on average been a net supplier of savings to the rest of the economy.

Table 5: Compustat and Flow of Funds data on Capital Expenditures and Investment

Moment	$CAPX_t$	$FoF\ CAPX_t$	$FoF\ I_t$
$\text{E}[\frac{CAPX_t}{V_t}]$	1	57.11%	35.23%
$\text{E}[\Sigma_{s=0}^{3} \frac{\Delta \log V_{t-s}}{4}]$	1.01%	1.07%	0.92%
$\text{Stdev}[\Sigma_{s=0}^{3} 100 \frac{\Delta \log V_{t-s}}{4}]$	1.60%	2.13%	1.45%
$\text{Corr}[\Sigma_{s=0}^{3} 100 \frac{\Delta \log V_{t-s}}{4}, \Sigma_{s=0}^{3} 100 \frac{\Delta \log CAPX_{t-s}}{4}]$	1	0.45	0.79

Variables V_t in columns are: $CAPX_t$: Compustat aggregate capital expenditure; $FoF\ CAPX_t$: Flow of Funds Corporate capital expenditure; $FoF\ I_t$: Flow of Funds Aggregate Investment. The table reports: 1. $\text{E}[\frac{CAPX_t}{V_t}]$: the average fraction that $CAPX_t$ represents of each variable V_t; 2. $\text{E}[\Sigma_{s=0}^{3} 100 \frac{\Delta \log V_{t-s}}{4}]$: the four-quarter trailing average of the growth rate of V_t; 3. $\text{Stdev}[\Sigma_{s=0}^{3} 100 \frac{\Delta \log V_{t-s}}{4}]$: the standard deviation of the four-quarter trailing average of the growth rate of V_t; 4. $\text{Corr}[\Sigma_{s=0}^{3} 100 \frac{\Delta \log V_{t-s}}{4}, \Sigma_{s=0}^{3} 100 \frac{\Delta \log CAPX_{t-s}}{4}]$: the correlation of the four-quarter trailing averages of the growth rate of V_t and $CAPX_t$. All series are seasonally adjusted using the Census X12 procedure. Sample Period 1989:Q1 - 2008:Q2.
Source: Compustat quarterly files and Flow of Funds Tables

B Mapping Compustat's Financing Gap into the Model

I interpret the aggregate of entrepreneurs in the model as the universe of corporations in Compustat and derive the equivalent of the financing gap share series, FGS_t, from their flow of funds constraints. Entrepreneurs earn operating cash flows from their capital stock and use them to finance new capital expenditures. They also access financial markets to either raise external financing or to liquidate part of their assets. Starting from the accounting cash flow identity (2) in section 1, I can map its components to the flow of funds constraint of an entrepreneur that is willing to buy and install new investment goods in my model in section 2:

$$\underbrace{PC_{e,t}}_{DIV_{e,t}} + \underbrace{P_t^K i_{e,t}}_{CAPX_{e,t}} - \left[\underbrace{Q_t^A \phi\left(1-\delta\right) N_{e,t-1}}_{NFI_{e,t}} + \underbrace{\left(R_{t-1}^B B_{e,t-1} - B_{e,t}\right)}_{\Delta CASH_{e,t}} \right] - \underbrace{\theta Q_t^A A_{e,t} i_{e,t}}_{\left(CF_{e,t}^D + CF_{e,t}^{EO}\right)} = \underbrace{R_t^K N_{e,t-1}}_{CF_{e,t}^O} \quad (36)$$

The returns on the equity holdings, $R_t^K N_{e,t-1}$, correspond to the operating cash flows, $CF_{e,t}^O$. Entrepreneur's nominal consumption, $P_t \mathrm{C}_{e,t}$, can be identified with dividends paid to equity holders, $DIV_{e,t}$, and the purchase of new investment goods, $P_t^K i_{e,t}$, with capital expenditures, $CAPX_{e,t}$. Net financial operations in Compustat, $NFI_{e,t}$, are mapped into net sales of old equity claims, $Q_t^A \phi\left(1-\delta\right) N_{e,t-1}$, 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 units of capital installed, $\theta Q_t^A A_{e,t} i_{e,t}$.

From (36), it is easy to derive the model equivalent of the financing gap share defined in (4). Entrepreneurs with the best technology to install capital (sellers) are willing to borrow resources and to utilize their liquid assets to carry on their investment. The aggregate Financing Gap over the $\chi_{s,t}$ measure of sellers, $S = \left[\frac{P_t^K}{Q_t^A}, A_t^{high}\right]$, can be written as:

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

so that the 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 liquid assets that come to maturity, $R_{t-1}^B \chi_{s,t} B_{t-1}$, over aggregate investment, I_t in each quarter:

$$FGS_t = \frac{Q_t^A \left(\phi\left(1-\delta\right) \chi_{s,t} N_t + \int_S \theta A_{s,t} i_{s,t} f(A_{s,t}) ds\right) + R_{t-1}^B \chi_{s,t} B_t}{I_t}.$$

. Following the definitions introduced in section 1, I compute the model equivalent for the Liquidation Share, $LIQS_t$, as the fraction of sellers' financing gap, FG_t, that is funded by the liquidation of financial claims and liquid assets:

$$LIQS_t = \frac{Q_t^A \left(\phi \left(1-\delta\right) \chi_{s,t} N_t\right) + R_{t-1}^B \chi_{s,t} B_{s,t-1}}{FG_t}. \tag{37}$$

and the Cash Share as the fraction of sellers' financing gap funded by the return on liquid assets:

$$CASHS_t = \frac{R_{t-1}^B \chi_{s,t} B_{s,t-1}}{FG_t}. \tag{38}$$

C Data: Observables

To estimate the model parameters, I use the following vector of eight observable variables:

$$\left[\Delta \log GDP_t,\ \ \Delta \log I_t,\ \ \Delta \log C_t,\ \ \Delta \log \frac{W_t}{P_t},\ \ \pi_t,\ \ R_t^B,\ \ \log L_t,\ \ Sp_t,\ \ \widehat{FGS}_t\right]$$

Aggregate series can be obtained from the BEA via Haver Analytics. The dataset is composed of the log growth rate of real per-capita GDP, GDP_t (Haver mnemonic: GDP@USECON minus net export XNET@USECON), investment, I_t (sum of durable consumption CD@USECON and investment I@USECON), aggregate consumption, C_t (sum of non-durable consumption CN@USECON and services CS@USECON) and real hourly wages, $\frac{W_t}{P_t}$ (non-farm business sector compensation per hour, LXNFC@USECON). The dataset also includes the federal funds rate (FFED@USECON), mapped into the model nominal risk-free rate R_t^B, the growth rate of the GDP price deflator (JGDP@USECON), mapped into the model inflation rate π_t, and the log of per-capita hours worked, L_t (non-farm payroll aggregate hours LHTNAGRA@USECON). Per-capita variables are obtained by dividing aggregates by the hp-filtered total U.S. population, defined as the sum of the civilian labor force and the individuals 16 and higher that are not in the labor force (LF@USECON and LH@USECON respectively). On top of the macro variables that are standard in the literature, the observables include the spread between the 10-year BBB-rated corporate bond yield (Moody's seasoned Baa) and the 10-year Treasury note yield, Sp_t (from the FRB H.15 table).

D Financial Intermediation and Liquidity Shocks

This section provides a comparison of the effects of *financial intermediation* shocks and *liquidity* shocks à la Kiyotaki and Moore (2012) on asset prices under different model assumptions.

Financial intermediation shocks in my model look similar to liquidity shocks described by KM and Del Negro et al. (2010), as they both hit the intertemporal Euler equation for equity holdings and affect the trading margin between sellers and buyers of equity. Following KM original contribution, I define a liquidity shock in the model as an exogenous change in the share of resalable assets in the economy, ϕ. In particular, I assume that $\phi = \phi_t$ follows an AR(1):

$$\phi_t = (1 - \rho_\phi)\phi + \rho_\phi \phi_{t-1} + \varepsilon_t^\phi,$$

with $\varepsilon_t^\phi \sim \mathrm{N}(0, \sigma_\phi^2)$, i.i.d.

In the section below I compare impulse responses of the economy to financial intermediation shocks and to liquidity shocks in the presence and in the absence of nominal rigidities and for different degrees of inertia in the central bank's nominal interest rate rule.

D.1 Nominal Rigidities and The Dynamics of Asset Prices

Figure 13 compares impulse responses of a negative financial intermediation shock (blue solid line) and a negative liquidity shock (red dashed line) with the same impact and persistence in the response of GDP, in the baseline model with price and wage stickiness. The two shocks are essentially equivalent, generating the same impulse responses for observable variables as well as for other endogenous variables such as use of liquid assets and cash reserves to fund financing gaps (a reduction in asset liquidity makes the liquidation share $LIQS_t$ drop and the use of cash reserves $CASHS_t$ rise). Figure 13 suggests that the two types of disturbances might not be separately identifiable, if a model that featured both shocks were to be estimated on macro and financial data for the United States. I confirmed this intuition by running numerous posterior maximizations and explorations under the assumption that both financial intermediation and liquidity shocks can affect my model. In all such attempts The posterior was clearly bimodal: in one mode the financial intermediation shock was more persistent than the liquidity shock and in the other the degree of persistence of the two shocks was reversed. Persistent shocks would leave to prolonged higher borrowing costs, lower financial dependence and reduced economic activity and would matter greatly in explaining business cycle fluctuations, while transient ones would mean-revert quickly and explain little of medium frequency fluctuations in macro aggregates.

In models without nominal rigidities, Shi (2015) shows that liquidity shock generate a negative co-movement between output and asset prices. I confirm this finding and show that financial intermediation shocks instead are immune to Shi (2015)'s critique in models without price and wage rigidities. I also show that Shi (2015)'s critique of liquidity shocks extends to models with nominal rigidities in which the degree of inertia in the central bank's nominal interest rate rule is low.

As noted by Shi (2015), under plausible calibrations of the KM model, a negative liquidity shocks generates a recession while on financial markets the contraction in asset supply pushes up the price of financial claims.[29] In contrast, Del Negro et al. (2010) emphasize that liquidity shocks can produce positive co-movement between output and asset prices in a calibrated variation of the

[29]Nezafat and Slavik (2015) show how shocks to the share of pledgeable units of capital θ in a model similar to KM also generate countercyclical asset price movements.

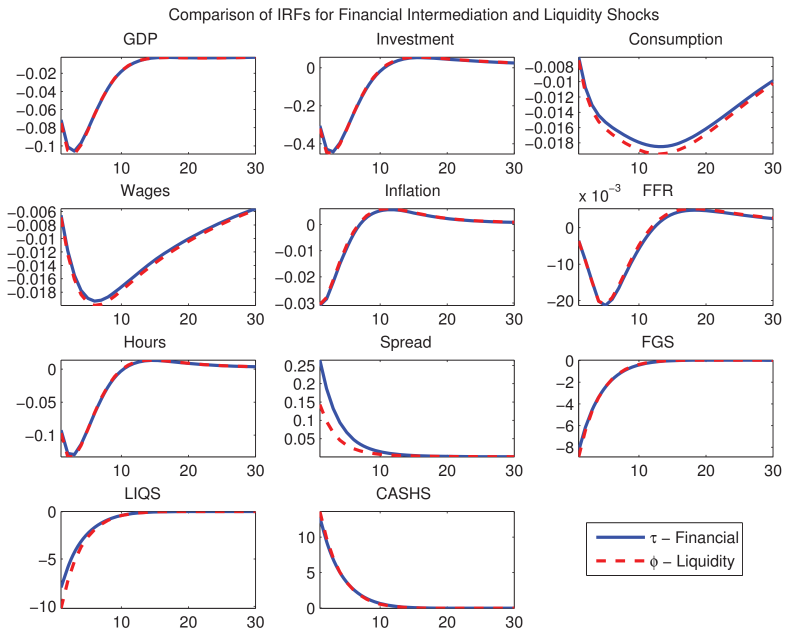

Figure 13: Comparison of impulse responses to a financial intermediation shock (black solid line) and liquidity shock (blue dashed line) in the baseline model with nominal rigidities.

original KM model when the economy features a certain degree of nominal rigidities and when the nominal interest rate in the economy is at the zero lower bound.

Figures 14 and 15 compare the impulse responses of the model to a negative liquidity shock and financial intermediation respectively, under different model parameterizations. The impulse responses are computed at the posterior mode of the model (black solid lines), under the assumption that prices and wages are nearly flexible to replicate an economy similar to KM and Shi (2015) ($\xi_p = \xi_w = 0.01$, magenta dotted line) and finally under the assumption of (nearly) flexible prices and wages and lower persistence of the shock ($\xi_p = \xi_w = 0.01$ and $\rho_\tau = \rho_\phi = 0.5$ compared to 0.96 in the baseline).[30]

The magenta lines in figure 14 confirm that a negative liquidity shock in a model without nominal rigidities is accompanied by a marked and prolonged drop in the real interest rate. Both the real purchase and resale prices of equity claims, q_t^B and q_t^A, rise to maintain the no-arbitrage equilibrium on equity and bond markets. The countercyclical responses of asset prices are more pronounced when the liquidity shock is less persistent.[31]

[30] All impulse responses are normalized so that the drop in aggregate GDP on impact is of the same magnitude as under the estimated baseline financial intermediation shock (figure 15, panel 1). The persistence of the baseline liquidity shock is set equal to that of the estimated financial intermediation shock, $\rho_\phi = \rho_\tau = 0.96$.

[31] If liquidity shocks are highly persistent, then the household considers equity claims to be more risky: they cannot be sold easily for longer periods of time once a negative liquidity shock hits. The demand for illiquid assets drops more after more persistent liquidity shocks. The drop in demand offsets the reduction in the supply of traded assets at first and delivers an initial drop in the resale price of equity, q_t^A. Nonetheless, after a short-lived reduction in the price of equity, the supply effect dominates and translates in a marked increase of the resale price of equity.

In contrast, in the presence of nominal rigidities and inertial nominal interest rates, liquidity shocks induce equity prices to drop on impact. As described in section 4.1.1, nominal rigidities and inertial nominal rates prevent the real rate to drop on impact after the shock hits. The black solid lines in figure 14 show that real rate rises on impact, while buyers' real purchase price of financial claims from intermediaries, q_t^B, drops to equate the expected returns on equity claims and bonds. The downward pressure on q_t^B translates one-to-one on the resale price of equity q_t^A, by means of the zero-profit conditions of the banking sector.

Figure 15, instead, shows the impulse responses of the model after a financial intermediation shock. Financial intermediation shocks captures an increase in intermediation costs in the banking sectors that drives down the resale price of equity, q_t^A, raising the borrowing costs of entrepreneurs, with negative effects on capital accumulation. The third panel in figure 15 reveals that a negative financial intermediation shock robustly generates a drop in the real resale price of equity claims, q_t^A, in models with and without nominal rigidities and a lower degree of persistence of the shock.

The evidence in this section corroborates the findings of the literature that point at a shortcoming of the original KM formulation of liquidity shocks as producing countercyclical asset price movements in models with flexible prices and wages. Financial intermediation shocks can instead deliver procyclical predictions for asset price dynamics that are robust to the absence of nominal rigidities.

In such models, the policy rule plays an important role on the dynamic adjustment of the economy. The next section explores this in more detail.

D.2 Monetary Policy Inertia and The Dynamics of Asset Prices

In this section, I offer a discussion on the role of nominal interest rate inertia in the transmission of liquidity and financial intermediation shocks in my New Keynesian model with nominal rigidities. Figures 16 and 17 compare the impulse responses of the model to a negative liquidity shock and financial intermediation shock, respectively. Each plot shows impulse responses of GDP, consumption, the real interest rate, and the real resale prices of equity, q_t^A, computed at the posterior mode (black solid lines), under a degree of interest rate inertia that is half of the one estimated in the baseline, $\rho_i = 0.43$ (magenta dotted lines) and under the extreme assumption of no interest rate smoothing, $\rho_i = 0$, (blue dashed lines).[32]

Figure 16 shows that the ability of liquidity shocks to produce a procyclical response of asset prices depends on the degree of inertia of the central bank's interest rate rule. In contrast figure 17 shows that the positive co-movement between asset prices and GDP induced by financial intermediation shocks is robust to changes in the nominal interest rate inertia parameter.

[32] All impulse responses are normalized so that the drop in aggregate GDP on impact is of the same magnitude as under the estimated baseline financial intermediation shock (figure 17, panel 1) The persistence of the baseline liquidity shock is set equal to that of the estimated financial intermediation shock, $\rho_\phi = \rho_\tau = 0.96$.

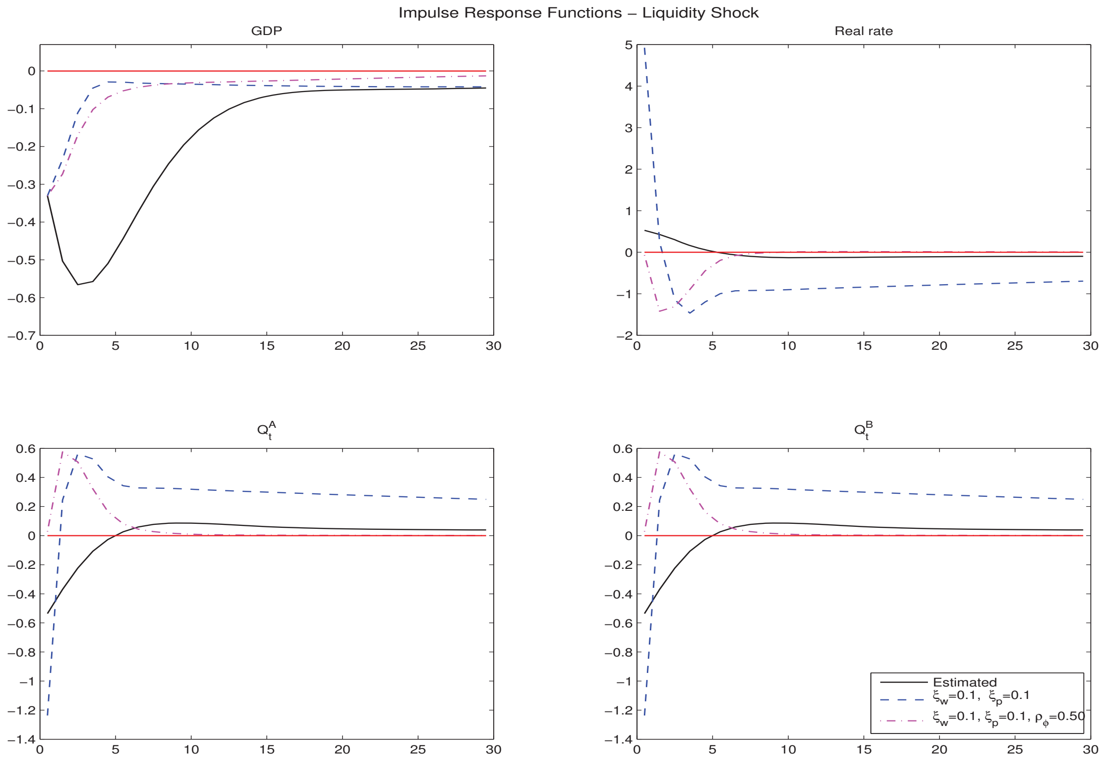

Figure 14: IR Functions to Liquidity Shock: comparison between baseline model with addition of persistent liquidity shock to ϕ(black solid lines), flex prices and wages model (blue dashed lines) and flex price and wage model where the liquidity shock has lower persistence $\rho_\phi = .50$ (dash-dot lines).

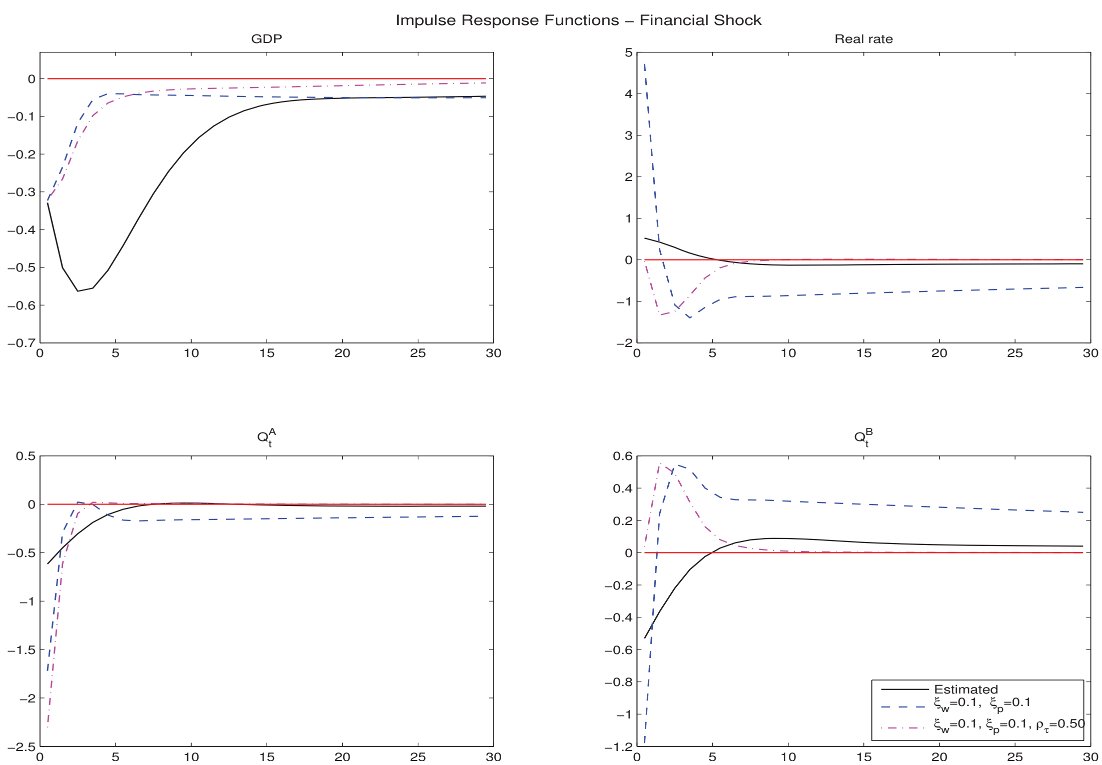

Figure 15: IR Functions to Financial Intermediation Shock: comparison between baseline model (black solid lines), flex prices and wages model (blue dashed lines) and flex price and wage model where the intermediation shock has lower persistence $\rho_\tau = .50$ (dash-dot lines).

Under the estimated degree of inertia for the nominal interest rate $\rho_i = 0.86$, both liquidity shocks and financial intermediation shocks deliver positive co-movement of asset prices and output in the baseline model. Financial intermediation shocks however generate more volatile responses in asset prices than liquidity shocks for a given change in output. If the Taylor rule features a high degree of interest rate inertia and prices and wages are sticky, after a shock hits, agents expect the real interest rate to rise on impact and adjust downward slowly. In the case of liquidity shocks, the rise in the real interest rate commands a drop of -0.35% in the real price of financial claims, q_t^A, to equate the expected return on equity to the real interest rate in a non-arbitrage equilibrium. After the initial drop, equity prices rise above their steady state level in around 7 quarters and stay persistently above it. In the case of financial intermediation shocks the resale price of equity, q_t^A, drops more, by -0.6% on impact in the baseline model. After the initial drop, equity prices stay persistently below their steady state level.

When I reduce the interest rate inertia parameter to half its estimated value, $\rho_i = 0.43$ (magenta dotted lines), and then to zero (dashed blue lines), negative liquidity shocks generate a recession in which asset prices drop initially but quickly reverse and stay above their steady-state level. Figure 16 shows that this reversal is faster and more pronounced than in the baseline model (solid black lines), weakening the positive co-movement between asset prices and GDP. In contrast the impulse responses to a negative financial intermediation shocks in figure 17 show patterns that are in line with those in the baseline model, with a strong positive correlation between asset prices and GDP.

It is important to note that changes in the degree of Taylor rule inertia do not have as stark as an effect on the cyclical properties of consumption in the model, while the presence or the absence of nominal rigidities do (see section 4.1.1): the impulse responses in figures 16 and 17 suggest that a lower degree of inertia of the interest rate rule does not change the procyclical behavior of consumption in response to both liquidity and financial intermediation shocks.

In conclusion, the degree of inertia of the central bank's interest rate rule proves crucial in generating a strong positive co-movement between output and asset prices in response to liquidity shocks in a model with nominal rigidities. In contrast, financial intermediation shocks deliver a robust positive co-movement between asset prices and output, regardless of the degree of inertia of the Taylor rule.

D.3 Model Fit and Stock Market Growth

In this section I verify that the asset market dynamics implied by my estimated model with financial intermediation shocks share important properties with U.S. financial market data, other than the corporate bond spreads.

My model with financial intermediation shocks is estimated by fitting data on credit spreads for corporate bonds of BBB rating. I discussed the properties of the estimated model in fitting the

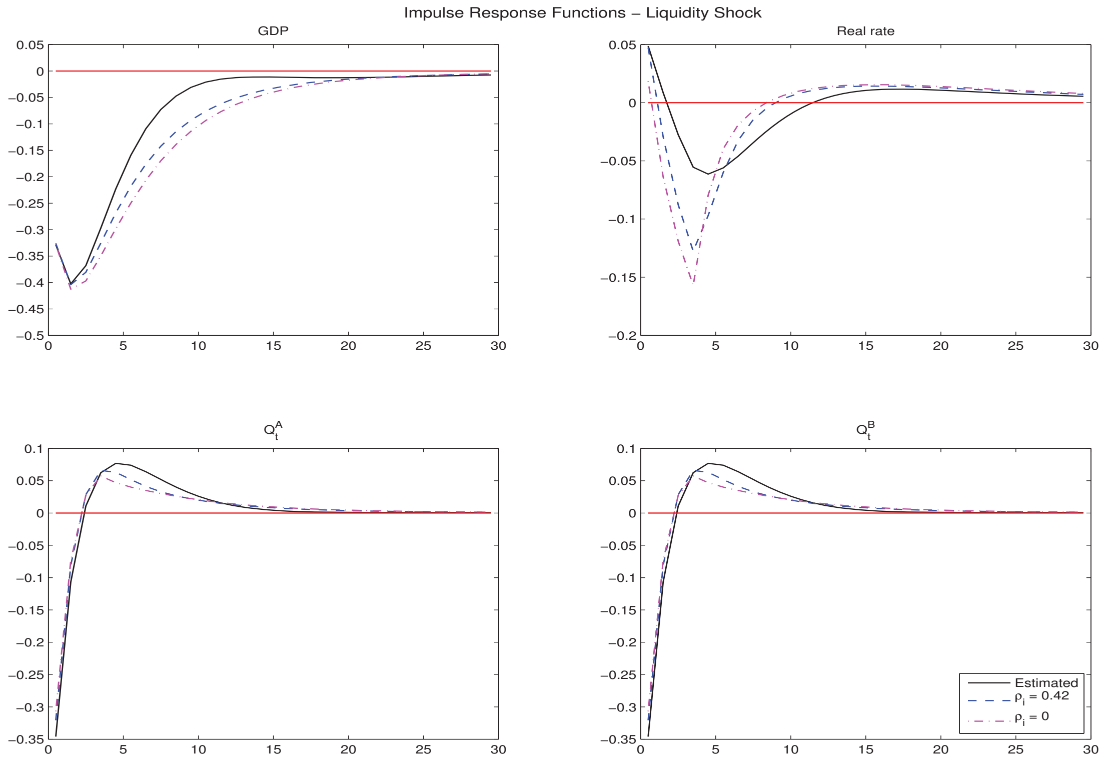

Figure 16: IR Functions to Liquidity Shock: comparison between baseline model (black solid lines), model with $\rho_i = 0.43$ (blue dashed lines) and model with $\rho_i = 0$ (dash-dot lines).

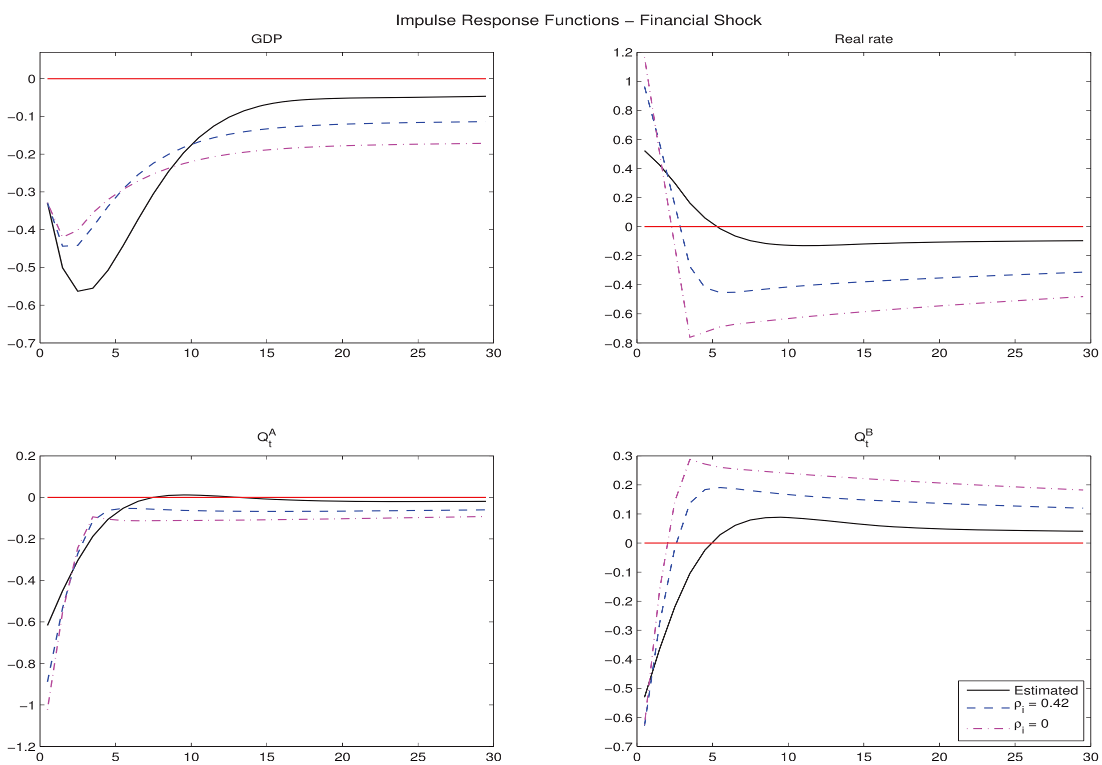

Figure 17: IR Functions to Financial Intermediation Shock: comparison between baseline model (black solid lines), model with $\rho_i = 0.43$ (blue dashed lines) and model with $\rho_i = 0$ (dash-dot lines).

observable corporate spread series in section 4.2. It is interesting, as a source of external validation of the model fit and in light of the procyclical responses of asset prices to financial intermediation shocks, to check how the estimated model performs in replicating the dynamics of stock market prices in the United States.

Table 6 compares first and selected second moments of per-capita real stock market growth in the data (per-capita SP 500 index normalized by the GDP deflator) and its model equivalent. Data and smoothed series are both detrended using a two-sided HP filter, to facilitate comparison between cyclical properties of the variables and in light of the different trend of stock market growth and macro variables feature in the data.[33]

$$SMG_t = \frac{\frac{Q_t^A N_t}{P_t}}{\frac{Q_{t-1}^A N_{t-1}}{P_{t-1}}} = \frac{q_t^A N_t}{q_{t-1}^A N_{t-1}}$$

The average historical realized returns on lower-medium grade corporate bonds (on which the model is estimated) are not as sizable as realized average equity returns and bond prices are not as volatile as equity prices in the data. Row 1 in table 6 shows that the average growth rate of the stock market in the data is higher than the one estimated in the model.[34] Moreover, row 2 highlights that the stock market growth data series features a higher standard deviation than its theoretical counterpart in the model computed at the posterior mode (2.6% vs. 0.51%). Consistently the standard deviation of the data series is also higher than the standard deviation of the smoothed stock market growth series computed at the posterior mode (2.6% vs. 0.17%).

Interestingly, however, stock market growth in the data and in the model show similar auto-correlation of order one (0.78 in the data, compared to a theoretical moment of 0.65, although the realized moment for the de-trended smoothed series is much lower at 0.31). Notably, in light of the discussion in section D.2, stock market growth correlates highly with GDP growth in the data (coefficient of 0.43) and in the model (theoretical estimate of 0.65 and smoothed estimate of .58). Most importantly, the stock market growth data series is positively correlated with its smoothed model equivalent with a correlation coefficient equal to 0.40. All coefficient are significantly different from zero at the 1% level or below.

The table reports the first and (selected) second moments for the 4-quarter trailing average of Stock Market Growth (SMG) in the data and in the model (theoretical and of the smoothed series at the posterior mode). Sample period: 1989:Q1 to 2008:Q2). The SMG rate in the data refers to the S&P 500 index divided by the GDP deflator and the growth rate the of the U.S. population. Moments for the data and (smoothed) model series are HP-filtered to facilitate comparison, excluding differences in trend. All moments are different from zero at a 5% or lower significance level. Data source: FRED

[33] The reference price used to compute the market value in the model is q_t^A: the resale price of equity shares, also defined as the highest price that competitive intermediaries are willing to spend to acquire one unit of financial claims from sellers. Moments computed using the household purchase price q_t^B do not differ significantly from those reported in table 6 and an available upon request.

[34] In the model the average growth rate of stock market growth coincides with the average growth rate of the economy γ.

Table 6: Stock Market Growth Moments - Estimated Model vs. Data

Moment	Data	Model (Theoretical)	Model (Smoothed)
Mean	1.26	0.50	0.52
Standard Deviation	2.59	0.51	0.17
AC(1)	0.78	0.75	0.31
Corr. with GDP Growth	0.43	0.65	0.58
Corr. with SMG data	1	−−	0.40

E Model Equilibrium Conditions

Intermediate Firms

The production function for a generic intermediate firm i takes the form:

$$Y_t(i) = A_t^{1-\alpha} K_{t-1}(i)^{\alpha} L_t(i)^{1-\alpha} - A_t F \, ,$$

where:

$$\log\left(\frac{A_t}{A_{t-1}}\right) = \log(z_t) = (1-\rho_z)\log(\gamma) + \rho_z \log(z_{t-1}) + \varepsilon_t^z \tag{39}$$

and $\varepsilon_t^z \sim N(0, \sigma_z)$. Firms minimize total costs by solving:

$$\min_{K_{t-1}(i), L_t(i)} W_t L_t(i) + R_t^K K_{t-1}(i)$$

subject to (E). The first order conditions are:

$$MC_t(i) A_t^{1-\alpha} \left(\frac{L_t(i)}{K_{t-1}(i)}\right)^{-\alpha} = \frac{W_t}{P_t}$$

$$MC_t(i) A_t^{1-\alpha} \left(\frac{L_t(i)}{K_{t-1}(i)}\right)^{1-\alpha} = \frac{R_t^k}{P_t} \, ,$$

where $MC_t(i)$ is the marginal cost for firm i. Taking the ratio of the two expressions above I obtain:

$$\frac{K_{t-1}(i)}{L_t(i)} = \frac{K_{t-1}}{L_t} = \frac{W_t}{R_t^k} \frac{\alpha}{(1-\alpha)} \, , \tag{40}$$

which pins down a common value for the marginal cost across different firms:

$$MC_t = \frac{1}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} R_t^{K\alpha} \left(\frac{W_t}{A_t}\right)^{1-\alpha} . \tag{41}$$

Firms' profits at time t are defined as the difference between revenues and total costs incurred producing output $Y_t(i)$. Those monopolistic intermediate firms that can re-optimize their price at time t maximize their future expected profits:

$$\max_{P_t(i)} E_t \left\{ \sum_{s=0}^{\infty} \xi_p^s \frac{\beta^s \mu_{t+s}^{\Sigma C}}{\mu_{t+s}^{\Sigma C}} \left[\left(P_t(i) \prod_{k=1}^{s} (\pi_{t+k-1}^{\iota_p} \pi^{1-\iota_p}) - MC_{t+s} \right) Y_{t+s}(i) \right] \right\}$$

subject to the demand for intermediate inputs from final producers:

$$Y_{t+s}(i) = \left(\frac{P_t(i) \prod_{k=1}^{s} (\pi_{t+k-1}^{\iota_p} \pi^{1-\iota_p})}{P_{t+s}} \right)^{\left(-\frac{1+\lambda_{p,t+s}}{\lambda_{p,t+s}}\right)} Y_{t+s}$$

where marginal costs MC_t in (41) are equal to average costs given the structure of the production function in (E) and:

$$\log\left(1+\lambda_{p,t}\right) = \left(1-\rho_p\right)\log\left(1+\lambda_p\right) + \rho_p \log\left(1+\lambda_{p,t-1}\right) + \varepsilon_t^p + \theta_p \varepsilon_{t-1}^p \tag{42}$$

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

Profits are discounted at the marginal rate of intertemporal substitution of the household, $\left(\beta^s b_{t+s}\frac{\mu_{t+s}^{\Sigma C}}{\mu_{t+s}^{\Sigma C}}\right)$, the shareholder of intermediate firms. The maximization is subject to the demand for intermediate product i, coming from final good producers. The optimality condition is then:

$$E_t\left\{\sum_{s=0}^{\infty}\xi_p^s\beta^s b_{t+s}\mu_{t+s}^{\Sigma C}\tilde{Y}_{t+s}\left[\tilde{P}_t\prod_{k=1}^{s}(\pi_{t+k-1}^{\iota_p}\pi^{1-\iota_p}) - (1+\lambda_{p,t+s})MC_{t+s}\right]\right\} = 0\,, \tag{43}$$

where $\tilde{P}$ is the optimal price chosen and $\tilde{Y} = Y_{t+s}(i)$ is the corresponding optimal demand. Note that the optimal price depends on present and future marginal costs and mark-ups, MC_{t+s} and $\lambda_{p,t+s}$ and is therefore common to all re-optimizing firms. Aggregate prices at time t will be a combination of prevalent aggregate prices at time $t-1$, P_{t-1}, and the new optimal prices, $\tilde{P}_t$:

$$P_t = \left[(1-\xi_p)\tilde{P}_t^{\frac{1}{\lambda_{p,t}}} + \xi_p(\pi_{t-1}^{\iota_p}\pi^{1-\iota_p}P_{t-1})^{\frac{1}{\lambda_{p,t}}}\right]^{\lambda_{p,t}}. \tag{44}$$

Investment Goods Producers

Investment 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 , transform them into investment goods, I_t, by means of a linear technology:

$$I_t = \mathrm{Y}_t^I.$$

Producers then have access to a capital production technology to produce i_t units of investment 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 $S\left(\cdot\right)$ is a convex function in $\frac{I_t}{I_{t-1}}$, with $S=0$ and $S'=0$ and $S''>0$ in steady state. Producers sell investment goods to the entrepreneurs on a competitive market at a price P_t^K.

In every period capital producers will choose the optimal amount of inputs, I_t as to maximize their expected discounted profits:

$$\max_{I_{t+s}} E_t\sum_{s=0}^{\infty}\beta^s b_{t+s}E_{t+s}\left\{\mu_{t+s}^{\Sigma C}\left[P_{t+s}^K i_{t+s} - P_{t+s}I_{t+s}\right]\right\}$$

s.t.

$$i_{t+s} = \left[1 - S\left(\frac{I_{t+s}}{I_{t+s-1}}\right)\right] I_{t+s}. \tag{45}$$

The first order condition for a generic time t will then be:

$$1 - \frac{P_t^K}{P_t}\left[\left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) - \frac{I_t}{I_{t-1}} S'\left(\frac{I_t}{I_{t-1}}\right)\right] = E_t\left\{(\beta b_t)\frac{\mu_{t+1}^{\Sigma C}}{\mu_t^{\Sigma C}}\frac{P_{t+1}}{P_t}\left[\frac{P_{t+1}^K}{P_{t+1}}\left(\frac{I_{t+1}^2}{I_t^2}\right) S'\left(\frac{I_{t+1}}{I_t}\right)\right]\right\}. \tag{46}$$

Household

The head of the household maximizes the aggregate lifetime utility of the household:

$$\max_{\substack{C_{t+s},\, \iota_{t+s},\, \Delta N_{t+s}^{+},\, \Delta N_{t+s}^{-},\, N_{t+s},\, B_{t+s},\\ C_{i,t+s},\, W_{i,t+s},\, \iota_{i,t+s},\, \Delta N_{i,t+s}^{+},\, \Delta N_{i,t+s}^{-},\, N_{i,t+s},\, B_{i,t+s}}} \sum_{s=0}^{\infty} (\beta)^{t+s} b_{t+s} E_t\left[log(C_{t+s} - hC_{t+s-1}) - \chi_0 \chi_{b,t} \frac{L_{t+s}^{(1+\nu)}}{(1+\nu)}\right]$$

subject to the individual flow of funds constraints (7), the individual equity accumulation equation (8), the individual borrowing constraint (14) the aggregate equity accumulation equation (11) together with the definition of aggregate consumption and aggregate bond holdings (10) and non-negativity constraints (2.1). The discount factor is subject to random shocks and follows a process:

$$\log b_t = \rho_b \log b_{t-1} + \varepsilon_t^b \tag{47}$$

where $\varepsilon_t^b \sim$ i.i.d. $\mathrm{N}\big(0, \sigma_b^2\big)$. Nominal transfers of profits of intermediate firms and banking costs are lumped into D_t defined as:

$$P_t D_t = \left(P_t Y_t - R_t^K K_{t-1} - W_t L_t\right) + \left(P_t^K\left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) I_t - P_t I_t\right) + \left(Q_t^B - Q_t^A\right)\Delta N_t \tag{48}$$

The first order conditions of the maximization problems are:

$$C_t : \frac{1}{(C_t - hC_{t-1})} - \beta b_t h E_t \left[\frac{1}{(C_{t+1} - hC_t)} \right] = \mu_t^{\Sigma C}$$
$$N_t : \mu_t^N = \beta b_t E_t \left\{ E_{A_{i,t+1}} \left[\lambda_{i,t+1} R_{t+1}^K + (1-\phi_{t+1}) \mu_{i,t+1}^N (1-\delta) + \phi_{t+1} (\mu_{i,t+1}^N + \mu_{i,t+1}^L)(1-\delta) \right] \right\}$$
$$B_t : \mu_t^{\Sigma B} = \beta b_t E_t \left\{ E_{A_{i,t+1}} \left[\lambda_{i,t+1} R_t^B \right] \right\}$$
$$C_{i,t} : \lambda_{i,t} P_t = \mu_t^{\Sigma C} + \mu_{i,t}^{C+}$$
$$\iota_{i,t} : \lambda_{i,t} P_t^K = \mu_{i,t}^N A_{i,t} + \mu_t^L \theta \frac{P_t^K}{Q_t^A} + \mu_{i,t}^{\iota+}$$
$$\Delta N_{i,t}^+ : \lambda_{i,t} Q_t^B = \mu_{i,t}^N + \mu_{i,t}^{\Delta++}$$
$$\Delta N_{i,t}^- : \lambda_{i,t} Q_t^A = \mu_{i,t}^N + \mu_{i,t}^L - \mu_{i,t}^{\Delta-+}$$
$$N_{i,t} : \mu_{i,t}^N = \mu_t^N$$
$$B_{i,t} : \lambda_{i,t} - \mu_{i,t}^{B+} = \mu_t^{\Sigma B}$$

together with constraints holding with equality (7), (8), (11), (10) and complementary slackness conditions:

$$\mu_{i,t}^{C+} C_{i,t} = 0$$
$$\mu_{i,t}^{\iota+} \iota_{i,t} = 0$$
$$\mu_{i,t}^{\Delta++} \Delta N_{i,t}^+ = 0$$
$$\mu_{i,t}^{\Delta-+} \Delta N_{i,t}^- = 0$$
$$\mu_{i,t}^L (-\Delta N_{s,t}^- + \theta \frac{P_t^K}{Q_t^A} \iota_{s,t} + \phi \left(1-\delta\right) N_{t-1})$$
$$\mu_{i,t}^{B+} B_{i,t} = 0$$

Conditional on their draw of the level of capital installation technology $A_{i,t}$ household members are optimally sorted into three categories: buyers, keepers and sellers. If $Q_t^B > Q_t^A$ their optimal contingencies plans are as follows:

Buyers receive instructions to set aside their relatively inefficient capital accumulation technology, not purchase investment goods $\iota_{b,t}$ and instead use their income to purchase consumption goods $C_{b,t}$, equity claims $\Delta N^{+}_{b,t}$ and liquid assets $B_{b,t} > 0$:

$$
\begin{aligned}
& C_{b,t} > 0,\ \mu^{C+}_{b,t} = 0 \\
& \iota_{b,t} = 0,\ \mu^{\iota+}_{i,t} > 0 \\
& \Delta N^{+}_{b,t} > 0,\ \mu^{\Delta++}_{b,t} = 0 \\
& \Delta N^{-}_{b,t} = 0,\ \mu^{\Delta-+}_{b,t} > 0 \\
& \Delta N^{-}_{b,t} < \theta \frac{P^K_t}{Q^A_t} \iota_{b,t} + \phi \left(1-\delta\right) N_{t-1},\ \mu^{L}_{b,t} = 0 \\
& B_{b,t} > 0,\ \mu^{B+}_{b,t} > 0
\end{aligned}
$$

Keepers receive instructions to use their capital accumulation technology and use their income to purchase investment goods $\iota_{k,t}$, while forgoing purchase of consumption goods $C_{k,t} = 0$, equity claims $\Delta N^{+}_{k,t} = 0$ and liquid assets $B_{k,t} = 0$:

$$
\begin{aligned}
& C_{k,t} = 0,\ \mu^{C+}_{k,t} > 0 \\
& \iota_{k,t} > 0,\ \mu^{\iota+}_{k,t} = 0 \\
& \Delta N^{+}_{k,t} = 0,\ \mu^{\Delta++}_{k,t} > 0 \\
& \Delta N^{-}_{k,t} = 0,\ \mu^{\Delta-+}_{k,t} > 0 \\
& \Delta N^{-}_{k,t} < \theta \frac{P^K_t}{Q^A_t} \iota_{k,t} + \phi \left(1-\delta\right) N_{t-1},\ \mu^{L}_{k,t} = 0 \\
& B_{k,t} = 0,\ \mu^{B+}_{k,t} > 0
\end{aligned}
$$

Sellers receive instructions to use their efficient capital accumulation technology and use their income and resources raised by selling equity on financial markets, $\Delta N^{-}_{s,t} > 0$, to purchase investment goods $\iota_{s,t}$, while forgoing purchase of consumption goods $C_{s,t} = 0$, equity claims $\Delta N^{+}_{s,t} = 0$ and liquid assets $B_{s,t}=0$:

$$\begin{aligned}
&C_{s,t}=0,\ \mu_{s,t}^{C+}>0\\
&\iota_{s,t}>0,\ \mu_{s,t}^{\iota+}=0\\
&\Delta N_{s,t}^{+}=0,\ \mu_{s,t}^{\Delta++}>0\\
&\Delta N_{s,t}^{-}>0,\ \mu_{s,t}^{\Delta-+}=0\\
&\Delta N_{s,t}^{-}=\theta\frac{P_t^K}{Q_t^A}\iota_{s,t}+\phi\left(1-\delta\right)N_{t-1},\ \mu_{s,t}^{L}>0\\
&B_{k,t}=0,\ \mu_{k,t}^{B+}>0
\end{aligned}$$

To verify that this is an equilibrium, I check that the first order conditions of the maximization problems hold once I substitute in the guessed solution for buyers, keepers and sellers.

Sellers:

$$\begin{aligned}
&C_{s,t}:\lambda_{s,t}P_t=\mu_t^{\Sigma C}+\mu_{s,t}^{C+}\\
&\iota_{s,t}:\frac{p_t^K(1-\theta)}{A_{s,t}-\theta\frac{p_t^K}{q_t^A}}=\frac{\mu_{s,t}^{N}}{P_t\lambda_{s,t}}=\tilde{q}_{t,s}^{A}\\
&\Delta N_{s,t}^{+}:q_t^B=\frac{\mu_{s,t}^{N}}{P_t\lambda_{s,t}}+\frac{\mu_{s,t}^{\Delta++}}{P_t\lambda_{s,t}}\\
&\Delta N_{s,t}^{-}:q_t^A=\frac{\mu_{s,t}^{N}}{P_t\lambda_{s,t}}+\frac{\mu_{s,t}^{L}}{P_t\lambda_{k,t}}\\
&N_{s,t}:\mu_{s,t}^{N}=\mu_t^{N}\\
&B_{s,t}:\lambda_{s,t}-\mu_{s,t}^{B+}=\mu_t^{\Sigma B}
\end{aligned}$$

Since $q_t^B>q_t^A>\frac{p_t^K}{A_{s,t}}$ then $\mu_{s,t}^{\iota+}=0$, $\mu_{s,t}^{\Delta++}>0$, $\mu_{s,t}^{\Delta-+}=0$, $\mu_{s,t}^{L}=0$, confirming the initial guess that sellers indeed sell equity claims up to their borrowing constraint to purchases investment goods $\iota_{s,t}>0$ but they do not purchase equity claims, $\Delta N_{b,t}^{+}=0$.

Keepers:

$$
\begin{aligned}
&C_{k,t} : \lambda_{k,t} P_t = \mu_t^{\Sigma C} + \mu_{k,t}^{C+} \\
&\iota_{i,t} : \frac{p_t^K}{A_{k,t}} = \frac{\mu_{k,t}^N}{P_t \lambda_{k,t}} \\
&\Delta N_{k,t}^+ : q_t^B = \frac{\mu_{k,t}^N}{P_t \lambda_{k,t}} + \frac{\mu_{k,t}^{\Delta ++}}{P_t \lambda_{k,t}} \\
&\Delta N_{k,t}^- : q_t^A = \frac{\mu_{k,t}^N}{P_t \lambda_{k,t}} - \frac{\mu_{k,t}^{\Delta -+}}{P_t \lambda_{k,t}} \\
&N_{k,t} : \mu_{k,t}^N = \mu_t^N \\
&B_{k,t} : \lambda_{k,t} - \mu_{k,t}^{B+} = \mu_t^{\Sigma B}
\end{aligned}
$$

Since $q_t^B > \frac{p_t^K}{A_{k,t}} > q_t^A$ then $\mu_{k,t}^{\iota^+} = 0$, $\mu_{k,t}^{\Delta ++} > 0$ and $\mu_{k,t}^{\Delta -+} > 0$, confirming the initial guess. Buyers purchases investment goods $\iota_{k,t} > 0$ but they do not purchase nor sell equity claims, $\Delta N_{b,t}^+ = 0$ $\Delta N_{b,t}^- = 0$.

Buyers:

$$
\begin{aligned}
&C_{b,t} : P_t \lambda_{b,t} = \mu_t^{\Sigma C} = \frac{1}{(C_t - hC_{t-1})} - \beta b_t h E_t \left[\frac{1}{(C_{t+1} - hC_t)} \right] \\
&\iota_{b,t} : \frac{p_t^K}{A_{b,t}} - q_t^B = \frac{\mu_{i,t}^{\iota^+}}{\mu_t^{\Sigma C}} > 0 \\
&\Delta N_{b,t}^+ : q_t^B = \frac{\mu_{b,t}^N}{\mu_t^{\Sigma C}} \\
&\Delta N_{b,t}^- : q_t^B - q_t^A = \frac{\mu_{b,t}^{\Delta -+}}{\mu_t^{\Sigma C}} > 0 \\
&N_{b,t} : \frac{\mu_{b,t}^N}{\mu_t^{\Sigma C}} = \frac{\mu_t^N}{\mu_t^{\Sigma C}} = q_t^B \\
&B_{b,t} : \lambda_{b,t} = \mu_t^{\Sigma B}
\end{aligned}
$$

Since $\frac{p_t^K}{A_{b,t}} > q_t^B > q_t^A$ then $\mu_{b,t}^{\iota^+} > 0$ and $\mu_{b,t}^{\Delta -+} > 0$, confirming the initial guess. Buyers do not purchases investment goods $\iota_{b,t} = 0$ nor they sell equity claims, $\Delta N_{b,t}^- = 0$.

Dividing the first order conditions with respect to $\iota_{s,t}$ by the first order condition with respect to $\iota_{b,t}$, I obtain:

$$
\frac{\lambda_{s,t}}{\lambda_{b,t}} = \frac{\lambda_{s,t}}{\mu_t^{\Sigma C}} = \frac{q_t^B}{\tilde{q}_{s,t}^A}
$$

and similarly using the first order condition with respect to $\iota_{k,t}$ I obtain:

$$\frac{\lambda_{k,t}}{\lambda_{b,t}} = \frac{\lambda_{k,t}}{\mu_t^{\Sigma C}} = \frac{q_t^B}{\frac{p_t^K}{A_{k,t}}}$$

These equalities, combined with the first order conditions with respect to consumption and bond holdings for sellers and keepers, imply that:

$$\mu_{s,t}^{C+} = \mu_{s,t}^{B+} = \frac{q_t^B}{\tilde{q}_{s,t}^A} - 1 > 0$$

and

$$\mu_{k,t}^{C+} = \mu_{k,t}^{B+} = \frac{q_t^B}{\frac{p_t^K}{A_{k,t}}} - 1 > 0$$

confirming that in equilibrium sellers and keepers do not purchase consumption goods $C_{i,t}$, nor liquid assets $B_{i,t}$ for $i = \{s, k\}$.

To conclude, the solution implies the following optimal choices for sellers, keepers and buyers:

- Sellers

$$C_{s,t} = 0, \quad B_{s,t} = 0.$$

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

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

Substituting the values above for $\Delta N_{s,t}^{-}$, $\Delta N_{s,t}^{+}$, $C_{s,t}$ and $B_{s,t}$ into the flow of funds constraint (7), allows to solve for the optimal level of investment goods purchased by seller s:

$$\iota_{s,t} = \frac{1}{P_t^K(1-\theta)}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t + Q_t^A \phi(1-\delta) N_{t-1}]$$

and for the seller's optimal equity stock:

$$N_{s,t} = \frac{1}{\tilde{Q}_{s,t}^A}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t + Q_t^A \phi(1-\delta) N_{t-1} + \tilde{Q}_{s,t}^A (1-\phi)(1-\delta) N_{t-1}].$$

where $\tilde{Q}_{s,t}^A$ is the replacement cost of one unit of internal capital:

$$\tilde{Q}_{s,t}^A = \frac{P_t^K(1-\theta)}{A_{s,t} - \theta \frac{P_t^K}{Q_t^A}}$$

The fraction of sellers can be computed using the CDF of $A_{i,t}$:

$$\chi_s = Pr\left(A_{i,t} \geq \frac{P_t^K}{Q_t^A}\right) = 1 - F\left(\frac{P_t^K}{Q_t^A}\right)$$

- Keepers

$$C_{k,t} = 0, \quad B_{k,t} = 0.$$

$$\iota_{k,t} = \frac{1}{P_t^K}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t]$$

$$\Delta N_{k,t}^- = 0, \quad \Delta N_{k,t}^+ = 0$$

$$N_{k,t} = \frac{A_{k,t}}{P_t^K}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t + \frac{P_t^K}{A_{k,t}}(1-\delta)N_{t-1}].$$

The measure of keepers in the economy is:

$$\chi_{k,t} = \Pr\left(Q_t^A \leq \frac{P_t^K}{A_{e,t}} \leq Q_t^B\right) = F\left(\frac{P_t^K}{Q_t^A}\right) - F\left(\frac{P_t^K}{Q_t^B}\right).$$

- Buyers

Buyers' intertemporal Euler equations for equity and bond holdings coincide with those of the household in its entirety:

$$C_t : \frac{1}{(C_t - hC_{t-1})} - \beta b_t h E_t\left[\frac{1}{(C_{t+1} - hC_t)}\right] = \mu_t^{\Sigma C} = P_t \lambda_{b,t} \quad (49)$$

$$\begin{aligned} N_t : Q_t^B = \beta b_t E_t \Bigg\{ & \frac{\mu_{t+1}^{\Sigma C}}{\mu_t^{\Sigma C}} \frac{1}{\pi_{t+1}} \times \\ & \times \left[\chi_{s,t+1} E_{A_{i,t+1}} \left[\frac{Q_{t+1}^B}{\tilde{Q}_{t+1}^A}\left(R_{t+1}^K + (1-\phi_{t+1})\tilde{Q}_{i,t+1}^A(1-\delta) + \phi_{t+1} Q_{i,t+1}^A (1-\delta)\right) \middle| \frac{P_{t+1}^K}{A_{i,t+1}} \leq Q_{t+1}^A\right] + \right. \\ & + \chi_{k,t+1} E_{A_{i,t+1}} \left[\frac{Q_{t+1}^B}{\frac{P_{t+1}^K}{A_{i,t+1}}}\left(R_{t+1}^K + \frac{P_{t+1}^K}{A_{i,t+1}}(1-\delta)\right) \middle| Q_{t+1}^A \leq \frac{P_{t+1}^K}{A_{i,t+1}} \leq Q_{t+1}^B\right] + . \\ & \left. + \quad \chi_{b,t+1} E_{A_{i,t+1}} \left(R_{t+1}^K + Q_{t+1}^B (1-\delta) \middle| \frac{P_{t+1}^K}{A_{i,t+1}} \geq Q_{t+1}^B\right)\right]\Bigg\} \end{aligned} \quad (50)$$

where $\tilde{Q}^A_{t+1} = \int_{\frac{P^K_t}{Q^A_t}}^{\infty} \frac{1}{\tilde{Q}^A_{s,t}} dF(A_{s,t})$.

$$B_t : 1 = \beta b_t E_t \left\{ \frac{\mu^{\Sigma C}_{t+1}}{\mu^{\Sigma C}_t} \frac{1}{\pi_{t+1}} \times \left[\chi_{s,t+1} E_{A_{i,t+1}} \left(\frac{Q^B_{t+1}}{\tilde{Q}^A_{i,t+1}} \middle| \frac{P^K_{t+1}}{A_{i,t+1}} \leq Q^A_{t+1} \right) + \right.\right.$$
$$\chi_{k,t+1} E_{A_{i,t+1}} \left(\frac{Q^B_{t+1}}{\frac{P^K_{t+1}}{A_{i,t+1}}} \middle| Q^A_{t+1} \leq \frac{P^K_{t+1}}{A_{i,t+1}} \leq Q^B_{t+1} \right) +$$
$$\left.\left. + \quad \chi_{b,t+1} E_{A_{i,t+1}} \left(1 \middle| \frac{P^K_{t+1}}{A_{i,t+1}} \geq Q^B_{t+1} \right) \right] R^B_t \right\}.$$

With the optimal plans for each household member in hand, I can aggregate their decision rules to compute the household-level purchase of investment goods, ι_t as well as asset positions:

$$\begin{aligned}
\iota_t =& \int_{\frac{P^K_t}{Q^A_t}}^{\infty} \iota_{s,t} dF(A_{s,t}) + \int_{\frac{P^K_t}{Q^B_t}}^{\frac{P^K_t}{Q^B_t}} \iota_{k,t} dF(A_{k,t}) \\
=& \int_{\frac{P_t}{Q^A_t}}^{\infty} \frac{1}{P^K_t(1-\theta)} [R^K_t N_{t-1} + R^B_{t-1} B_{t-1} + P_t D_t - P_t T_t + Q^A_t \phi(1-\delta) N_{t-1}] dF(A_{s,t}) \\
&+ \int_{\frac{P^K_t}{Q^B_t}}^{\frac{P^K_t}{Q^A_t}} \frac{1}{P^K_t} [R^K_t N_{t-1} + R^B_{t-1} B_{t-1} + P_t D_t - P_t T_t] dF(A_{k,t}) \\
=& \chi_{s,t} \frac{1}{P^K_t(1-\theta)} [R^K_t N_{t-1} + R^B_{t-1} B_{t-1} + P_t D_t - P_t T_t + Q^A_t \phi(1-\delta) N_{t-1}] dF(A_{s,t}) \\
&+ \chi k, t \frac{1}{P^K_t} [R^K_t N_{t-1} + R^B_{t-1} B_{t-1} + P_t D_t - P_t T_t] dF(A_{k,t})
\end{aligned} \tag{51}$$

and using the definition of $\tilde{Q}^A_t$ and $\tilde{Q}^s_t$:

$$\begin{aligned}
N_t =& \int_{\frac{P^K_t}{Q^A_t}}^{\infty} A_{s,t} \iota_{s,t} dF(A_{s,t}) + \int_{\frac{P^K_t}{Q^B_t}}^{\frac{P^K_t}{Q^B_t}} A_{k,t} \iota_{k,t} dF(A_{k,t}) + (1-\delta) N_{t-1} \\
=& \left(\int_{\frac{P^K_t}{Q^A_t}}^{\infty} \frac{1}{\tilde{Q}^A_{s,t}} dF(A_{s,t}) \right) [R^K_t N_{t-1} + R^B_{t-1} B_{t-1} + P_t D_t - P_t T_t + Q^A_t \phi(1-\delta) N_{t-1}] \\
&+ \frac{1}{P^K_t} \left(\int_{\frac{P^K_t}{Q^B_t}}^{\frac{P^K_t}{Q^A_t}} A_{k,t} dF(A_{k,t}) \right) [R^K_t N_{t-1} + R^B_{t-1} B_{t-1} + P_t D_t - P_t T_t] + (1-\delta) N_{t-1}.
\end{aligned} \tag{52}$$

- Wage Setting Decision

The first order conditions of the households' wage setting decision is:

$$E_t \left\{ \sum_{s=0}^{\infty} {\xi_w}^s \beta^s \frac{\mu_{t+s}^{\Sigma C}}{P_{t+s}} \tilde{L}_{t+s} \left[\frac{\tilde{W}_{b,t}}{\chi_{b,t+s}} \Pi_{t,t+s}^w - (1+\lambda_{w,t+s}) \omega \frac{\tilde{L}_{t+s}^{\nu}}{\mu_{t+s}^{\Sigma C}} \right] \right\} = 0 \tag{53}$$

where:

$$\Pi_{t,t+s}^w = \prod_{k=1}^{s} \left[(\pi e^{\gamma})^{1-\iota_w} (\pi_{t+k-1} e^{z_{t+k-1}})^{\iota_w}) \right]$$

and:

$$\log(1+\lambda_{w,t}) = (1-\rho_w) \log(1+\lambda_w) + \rho_w \log(1+\lambda_{w,t-1}) + \varepsilon_t^w + \theta_p \varepsilon_{t-1}^w \tag{54}$$

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

$$\begin{aligned} W_t &= \chi_{b,t} \left\{ (1-\xi_w) \left(\frac{\tilde{W}_{b,t}}{\chi_{b,t}} \right)^{\frac{1}{\lambda_w}} + \xi_w \left[(\pi e^{\gamma})^{(1-\iota_w)} (\pi_{t-1} e^{z_{t-1}})^{(\iota_w)} \frac{W_{t-1}}{\chi_{b,t}} \right]^{\frac{1}{\lambda_w}} \right\}^{\lambda_w} \\ &= \left\{ (1-\xi_w) \left(\tilde{W}_{b,t} \right)^{\frac{1}{\lambda_w}} + \xi_w \left[(\pi e^{\gamma})^{(1-\iota_w)} (\pi_{t-1} e^{z_{t-1}})^{(\iota_w)} W_{t-1} \right]^{\frac{1}{\lambda_w}} \right\}^{\lambda_w} . \end{aligned} \tag{55}$$

Financial Intermediaries

In each period, bank i maximizes its nominal profits:

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

s.t.

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

where:

$$\tau_t^q = \bar{\tau}_t^q + \tilde{\tau}_t^q$$

where:

$$\bar{\tau}_t^q = (1-\rho_{\bar{\tau}}) \tau_{ss}^q + \rho_{\bar{\tau}} \bar{\tau}_{t-1}^q + \varepsilon_t^{\bar{\tau}}$$

$$\tilde{\tau}_t^q = \rho_{\tilde{\tau}} \tilde{\tau}_{t-1}^q + \varepsilon_t^{\tilde{\tau}}$$

and $\rho_{\tilde{\tau}} = \omega_\tau \rho_{\bar{\tau}}$ with $\omega_\tau < 1$. The two processes are buffeted by i.i.d. shocks $\varepsilon_t^{\bar{\tau}} \sim N\left(0, \sigma_{\tau}^2\right)$ and $\varepsilon_t^{\tilde{\tau}} \sim N\left(0, \sigma_{\tilde{\tau}}^2\right)$. Perfect competition among intermediaries implies that their profits are equal to zero in equilibrium so that:

$$Q_t^B = (1+\tau_t^q) Q_t^A \tag{56}$$

Monetary Authority

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

$$\frac{R_t^B}{R^B} = \left(\frac{R_{t-1}^B}{R^B}\right)^{\rho_R} \left[\left(\frac{\bar{\pi}_t}{\pi}\right)^{\phi_\pi}\right]^{1-\rho_R} \left(\frac{\Delta \overline{X}_{t-s}}{\gamma}\right)^{\phi_Y} \eta_{mp,t} \tag{57}$$

where the central bank responds to realized 4-quarter average inflation $\bar{\pi}_t$ and output growth $\Delta\overline{Y}_{t-s}$ and

$$\log \eta_{mp,t} = \varepsilon_{mp,t} \tag{58}$$

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

Fiscal Authority

The government runs a balanced budget in every period:

$$B_t + T_t = R_{t-1}^B B_{t-1} + G_t\,. \tag{59}$$

The share of government spending over total output follows an exogenous process:

$$G_t = \left(1 - \frac{1}{g_t}\right) Y_t\,, \tag{60}$$

where:

$$\log g_t = (1-\rho^g)\, g_{ss} + \rho^g \log g_{t-1} + \varepsilon_t^g \tag{61}$$

and $\varepsilon_t^g \sim iidN\left(0, \sigma^{g2}\right)$. I assume the share of transfers over total output, T_t/Y_t, evolve according to:

$$\frac{T_t/Y_t}{ToY} = \left(\frac{B_t/Y_t}{BoY}\right)^{-\varphi_B}\,. \tag{62}$$

Equilibrium

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

$$\{P_t^K, Q_t^A, Q_t^B, W_t, R_t^K, R_t^B\}$$

such that for a given realization of aggregate shocks:

- final goods producers choose inputs $\mathrm{Y}_t(i)$ and output $\{Y_t\}$ levels to maximize their profits subject the available technology;
- intermediate goods producers set their prices $\tilde{P}_t(i)$ 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 $\left\{Y_t^I, i_t\right\}$ that maximize their profits (E) under their technological constraint (45);
- household members choose optimal consumption, investment goods purchases, equity sales and purchases as well as asset holdings and their relative wage rate:

$$\left\{C_{i,t}, \iota_{i,t}, \Delta N_{i,t}^{+}, \Delta N_{i,t}^{-}, N_{i,t}, B_{i,t}, \tilde{W}_{i,t}\right\}$$

  that maximize their lifetime utility (6), under their flow of funds constraint (7), and the law of accumulation of equity (8), while satisfying the liquidity constraint (14) and the non-negativity conditions (2.1) and the demand for hours worked of employment agencies 19;
- banks maximize their profits (E), to intermediate an amount of equity claims $\Delta N_{i,t}^{+} = \Delta N_{i,t}^{-}$ 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, $L_{b,t}$;
- Markets clear:

$$Y_t = \int_0^1 Y_t(i)di \tag{63}$$

$$Y_t = \int_{A^{low}}^{A_t^{high}} C_{i,t} dF(A_{i,t}) + I_t + G_t \tag{64}$$

$$\Delta N_t = \int_{A^{low}}^{A_t^{high}} \left[\Delta N_{i,t}^{+}\right] dF(A_{i,t}) = \int_{A^{low}}^{A_t^{high}} \left[\Delta N_{i,t}^{-}\right] dF(A_{i,t}) \tag{65}$$

$$i_t = \int_{A^{low}}^{A_t^{high}} \iota_{i,t} dF(A_{i,t}) \tag{66}$$

$$N_t = K_t \tag{67}$$

The 26 equations and 7 exogenous processes (39)-(67) summarize the set of non-linear equilibrium conditions of the rational expectation model in the 33 variables:

$$\begin{bmatrix} K_t, L_t, MC_t, R_t^K, \tilde{W}_t, W_t, P_t, \tilde{P}_t, P_t^K, R_t^B, Q_t^A, Q_t^B \\ Y_t, C_t, I_t, i_t, \iota_t, G_t, B_t, N_t, T_t, D_t, \Delta N_t, \mu_t^{\Sigma C}, A_t^{high}, a_t, A_t, \lambda_{p,t}, \lambda_{w,t}, b_t, \tau_t^q, \eta_{mp,t}, g_t \end{bmatrix}$$

Productivity A_t follows a non-stationary process. The price level is also non-stationary. The model variables can be scaled so that all equations are expressed in terms of stationary real variables:

$$
\begin{aligned}
k_t &= \frac{K_t}{A_t} \quad , & \Delta n_t &= \frac{\Delta N_t}{A_t} \\
n_t &= \frac{N_t}{A_t} \quad , & r_t^K &= \frac{R_t^K}{P_t} \\
y_t &= \frac{Y_t}{A_t} \quad , & w_t &= \frac{W_t}{P_t A_t} \\
\hat{I}_t &= \frac{I_t}{A_t} \quad , & \tilde{w}_{b,t} &= \frac{\tilde{W}_t}{P_t A_t} \\
\hat{i}_t &= \frac{i_t}{A_t} \quad , & mc_t &= \frac{MC_t}{P_t} \\
\hat{\iota}_t &= \frac{\iota_t}{A_t} \quad , & p_t^K &= \frac{P_t^K}{P_t} \\
c_t &= \frac{C_t}{A_t} \quad , & q_t^A &= \frac{Q_t^A}{P_t} \\
\hat{G}_t &= \frac{G_t}{A_t} \quad , & \tilde{q}_{s,t}^A &= \frac{\tilde{Q}_{s,t}^A}{P_t} \\
\hat{B}_t &= \frac{B_t}{A_t} \quad , & q_t^B &= \frac{Q_t^B}{P_t} \\
t_t &= \frac{T_t}{A_t} \quad , & \hat{\mu}_t^{\Sigma C} &= \frac{\mu_t^{\Sigma C}}{A_t} \\
d_t &= \frac{D_t}{A_t} \quad , & \pi_t &= \frac{P_t}{P_{t-1}} \\
\tilde{p}_t &= \frac{\tilde{P}_t}{P_t} \quad , & &
\end{aligned}
$$

The system of stationary equations is composed of the:

$$\log(z_t) = (1-\rho_z)\log(\gamma) + \rho_z \log(z_{t-1}) + \varepsilon_t^z \tag{68}$$

$$\log(1+\lambda_{p,t}) = \left(1-\rho_p\right)\log(1+\lambda_p) + \rho_p \log(1+\lambda_{p,t-1}) + \varepsilon_t^p + \theta_p \varepsilon_{t-1}^p \tag{69}$$

$$\log(1+\lambda_{w,t}) = (1-\rho_w)\log(1+\lambda_w) + \rho_w \log(1+\lambda_{w,t-1}) + \varepsilon_t^w + \theta_p \varepsilon_{t-1}^w \tag{70}$$

$$\log b_t = \rho_b \log b_{t-1} + \varepsilon_t^b \tag{71}$$

$$\bar{\tau}_t^q = (1-\rho_{\bar{\tau}})\tau_{ss}^q + \rho_{\bar{\tau}}\bar{\tau}_{t-1}^q + \varepsilon_t^{\bar{\tau}} \tag{72}$$

$$\tilde{\tau}_t^q = \rho_{\tilde{\tau}}\tilde{\tau}_{t-1}^q + \varepsilon_t^{\tilde{\tau}} \tag{73}$$

$$\log \eta_{mp,t} = \varepsilon_{mp,t} \tag{74}$$

$$\log g_t = (1-\rho^g)\, g_{ss} + \rho^g \log g_{t-1} + \varepsilon_t^g \tag{75}$$

$$\frac{k_{t-1}\exp(z_t)^{-1}}{L_t(i)} = \frac{w_t}{r_t^k}\frac{\alpha}{(1-\alpha)} \tag{76}$$

$$MC_t = \frac{1}{\alpha^\alpha(1-\alpha)^{1-\alpha}} r_t^\alpha (w_t)^{1-\alpha} \tag{77}$$

$$E_t\left\{\sum_{s=0}^{\infty}\xi_p^s\beta^s b_{t+s}\hat{\mu}_{t+s}^{\Sigma C}\tilde{y}_{t+s}\left[\tilde{p}_t\prod_{k=1}^{s}(\pi_{t+k-1}^{\iota_p}\pi^{1-\iota_p}\pi_{t+k}^{-1}) - (1+\lambda_{p,t+s})mc_{t+s}\right]\right\} = 0 \tag{78}$$

$$1 = \left[(1-\xi_p)\tilde{p}_t^{\frac{1}{\lambda_{p,t}}} + \xi_p(\pi_{t-1}^{\iota_p}\pi^{1-\iota_p}\pi_t^{-1})^{\frac{1}{\lambda_{p,t}}}\right]^{\lambda_{p,t}} \tag{79}$$

$$\hat{i}_t = \left[1 - S\left(\frac{\hat{I}_t\exp z_t}{\hat{I}_{t-1}}\right)\right]\hat{I}_t. \tag{80}$$

$$\begin{aligned} p_t^K\left[\left(1 - S\left(\frac{\hat{I}_t\exp(z_t)}{\hat{I}_{t-1}}\right)\right) - \frac{\hat{I}_t\exp(z_t)}{\hat{I}_{t-1}}S'\left(\frac{\hat{I}_t\exp(z_t)}{\hat{I}_{t-1}}\right)\right] - 1 \quad &= \\ E_t\left\{(\beta b_t)\frac{\hat{\mu}_{t+1}^{\Sigma C}}{\hat{\mu}_t^{\Sigma C}}\left[p_{t+1}^K\left(\frac{\hat{I}_{t+1}^2\exp(z_{t+1})^2}{\hat{I}_t^2}\right)S'\left(\frac{\hat{I}_{t+1}\exp(z_{t+1})}{\hat{I}_t}\right)\right]\right\} \end{aligned} \tag{81}$$

$$\frac{1}{(c_t - hc_{t-1}\exp(z_t)^{-1})} - \beta b_t h E_t\left[\frac{1}{(c_{t+1}\exp(z_t) - hc_t)}\right] = P_t\hat{\mu}_t^{\Sigma C} \tag{82}$$

$$\begin{aligned} q_t^B = \beta b_t E_t &\left\{\frac{\hat{\mu}_{t+1}^{\Sigma C}}{\hat{\mu}_t^{\Sigma C}}e^{z_{t+1}}\frac{1}{\pi_{t+1}}\times\right. \\ &\times\left[\chi_{s,t+1}E_{A_{i,t+1}}\left[\frac{q_{t+1}^B}{\tilde{q}_{t+1}^A}\left(r_{t+1}^K + (1-\phi_{t+1})\tilde{q}_{i,t+1}^A(1-\delta) + \phi_{t+1}q_{i,t+1}^A(1-\delta)\right)\middle|\frac{p_{t+1}^K}{A_{i,t+1}} \le q_{t+1}^A\right]+\right. \\ &+\chi_{k,t+1}E_{A_{i,t+1}}\left[\frac{q_{t+1}^B}{\frac{p_{t+1}^K}{A_{i,t+1}}}\left(r_{t+1}^K + \frac{p_{t+1}^K}{A_{i,t+1}}(1-\delta)\right)\middle|q_{t+1}^A \le \frac{p_{t+1}^K}{A_{i,t+1}} \le q_{t+1}^B\right]+. \\ &+\quad\left.\left.\chi_{b,t+1}E_{A_{i,t+1}}\left(r_{t+1}^K + q_{t+1}^B(1-\delta)\middle|\frac{p_{t+1}^K}{A_{i,t+1}} \ge q_{t+1}^B\right)\right]\right\} \end{aligned} \tag{83}$$

$$\begin{aligned} 1 = \beta b_t E_t &\left\{\frac{\hat{\mu}_{t+1}^{\Sigma C}}{\hat{\mu}_t^{\Sigma C}}e^{z_{t+1}}\frac{1}{\pi_{t+1}}\times\left[\chi_{s,t+1}E_{A_{i,t+1}}\left(\frac{q_{t+1}^B}{\tilde{q}_{i,t+1}^A}\middle|\frac{p_{t+1}^K}{A_{i,t+1}} \le q_{t+1}^A\right)+\right.\right. \\ &\chi_{k,t+1}E_{A_{i,t+1}}\left(\frac{q_{t+1}^B}{\frac{p_{t+1}^K}{A_{i,t+1}}}\middle|q_{t+1}^A \le \frac{p_{t+1}^K}{A_{i,t+1}} \le q_{t+1}^B\right)+ \\ &+\quad\left.\left.\chi_{b,t+1}E_{A_{i,t+1}}\left(1\middle|\frac{p_{t+1}^K}{A_{i,t+1}} \ge q_{t+1}^B\right)\right]r_t^B\right\}. \end{aligned} \tag{84}$$

$$1 = \beta b_t E_t \left\{ \frac{\hat{\mu}^{\Sigma C}_{t+1}}{\hat{\mu}^{\Sigma C}_t} e^{z_{t+1}} \times \left[\chi_{s,t+1} E_{A_{i,t+1}} \left(\frac{q^B_{t+1}}{\tilde{q}^A_{i,t+1}} \middle| \frac{p^K_{t+1}}{A_{i,t+1}} \leq q^A_{t+1} \right) + \right. \right.$$

$$\chi_{k,t+1} E_{A_{i,t+1}} \left(\frac{q^B_{t+1}}{\frac{p^K_{t+1}}{A_{i,t+1}}} \middle| q^A_{t+1} \leq \frac{p^K_{t+1}}{A_{i,t+1}} \leq q^B_{t+1} \right) +$$

$$\left. \left. + \quad \chi_{b,t+1} E_{A_{i,t+1}} \left(1 \middle| \frac{p^K_{t+1}}{A_{i,t+1}} \geq q^B_{t+1} \right) \right] R^B_t \right\}. \tag{85}$$

$$\tilde{q}^A_{s,t} = \int_{\frac{p^K_t}{q^A_t}}^{\infty} \frac{p^K_t (1-\theta)}{A_{s,t} - \theta \frac{p^K_t}{q^A_t}} dF(A_{s,t}) \tag{86}$$

$$\begin{aligned} \iota_t =& \int_{\frac{p^K_t}{q^A_t}}^{\infty} \frac{1}{p^K_t (1-\theta)} [r^K_t n_{t-1} + r^B_{t-1} b_{t-1} + d_t - t_t + q^A_t \phi (1-\delta) n_{t-1}] dF(A_{s,t}) \\ &+ \int_{\frac{p^K_t}{q^B_t}}^{\frac{p^K_t}{q^A_t}} \frac{1}{p^K_t} [r^K_t n_{t-1} + r^B_{t-1} b_{t-1} + d_t - t_t] dF(A_{k,t}) \\ &= \chi_{s,t} \frac{1}{p^K_t (1-\theta)} [r^K_t n_{t-1} + r^B_{t-1} b_{t-1} + d_t - t_t + q^A_t \phi (1-\delta) N_{t-1}] dF(A_{s,t}) \\ &+ \chi k, t \frac{1}{p^K_t} [r^K_t N_{t-1} + r^B_{t-1} B_{t-1} + D_t - T_t] dF(A_{k,t}) \end{aligned} \tag{87}$$

$$\begin{aligned} n_t =& \left(\int_{\frac{p^K_t}{q^A_t}}^{\infty} \frac{1}{\tilde{q}^A_{s,t}} dF(A_{s,t}) \right) [r^K_t n_{t-1} + r^B_{t-1} b_{t-1} + d_t - t_t + q^A_t \phi (1-\delta) n_{t-1}] \\ &+ \frac{1}{p^K_t} \left(\int_{\frac{p^K_t}{q^B_t}}^{\frac{p^K_t}{q^A_t}} A_{k,t} dF(A_{k,t}) \right) [r^K_t n_{t-1} + r^B_{t-1} b_{t-1} + d_t - t_t] + (1-\delta) n_{t-1}. \end{aligned} \tag{88}$$

$$E_t \left\{ \sum_{s=0}^{\infty} {\xi_w}^s \beta^s \hat{\mu}^{\Sigma C}_{t+s} \tilde{L}_{t+s} \left[\frac{\tilde{w}_{b,t}}{\chi_{b,t+s}} \prod_{k=1}^{s} (\pi^{-1}_{t+k} \exp(z_{t+k})^{-1}) \Pi^w_{t,t+s} - (1+\lambda_{w,t+s}) \omega \frac{\tilde{L}^{\nu}_{t+s}}{\hat{\mu}^{\Sigma C}_{t+s}} \right] \right\} = 0 \tag{89}$$

$$w_t = \left\{ (1-\xi_w) (\tilde{w}_{b,t})^{\frac{1}{\lambda_w}} + \xi_w \left[(\pi e^{\gamma})^{(1-\iota_w)} (\pi_{t-1} e^{z_{t-1}})^{(\iota_w)} w_{t-1} \exp(\pi_t z_t)^{-1} \right]^{\frac{1}{\lambda_w}} \right\}^{\lambda_w} \tag{90}$$

$$q^B_t = (1 + \tau^q_t) q^A_t \tag{91}$$

$$\frac{R^B_t}{R^B} = \left(\frac{R^B_{t-1}}{R^B} \right)^{\rho_R} \left[\left(\frac{\bar{\pi}_t}{\pi} \right)^{\phi_\pi} \right]^{1-\rho_R} \left(\frac{\Delta \overline{X}_{t-s}}{\gamma} \right)^{\phi_Y} \eta_{mp,t} \tag{92}$$

$$\hat{B}_t + t_t = r^B_{t-1} \hat{B}_{t-1} + \hat{G}_t \tag{93}$$

$$\hat{G}_t = \left(1 - \frac{1}{g_t} \right) y_t \tag{94}$$

$$\frac{t_t/y_t}{ToY} = \left(\frac{\Delta \log(y_t \exp(z_t))}{\gamma}\right)^{-\varphi_Y} \left(\frac{\hat{B}_t/y_t}{BoY}\right)^{-\varphi_B} \tag{95}$$

$$d_t = \left(y_t - r_t^K k_{t-1} \exp(z_t)^{-1} - w_t L_t\right) + \left(p_t^K \left(1 - S\left(\frac{\hat{I}_t \exp(z_t)}{\hat{I}_{t-1}}\right)\right) \hat{I}_t - \hat{I}_t\right) + \left(q_t^B - q_t^A\right) \Delta n_t \tag{96}$$

$$y_t = k_t^\alpha \exp(z_t)^{-\alpha} L_t^{1-\alpha} \tag{97}$$

$$y_t = c_t + \hat{I}_t + \hat{G}_t \tag{98}$$

$$\Delta n_t = \theta \int_{A^{low}}^{\infty} A_{i,t} \hat{\imath}_{i,t} dF(A_{i,t}) + \phi(1-\delta) n_{t-1} \exp(z_t)^{-1} \tag{99}$$

$$\hat{\hat{\imath}}_t = \hat{\imath}_t \tag{100}$$

$$n_t = k_t \tag{101}$$

The system is composed of 33 equation, including equation (84) to determine the equilibrium real interest rate, r_t^B, and is expressed in 34 stationary variables:

$$\begin{bmatrix} k_t, L_t, mc_t, r_t^K, \tilde{w}_t, w_t, \pi_t, \tilde{p}_t, p_t^K, R_t^B, r_t^B, q_t^A, q_t^B, \tilde{q}_t^A \\ y_t, c_t, \hat{I}_t, \hat{\hat{\imath}}_t, \hat{\imath}_t, \hat{G}_t, \hat{B}_t, n_t, t_t, d_t, \Delta n_t, \hat{\mu}_t^{\Sigma C}, z_t, \lambda_{p,t}, \lambda_{w,t}, b_t, \bar{\tau}_t^q, \tilde{\tau}_t^q, \eta_{mp,t}, g_t \end{bmatrix}$$

The stationary model has a steady state solution for a given set of parameters and a steady state level of inflation, π_{ss}, and hours worked, L_{ss}.

I derive a log-linear approximation of the stationary equilibrium conditions (68)-(101) around the steady state equilibrium, using the analytical differentiation routines built into Matlab.[35] For a given parameter vector, I solve for the steady state equilibrium numerically and evaluate the coefficients of the log-linear approximation of the dynamic model's first order conditions. With the numerical approximation of the model at hand, I finally I then solve the system of linear rational expectation equation using the algorithm in Anderson and Moore (1985).

[35] I follow Justiniano, Primiceri and Tambalotti (2010) to compute the log-linear price and wage Phillips curves analytical from equations (41), (43), (44) and (53) - (55)

F The Great Recession

In this section I use the baseline model estimates in table 3, to simulate the model buffeted by aggregate shocks and replicate features of the Great Recessions, in the spirit of Christiano, Eichenbaum and Trabandt (2015). To conduct the experiment, I define the notional nominal interest rate, R_t^{not} as the nominal rate that follows the estimated Taylor rule:

$$\frac{R_t^{not}}{R^B} = \left(\frac{R_{t-1}^{not}}{R^{not}}\right)^{\rho_R} \left[\left(\frac{\bar{\pi}_t}{\pi}\right)^{\phi_\pi} \left(\frac{\Delta \overline{Y}_{t-s}}{\gamma}\right)^{\phi_Y}\right]^{1-\rho_R} \eta_{mp,t}.$$

I assume that the central bank can set the actual nominal interest rate, R_t^B to be equal to the notional rate when $R_t^{not} > 0$ or equal to zero otherwise:

$$R_t^B = max(R_t^{not}, 0) \tag{102}$$

The economy can transition across two regimes, one in which the nominal interest rate is zero and the other in which it is constrained by the zero lower bound. I compute a piecewise-linear perturbation solution for the model with the occasionally binding zero bound constraint on the federal funds rate subject to a series of predetermined aggregate shock, following Guerrieri and Iacoviello (2015).

I simulate the model under the baseline parameters at the posterior mode. I start the estimation using the smoothed state vector in 2008:Q2 as an initial condition. I then calibrate 4 quarters of selected aggregate shocks to hit the economy from 2008:Q3 to 2009:Q2 and observe the response of the macro variables until the end of 2012. I calibrate the shocks to total factor productivity, government spending, financial intermediation costs, intertemporal preferences and price mark-ups.

I fit the processes for TFP growth estimated in the model (26) to growth data for total factor productivity from Fernald (2012). This allows me to back out TFP growth shocks that hit the U.S. economy from 2008:Q3 to 2009:Q2 (see figure 31 for a direct comparison of Fernald's TFP growth series and the smoothed TFP growth generated by my model's estimates). Similarly, I fit the estimated process for g_t, in equation (2.8) to data on the share of government spending over GDP for the same period to back out a measure of model-consistent shocks to government spending that hit the economy during the Great Recession.

The financial intermediation shocks affect the intertemporal capital accumulation decision, while preference shocks affect all intertemporal Euler equations and are the main drivers of aggregate consumption in the model (see variance decomposition table 4). I select a mix of persistent and transitory financial intermediation shocks, $\varepsilon_t^{t\bar{a}u}$ and $\varepsilon_t^{t\tilde{a}u}$ to match the rise in corporate spreads after the collapse of Lehman Brothers and to closely mimic their reversion over the course of 2009. I select a sequence of preference shocks ε_t^{β} to match the drop in aggregate consumption observed in the data. Christiano, Eichenbaum and Trabandt (2015) report that financial shocks that affect the cost of raising working capital and firms' marginal costs are important to explain the moderate decrease in inflation during the Great Recession. In the absence of such working capital channel, I introduce a sequence of exogenous positive price mark-up shocks that can match the inflation profile over the simulation period.

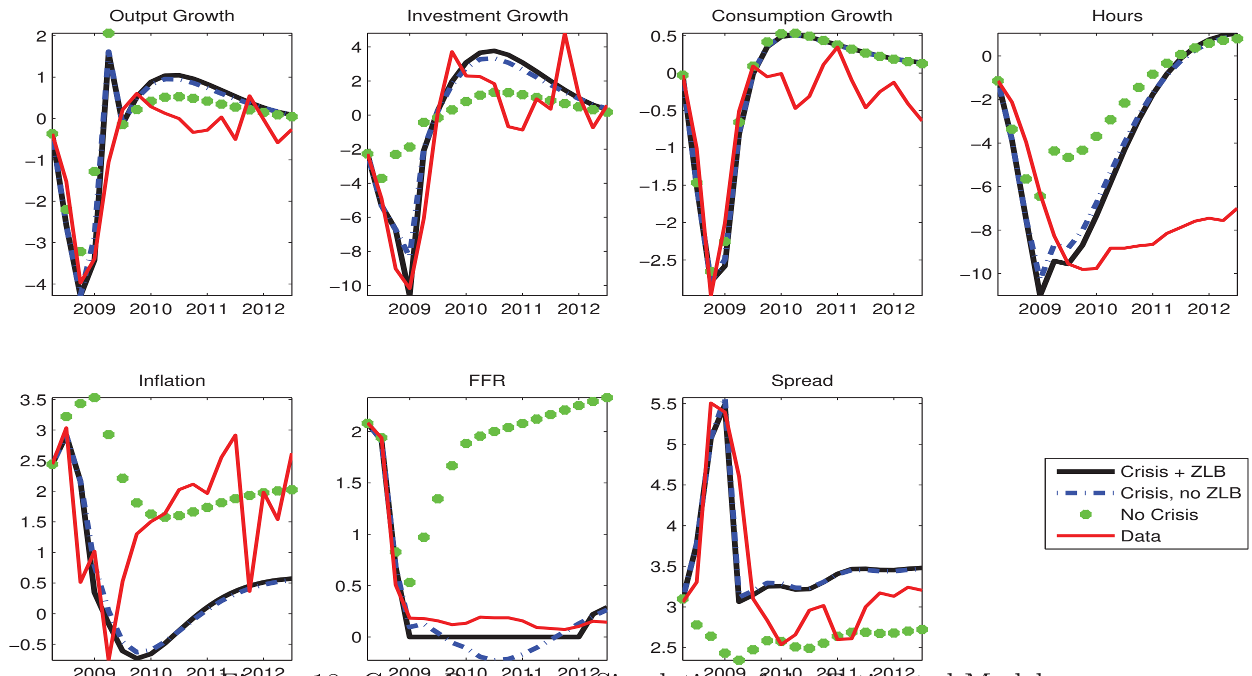

Figure 18: Great Recession - Simulation of the Estimated Model

Figure 18 compares the evolution of GDP, investment and consumption growth, hours worked, inflation, the federal funds rate and corporate spreads in the data with the responses of the model to the 4-quarter sequences of aggregate shocks, solved using first order perturbations without accounting for the zero lower bound (blue dashed lines, labeled as 'Crisis, No ZLB') and using piecewise linear perturbation methods to account for the occasionally binding constraint on the risk free rate (black lines, labeled as 'Crisis + ZLB'). The figure also includes impulse responses of the same variables in the absence of the financial intermediation shocks (green stars, labeled as 'No Crisis').

The calibration matches the short-run evolution of the data series and the mean reversion of output growth fairly well, although the 4-quarter sequence of shocks misses to capture the persistence of hours worked after 2009. Comparing the crisis scenario solved taking into account of the ZLB (black lines) with the non-crisis scenario (green stars) reveals that financial intermediation shocks can account for as much as half of the drop in investment growth and hours worked observed during the Great Recession, as well as for 25% of the drop in output growth. In the absence of the sudden rise of corporate spreads inflation would have remained close to 2% and the federal funds rate would not have reached its zero bound.

Finally, comparing the crisis scenario solved taking into account of the ZLB (black lines) with a crisis scenario in which the monetary policy instrument is unconstrained (blue dashed lines) shows that the expectation of a zero-bound spell lasting approximately 3 years has a dragging albeit somewhat limited effect on aggregate investment growth, hours worked and output.

G Model with Constant Aggregate Investment Technology

In every period household members are endowed with Markov draws of investment technologies, from a continuous probability distribution, $f(A_{i,t})$. Members with more efficient technologies (keepers and sellers with $A_{i,t} > \frac{P_t^K}{Q_t^B}$, see figure 3) adopt them to build more capital for the household. Members with the highest technology draws (sellers, with $A_{i,t} > \frac{P_t^K}{Q_t^A}$) also borrow resources from the less efficient household members through the financial system.

A negative financial intermediation shock in the model propagates through two channels: 1) it directly raises the cost of external funds and limits borrowing for household members with better technologies, lowering their demand for investment goods, and 2) it decreases the return on financial claims and creates an incentive for household members with poorer technologies to adopt them and accumulate new physical capital instead of financial assets (the productivity of the marginal keeper, $\frac{P_t^K}{Q_t^B}$, drops). The credit crunch has an immediate effect on both the demand of investment goods and on the capital accumulation technology in the system. In other words, the negative financial shock is accompanied by a negative investment technology shift, in line with the intuition in Buera and Moll (2015).

When trying to separate the demand effect from the technology effect, it is important to notice that the individual demands for investment goods for sellers and keepers, $\iota_{s,t}$ and $\iota_{k,t}$ are homogenous within member types:

$$\iota_{s,t} = \frac{1}{P_t^K(1-\theta)}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t + Q_t^A \phi(1-\delta) N_{t-1}]$$

$$\iota_{k,t} = \frac{1}{P_t^K}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t]$$

Summing up over sellers and keepers, I can compute the aggregate demand for each type of the household members:

$$I_{s,t} = \chi_{s,t}\frac{1}{P_t^K(1-\theta)}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t + Q_t^A \phi(1-\delta) N_{t-1}]$$

$$I_{k,t} = \chi_{k,t}\frac{1}{P_t^K}[R_t^K N_{t-1} + R_{t-1}^B B_{t-1} + P_t D_t - P_t T_t]$$

The aggregate capital accumulation equation is then equal to:

$$K_t = \int_{fracP_t^K Q_t^B}^{\infty} A_{i,t}\iota_{i,t} dF(A_{i,t}) + (1-\delta)K_{t-1} \tag{103}$$

$$= I_{k,t}\int_{\frac{P_t^K}{Q_t^B}}^{\frac{P_t^K}{Q_t^A}} A_{i,t} dF\left(A_{i,t} \| \frac{P_t^K}{Q_t^B} < A_{i,t} < \frac{P_t^K}{Q_t^A}\right) + I_{s,t}\int_{\frac{P_t^K}{Q_t^A}}^{\infty} A_{i,,t} dF\left(A_{i,t} \| A_{i,,t} > \frac{P_t^K}{Q_t^A}\right) + (1-\delta)K_{t-1}$$

I can define the effective investment technology, A_t^{eff}, in the model as an auxiliary variable that solves the following equation:

$$K_t = A_t^{eff}(I_{s,t} + I_{k,t}) + (1 - \delta)K_{t-1} \tag{104}$$

A_t^{eff} represents the level of investment technology that is necessary to transform investment goods purchased by sellers and keepers $(I_{s,t} + I_{k,t})$ into aggregate capital in period t, K_t. By comparing equations (103) and (104), one can see that the effective investment technology maps into the average technologies adopted by sellers and keepers and depends on the parameters of the distribution $F(A_{i,t})$. I then assume that the location parameter of the lognormal distribution of idiosyncratic investment technologies $\mu_{A,t}$ be time-varying and that it adjusts so to keep the effective investment technology A_t^{eff} constant in every period and equal to its steady state value:

$$A_t^{eff} = A_{ss}^{eff} \tag{105}$$

The mean of the lognormal distribution can adjust so to keep the effective investment technology adopted by keepers and sellers constant over time. Figure 19 plots the impulse responses of the observables to a persistent financial intermediation shock for the model with constant technology. I obtain these plots by adding equations (104) and (105) to the model and calibrating it at the posterior mode from table 3. The impulse responses clearly show that keeping the effective level of investment technology, A_t^{eff}, constant does not alter the impact of the financial intermediation shock.

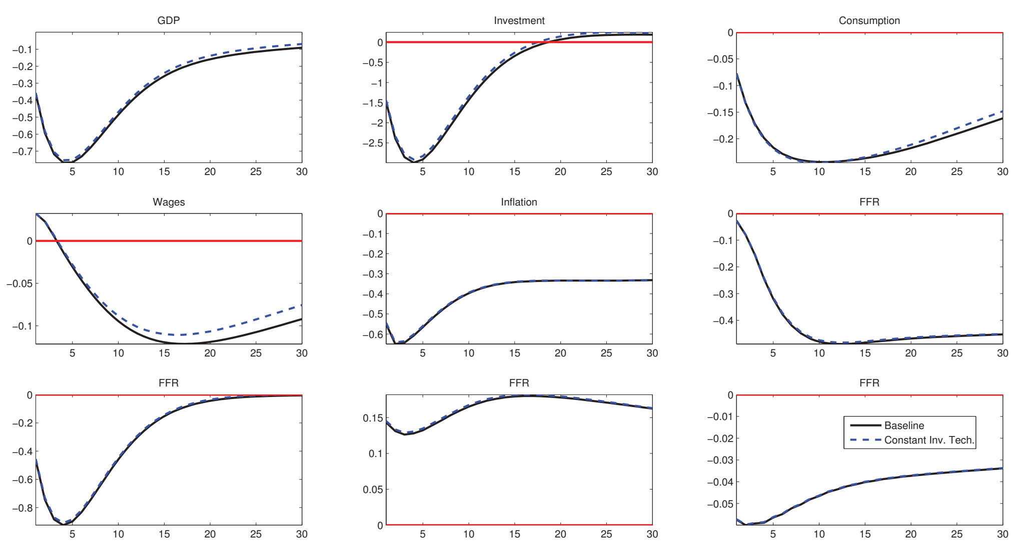

Figure 19: Impulse response functions to a one standard deviation financial shock. Comparison between baseline model (black solid line) and model with high price stickiness and low wage stickiness (blue dashed line).

H Accuracy of the Log-linearized Solution

Due to the degree of curvature of the pdf function, the accuracy of the first order approximation of the model equilibrium conditions that include integrals of $f(A_{i,t})$, including the definition of the financing gap share observable, $\widehat{FGS}_t$, can come into question when random shocks take the system sufficiently away from the steady state. To diagnose the inaccuracy problem, I simulate the model under different parmeterizations and model assumptions. For each version of the model, I simulate its log-linearized solution at the posterior mode to produce 10,000 observations (burning the first 5,000). For each observation in the simulated sample I compute the absolute errors of the log-linearized solution for the share of borrowers in the household, $\chi_{s,t}$ from the non-linear expressions of the CDF , $\chi^{nl}_{s.t} = 1 - F(\frac{p^K_t}{q^A_t})$:

$$\varepsilon_{\chi_s} = \frac{\|\chi_{s,t} - (1 - F(\frac{p^K_t}{q^A_t}))\|}{(1 - F(\frac{p^K_t}{q^A_t}))}$$

Table 7 reports the absolute average errors expressed in base-10 logarithms mode under different model and estimation assumptions. The baseline estimated model is highlighted in bold. The table also reports the variance decomposition share of financial intermediation shocks for output growth and shows that each model variant confirms that financial intermediation shocks are the largest drivers of business cycle fluctuations in output growth.

- *Baseline estimation: lognormal idiosyncratic risk and endogenous prior on the volatility of the observable* $\widehat{FGS}_t$

  The baseline estimation in the paper constrains the model-implied unconditional standard deviation of the financing gap share, $\widehat{FGS}_t$, by imposing a prior distribution on it, centered around the sample standard deviation of the observable. The penalty can be interpreted as a GMM-type endogenous prior that reinforces the incentive of the optimizer to match the second moment of the financing gap share. The prior is useful to penalize parameterizations under which the model is more likely to visit regions of the state space where the log-linear approximation of its solution is inaccurate and parameter estimates may be distorted. The prior is Gaussian, centered around the empirical standard deviation of the Compustat series (0.12) and has standard deviation equal to 0.06. Line 5 of table 7 reports the average absolute errors for $\chi_{s,t}$ at the posterior mode is less than 1% (≤ -2 in $\log_{10}$). Line 3 of Table 7 also reports the average absolute error in the absence of the prior on the volatility of the financing gap shares. Absent the prior, the average absolute error goes up to 6% (-1.2 in $\log_{10}$). I verify that also the average absolute error for the share of keepers, $\chi_{k,t}$, (another determinant of the dynamics of the financing gap share) is also small, faring -1.65 in $\log_{10}$ or approximately 2% in percentage terms. In the absence of the prior, the average absolute error for $\chi_{k,t}$ would be -0.49 in $\log_{10}$, or 32% in percentage terms.

- *Assumption on distribution of idiosyncratic technologies* In the previous versions of the paper I had assumed that $f(A_{i,t})$ could be approximated by a generic quadratic function:

$$f(A_{i,t}) = a + bA_{i,t} + cA_{i,t}^2$$

This assumption was necessary to allow for aggregation of the household's first order conditions over its members. Since then, I modified the borrowing constraint of household members slightly so to allow aggregation under any distributions of idiosyncratic technology risk that have finite first moments. In the current version of the paper the model is solved under the assumption of log-normal distribution for $A_{i,t}$:

$$f(A_{i,t}) = \frac{1}{A_{i,t}\sigma_A\sqrt{2\pi}} \exp^{\frac{\log(A_{i,t})-\mu_A}{\sqrt{2}\sigma_A}}$$

Lines 1 and 3 of the Table 7 shows that model simulations of the share of sellers, $\chi_{s,t}$, performed under the quadratic distribution are less accurate than those performed under the lognormal distribution, everything else equal.

- *Robustness check 1: Prior on the persistence of financial shocks*

The model-implied volatility of the financing gap share is a function of the deep parameters of the model. By imposing a prior distribution on the volatility of $\widehat{FGS}_t$ as in the baseline estimation, I remain agnostic on what model parameter estimates exacerbates the inaccuracy of the model solution.

I verified that I could also obtain more accurate simulations for $\chi_{s,t}$ by imposing a prior directly on the autoregressive coefficient of the financial shock, $\rho_{\bar{\tau}}$. The shock is generally estimated to be very persistent ($\rho_{\bar{\tau}} \approx 0.99$ at the mode). By imposing a Beta prior on $\rho_{\bar{\tau}}$ with mean 0.2 and standard deviation 0.10, I can penalize extreme values of the parameter and at the same time reduce the average absolute errors for $\chi_{s,t}$ to 1.5% from 6% in the unconstrained lognormal case.

Evidence on the role of transitory financial intermediation shocks $t\tilde{a}u_t^q$ in section 4 shows that lower persistence for financial shocks reduces their relevance on output and investment at business cycle frequencies. Imposing a tight prior on low values of $\rho_{\bar{\tau}}$ then biases the estimation against the main result of my paper. Nonetheless, these estimates show that the data strongly favor high values for $\rho_{\bar{\tau}}$ and that the financial intermediation shock still explains around 30% of variation in GDP growth at business cycle frequencies.

- *Robustness check 2: Estimation of model with constant household member shares*

I estimated a version of the model with constant technologies and household member shares.

This is described in online appendix I. In such a model results cannot be affected by inaccuracies of the log-linearized distribution of capital installation technologies away from steady state. Results from this simplified model confirm that financial shocks have an important first-order effect in driving business cycles, explaining around 32% of output growth fluctuations.

Table 7: Mean Absolute Errors - $\chi_{s,t}$

Model		Mean Absolute Errors in $\log_{10}$	Var Decomp Share of Fin Shock (GDP Growth)
Distribution	Prior	χ_s	
Quad.	None	-0.295	25%
Quad.	FGS	-1.0378	28%
LogNorm.	None	-1.2838	30%
LogNorm.	ρ_τ	-1.6773	30%
LogNorm.	**FGS**	**-2.048**	**24%**
Constant	None	No Error	35%

The table reports mean absolute errors between the log-linear approximations of the share of sellers in the household, χ_s, and its non-linear counterparts. The errors are expressed in base-10 logs, so that an error of -1 and -2 corresponds respectively to errors of 10% and 1% . The baseline is highlighted in bold. The table reports, in rows, the models for which the errors are computed. These include the model with a quadratic pdf with no prior on the volatility of the FGS, the model with quadratic pdf and a prior (N(12.58%, 6%)) on the standard deviation of log(FGS), the model with a lognormal pdf and no priors, the model with the lognormal pdf and a conservative prior on the persistence of the financial shock, the model with a lognormal pdf and a prior on the volatility of the log(FGS), and finally the model with constant member shares.

I Model with Constant Shares of Buyers, Keeper and Sellers

In section H I discussed how the log-linearized approximation of the integrals of the distribution $f(A_{i,t})$ can cause the model solution to be inaccurate away from the steady state under certain parameterizations. To verify the validity of my results for a model whose solution is not subject to this source of inaccuracy, I modify the baseline model in the paper to feature time-invariant shares of member types in the household. In this version of the model the shares of sellers, keepers and buyers in the economy are set equal to their steady state value in each period:

$$\chi_{i,t} = \chi_{i,ss} \text{ for each } i = s, k, b$$

and the investment technology of each member is assumed to be equal to the steady-state average technology of their member type ($\bar{A}_s$ for sellers, $\bar{A}_k$ for keepers and $\bar{A}_b$ for buyers) in every period, so that the aggregate capital accumulation equation simplifies to:

$$K_t = \iota_{s,t} \int_{\frac{p_{ss}{}^K}{q_{ss}{}^A}}^{\infty} A_i dF(A_{i,t}) + \iota_{k,t} \int_{\frac{p_{ss}{}^K}{q_{ss}{}^B}}^{\frac{p_{ss}{}^K}{q_{ss}{}^A}} A_i dF(A_{i,t}) = \bar{A}_s \iota_{s,t} + \bar{A}_k \iota_{k,t}$$

and the Euler equation for equity in the model becomes:

$$\begin{aligned}
q_t^B = \beta b_t E_t \Bigg\{ & \frac{\hat{\mu}_{t+1}^{\Sigma C}}{\hat{\mu}_t^{\Sigma C}} e^{z_{t+1}} \frac{1}{\pi_{t+1}} \times \\
& \times \Bigg[\chi_{s,ss} \left[\frac{q_{t+1}^B}{\bar{\tilde{q}}^A} \left(r_{t+1}^K + (1-\phi_{t+1}) \tilde{q}_{i,t+1}^A (1-\delta) + \phi_{t+1} q_{i,t+1}^A (1-\delta) \right) \right] + \\
& + \chi_{k,ss} \left[\frac{\bar{A}_k q_{t+1}^B}{p_{t+1}^K} \left(r_{t+1}^K + \frac{p_{t+1}^K}{A_{i,t+1}} (1-\delta) \right) \right] + . \\
& + \quad \chi_{b,ss} \left(r_{t+1}^K + q_{t+1}^B (1-\delta) \middle| \frac{p_{t+1}^K}{A_{i,t+1}} \geq q_{t+1}^B \right) \Bigg] \Bigg\}
\end{aligned} \tag{106}$$

where:

$$\frac{q_t^B}{\bar{\tilde{q}}^A} = \frac{q_t^B (\bar{A}_s - \theta \frac{p_{ss}^K}{q_{ss}^A})}{p_{ss}^K (1-\theta)} \tag{107}$$

When I estimate this model, I confirm that financial shocks are the most important drivers of business cycle fluctuations. Table 9 reports the variance decomposition of the observables in fundamental shocks computed around the posterior mode in table 8. Financial intermediation shocks explain more than 30% of fluctuations in output growth, however, the model with fixed shares of member types has a hard time explaining fluctuations in the financing gap share and in matching the second moments of corporate spreads. Without endogenous changes in the composition of sellers, keepers and buyers, the model needs larger financial intermediation shocks than in the baseline model to match the volatility of the macro variables, but fails to explain cyclical fluctuations in the Compustat financing gap share (more than 70% of its business cycle volatility is explained by measurement error). Larger financial shocks, can increase the volatility of asset prices (q_t^A) in boom and recessions. Table 10, however, shows that this has the counterfactual implication of increasing the volatility of borrowing spreads, that become 16 times more volatile than output growth in the model and than corporate spreads in the data.[36].

[36]The steady-state intermediation cost is calibrated to be 2% for these estimates. Estimating the parameter increases the average intermediation costs from 2%, up to 10% without altering the relevance of financial intermediation costs, nor reducing the volatility of corporate spreads in the model. The standard deviation of the discount factor shocks is also more elevated than in the baseline model. This is compensating for the absence of time-varying weights for household types in the Euler equation (106) with respect to (83)

Table 8: Calibrated Values, Priors and Posterior Estimates for the Model Parameters

Parameter	Explanation	Prior	Mode	[	5%[2]		95%[1]	]
γ	SS Output Growth	Calibrated	0.5	[	–	–	–	]
$(\beta^{-1}-1)\times 100$	Discount Factor	Gamma(0.75,0.05)	1.43	[	1.21	–	1.65	]
δ	Capital Depreciation	Calibrated	0.025	[	–	–	–	]
ν	Inverse Frisch	Gamma(2,0.75)	2.48	[	1.35	–	3.44	]
h	Habit	Beta(0.5,0.2)	0.999	[	0.999	–	0.999	]
l_{ss}	Labor Supply	Calibrated	0	[	–	–	–	]
η	Labor Share	Beta(0.6,0.10)	0.611	[	0.586	–	0.633	]
λ_p	Price Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_p	Calvo Prices	Beta(0.75,0.15)	0.832	[	0.778	–	0.883	]
ι_p	Index Prices	Beta(0.50,0.15)	0.244	[	0.17	–	0.357	]
λ_w	Wage Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_w	Calvo Wages	Beta(0.75,0.15)	0.987	[	0.97	–	0.993	]
ι_w	Index Wages	Beta(0.50,0.15)	0.345	[	0.198	–	0.532	]
μ_A	Mean Idiosyn. Technology	Calibrated	0	[	–	–	–	]
σ_A	Std. Idiosyn. Technology	Gamma(0.1,0.04)	0.896	[	0.876	–	0.916	]
FGS_{ss}	FGS Steady State	Calibrated	0.35	[	–	–	–	]
θ	Collateral Constr.	Collateral Constr.	0	[	0	–	0	]
Bs_{ss}	Liquidity over GDP	Calibrated	0.02	[	–	–	–	]
gs_{ss}	Govt. Spend. over GDP	Calibrated	0.17	[	–	–	–	]
$\tau_{q_{ss}}\times 100$	SS Intermediation Cost	Calibrated	2	[	–	–	–	]
θ_I	IAC	Gamma(4,2)	0.543	[	0.425	–	0.713	]
π_{ss}	SS inflation	Normal(0.5,0.1)	0.0106	[	0.00931	–	0.0118	]
ρ_i	Taylor Rule inertia	Beta(0.85,0.1)	0.77	[	0.694	–	0.849	]
ϕ_π	Taylor Rule inflation	Normal(0.7,0.05)	0.172	[	0.107	–	0.226	]
ϕ_{DY}	Taylor Rule GDP growth	Normal(0.125,0.1)	0.221	[	0.204	–	0.236	]
φ_B	Fiscal Rule - Debt	Normal(0.5,0.2)	0.346	[	0.223	–	0.52	]
ρ_z	AR(1) TFP growth shock	Beta(0.5,0.2)	0.927	[	0.896	–	0.956	]
ρ_g	AR(1) G shock	Beta(0.5,0.2)	0.358	[	0.226	–	0.554	]
$\rho_{\bar{\tau}}$	AR(1) Fin. shock Pers.	Beta(0.5,0.2)	0.92	[	0.89	–	0.952	]
$\omega_{\tilde{\tau}}$	AR(1) Fin. shock Trans.	Beta(0.5,0.2)	0.618	[	0.528	–	0.706	]
ρ_β	AR(1) Beta shock	Beta(0.5,0.2)	0.971	[	0.965	–	0.976	]
ρ_p	AR(1) P Mark-up shock	Beta(0.5,0.2)	0.403	[	0.183	–	0.781	]
ρ_w	AR(1) W Mark-up shock	Beta(0.5,0.2)	0.263	[	0.0248	–	0.381	]
θ_p	MA(1) P shock	Beta(0.5,0.2)	0.2	[	0.0283	–	0.368	]
θ_w	MA(1) W shock	Beta(0.5,0.2)	0.728	[	0.681	–	0.779	]
σ_z	Stdev TFP Growth Shock	InvGamma2(0.5,1)	0.717	[	0.623	–	0.821	]
σ_g	Stdev G Shock	InvGamma2(0.5,1)	0.203	[	0.166	–	0.257	]
σ_i	Stdev MP Shock	InvGamma2(0.1,1)	0.686	[	0.565	–	0.805	]
$\sigma_{\bar{\tau}}$	Stdev Fin. Shock Pers.	InvGamma2(0.5,1)	0.0582	[	0.0388	–	0.0911	]
$\sigma_{\tilde{\tau}}$	Stdev Fin. Shock Trans.	InvGamma2(0.5,1)	8.31	[	7.51	–	9.15	]
σ_β	Stdev Beta Shock	InvGamma2(0.5,1)	53.6	[	47.7	–	60.6	]
σ_p	Stdev P Mark-up Shock	InvGamma2(0.1,1)	0.222	[	0.156	–	0.298	]
σ_w	Stdev W Mark-up Shock	InvGamma2(0.1,1)	4.45	[	3.74	–	5.29	]
$\sigma_{ME_{sp}}$	Stdev ME Spread	InvGamma2(0.05,0.05)	0.0397	[	0.0116	–	0.0858	]
$\sigma_{ME_{fgs}}$	Stdev ME FGS	InvGamma2(0.05,0.05)	0.202	[	0.189	–	0.216	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis-Hasting algorithm.
Acceptance rate 19%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.

Table 9: Model with Constant Shares of Member Types: Posterior Variance Decomposition

	TFP	Gov't	MP	Fin.(pers.)	Fin.(trans.)	Preference	P. Mark-up	W. Mark-up	ME FGS	ME Spread
$\Delta \log GDP_t$	**8.6**	**11.2**	**0.4**	**35.8**	**9.8**	**18.1**	**1.7**	**12.3**	**0.0**	**0.0**
	[5.7 - 11.7]	[8.1 - 16.9]	[0.0 - 0.8]	[29.9 - 40.2]	[7.4 - 13.2]	[13.5 - 23.9]	[0.3 - 7.1]	[8.7 - 16.6]	[0 - 0]	[0 - 0]
$\Delta \log I_t$	**9.2**	**0.1**	**0.2**	**52.0**	**14.7**	**0.1**	**11.4**	**11.1**	**0.0**	**0.0**
	[6.3 - 12.3]	[0.0 - 0.1]	[0.1 - 0.3]	[45.0 - 58.5]	[11.2 - 19.7]	[0.0 - 0.3]	[5.8 - 19.3]	[4.4 - 15.1]	[0 - 0]	[0 - 0]
$\Delta \log C_t$	**2.3**	**0.0**	**1.0**	**0.0**	**0.0**	**78.6**	**10.6**	**6.4**	**0.0**	**0.0**
	[0.7 - 5.0]	[0.0 - 0.0]	[0.2 - 2.1]	[0.0 - 0.2]	[0.0 - 0.0]	[66.7 - 87.9]	[2.0 - 18.1]	[3.1 - 11.6]	[0 - 0]	[0 - 0]
$\Delta \log w_t$	**9.7**	**0.1**	**0.4**	**0.1**	**0.0**	**0.3**	**39.1**	**50.0**	**0.0**	**0.0**
	[5.6 - 14.6]	[0.0 - 0.1]	[0.0 - 1.9]	[0.0 - 0.3]	[0.0 - 0.0]	[0.1 - 0.7]	[26.2 - 63.5]	[24.1 - 62.1]	[0 - 0]	[0 - 0]
π_t	**3.1**	**0.4**	**7.4**	**1.8**	**0.1**	**3.8**	**55.9**	**25.7**	**0.0**	**0.0**
	[1.1 - 6.0]	[0.2 - 0.6]	[1.5 - 15.6]	[0.7 - 3.2]	[0.0 - 0.1]	[1.4 - 6.5]	[25.4 - 75.2]	[9.3 - 46.4]	[0 - 0]	[0 - 0]
R_t^B	**1.3**	**0.2**	**51.7**	**1.4**	**0.1**	**2.3**	**28.9**	**11.3**	**0.0**	**0.0**
	[0.3 - 2.7]	[0.1 - 0.4]	[38.2 - 64.4]	[0.7 - 2.5]	[0.0 - 0.1]	[1.0 - 3.8]	[13.0 - 41.4]	[4.3 - 26.1]	[0 - 0]	[0 - 0]
$\log L_t$	**26.3**	**4.8**	**0.3**	**22.0**	**3.1**	**19.4**	**3.2**	**15.3**	**0.0**	**0.0**
	[19.1 - 36.6]	[3.1 - 6.9]	[0.0 - 1.1]	[17.0 - 27.3]	[2.0 - 4.5]	[10.1 - 29.3]	[0.7 - 14.5]	[8.7 - 21.7]	[0 - 0]	[0 - 0]
Sp_t	**0.1**	**0.1**	**1.7**	**21.7**	**73.0**	**0.1**	**2.3**	**0.6**	**0.0**	**0.0**
	[0.0 - 0.1]	[0.0 - 0.1]	[0.9 - 2.7]	[16.9 - 27.0]	[67.5 - 79.2]	[0.0 - 0.2]	[1.3 - 3.2]	[0.2 - 1.3]	[0 - 0]	[0.0 - 0.0]
FGS_t	**0.1**	**0.2**	**0.0**	**17.0**	**2.8**	**0.0**	**1.1**	**0.4**	**78.1**	**0.0**
	[0.1 - 0.2]	[0.1 - 0.2]	[0.0 - 0.1]	[14.4 - 20.0]	[1.9 - 4.2]	[0.0 - 0.0]	[0.5 - 1.8]	[0.2 - 0.6]	[74.6 - 81.6]	[0 - 0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Mode values and 90% confidence intervals. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random Walk Metropolis-Hasting algorithm. Acceptance rate 19%. Burning period: 20,000 draws. Statistics computed over 1,000 randomly-chosen accepted draws.
Values are percentages. Rows may not sum up to 100% due to rounding error. Computed used parameter estimates in table 8.

Table 10: Model Fit : Standard Deviations

Observables	Data	Data(Hist.)	Model Median	[	5%	-	95%	]
Abs. Stdev($\Delta \log GDP_t$)	0.58	0.97	0.65	[	0.56	–	0.75	]
Stdev($\Delta \log I_t$)	3.55	3.56	3.10	[	2.67	–	3.55	]
Stdev($\Delta \log C_t$)	0.65	0.49	0.64	[	0.51	–	0.82	]
Stdev($\Delta \log w_t$)	1.24	0.58	1.68	[	1.29	–	2.21	]
Stdev(π_t)	0.39	0.59	0.81	[	0.56	–	1.15	]
Stdev(R_t^B)	0.89	0.84	0.80	[	0.48	–	1.30	]
Stdev($\log L_t$)	4.98	5.81	6.23	[	3.53	–	11.91	]
Stdev(Sp_t)	0.91	0.71	16.05	[	11.48	–	23.42	]
Stdev($\widehat{FGS}_t$)	21.68	–	25.51	[	16.18	–	43.62	]

Standard deviations of observable variables. Model implied vs. Data. Source: Haver Analytics. Sample period: 1989:Q1 - 2008:Q2. Posterior percentiles from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm. Acceptance rate 19%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly-selected accepted draws. For each draw, I simulate 1 sample of length equal to the sample period (178 periods, burning the first 100 observations to control for randomness of the initial condition). The table reports the 5th, 50th and 95th percentile mean standard deviations for the 1,000 parameter draws.

J Model with Shocks to the Dispersion of Investment Technologies

In this section, I study the implications of a shock to the dispersion of the idiosyncratic investment technologies. I assume that the volatility of idiosyncratic technologies, σ_A follows an exogenous process:

$$\log \sigma_{A,t} = (1 - \rho_A) \log \sigma_{A,ss} + \rho_A \log \sigma_{A,t-1} + \varepsilon_t^{\sigma_A}$$

where $\varepsilon_t^{\sigma_A} \sim N(0, \sigma_{sg})$. I estimate the baseline model and add this additional shock to σ_A as a potential source of aggregate fluctuations. I assume no measurement error on corporate spreads nor on the financing gap share. Figure 20 shows that the shock has implications for macro and financial variables that are different than those of the financial intermediation shocks and liquidity shocks described in section D.

Figure 20 shows that an increase in technology dispersion creates an economic contraction. Increased dispersion fattens the tails of the technology distribution: it raises the share of inefficient household members that will not use their technologies to build more capital stock (buyers) and increases the share and average quality of investing members who are subject to binding credit constraints (sellers). More technology dispersion can cause a recession in which fewer individuals are willing to buy investment goods. Those who do, however, fiercely compete for constrained external funding, pushing up both credit spreads and the aggregate financing gap share. Since spreads and the financing gap share move in the same direction, the shock can be separately identified from financial intermediation shocks. Notice that this type of risk shocks is very different from those considered in Christiano, Motto and Rostagno (2012). In their paper, a risk shock increases the dispersion of the return on capital of entrepreneurs and their probability of defaulting on nominal debt. Defaults are costly and larger expected losses on credit contracts lower asset prices, entrepreneurs' net worth and aggregate demand. Here dispersion shocks to investment technology squeeze household members out of the pool of viable investment projects and exacerbate credit constraints for those members with the best technologies.

Tables 11 and 12 report the estimated parameters and the variance decomposition of the observables at business cycle frequencies. The variance decomposition shows that the financial intermediation shocks are still the most important drivers of business cycle fluctuations explaining more than 20% of output growth volatility. Exogenous changes in technology dispersion $\sigma_{A,t}$ can explain 30% of volatility in the financing gap share that was left to the measurement error in the baseline estimation. However, dispersion shocks have very limited effect on macro aggregates, explaining less than 5% of business cycle volatility of output growth.

Comparing the shock decompositions of the financing gap share for the modified model in figure 21 with the one of the baseline estimates in figure 11 also shows that dispersion shocks play a very similar role in explaining the historical dynamics of the financing gap share to the one played by the measurement error in the baseline estimates.

Table 11: Calibrated Values, Priors and Posterior Estimates for the Model Parameters - Model with Technology Dispersion Shocks

Parameter	Description	Prior	Mode	[	5%[2]		95%[2]	]
γ	SS Output Growth	Gamma(0.5,0.25)	0.5	[	–	–	–	]
$(\beta^{-1}-1)\times 100$	Discount Factor	Calibrated	0.45	[	0.297	–	0.594	]
δ	Capital Depreciation	Calibrated	0.025	[	–	–	–	]
ν	Inverse Frisch	Gamma(2,0.75)	1.51	[	0.64	–	2.49	]
h	Habit	Beta(0.5,0.2)	0.851	[	0.794	–	0.903	]
l_{ss}	Labor Supply	Calibrated	0	[	–	–	–	]
η	Labor Share	Beta(0.6,0.05)	0.762	[	0.744	–	0.781	]
λ_p	Price Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_p	Calvo Prices	Beta(0.66,0.1)	0.788	[	0.74	–	0.834	]
ι_p	Index Prices	Beta(0.5,0.15)	0.313	[	0.136	–	0.501	]
λ_w	Wage Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_w	Calvo Wages	Beta(0.66,0.1)	0.861	[	0.802	–	0.913	]
ι_w	Index Wages	Beta(0.5,0.15)	0.492	[	0.314	–	0.671	]
μ_A	Mean Idiosyn. Technology	Calibrated	0	[	–	–	–	]
σ_A	Std. Idiosyn. Technology	Gamma(0.1,0.04)	0.0176	[	0.0141	–	0.0219	]
FGS_ss	FGS Steady State	Calibrated	0.35	[	–	–	–	]
θ	Collateral Constr.	Beta(0.75,0.05)	0.515	[	0.426	–	0.594	]
Bs_{ss}	Liquidity over GDP	Calibrated	0.02	[	–	–	–	]
gs_{ss}	Govt. Spend. over GDP	Calibrated	0.17	[	–	–	–	]
$\tau_{q_{ss}}\times 100$	SS Intermediation Cost	Gamma(1,0.4)	1.72	[	1.42	–	2.03	]
θ_I	IAC	Gamma(4,2)	0.794	[	0.558	–	1.07	]
π_{ss}	SS inflation	Normal(0.5,0.1)	0.344	[	0.246	–	0.463	]
ρ_i	Taylor Rule inertia	Beta(0.85,0.1)	0.85	[	0.812	–	0.887	]
ϕ_π	Taylor Rule inflation	Normal(0.7,0.05)	0.355	[	0.249	–	0.461	]
ϕ_{DY}	Taylor Rule GDP growth	Normal(0.125,0.1)	0.173	[	0.0994	–	0.248	]
φ_B	Fiscal Rule - Debt	Normal(0.5,0.2)	0.224	[	0.189	–	0.245	]
ρ_z	AR(1) TFP growth shock	Beta(0.5,0.2)	0.366	[	0.213	–	0.517	]
ρ_g	AR(1) G shock	Beta(0.5,0.1)	0.936	[	0.909	–	0.961	]
$\rho_{\bar{\tau}}$	AR(1) Fin. shock Trend	Beta(0.5,0.2)	0.989	[	0.984	–	0.993	]
$\omega_{\tilde{\tau}}$	AR(1) Fin2 shock Cycle	Beta(0.5,0.2)	0.777	[	0.704	–	0.84	]
ρ_{σ_A}	AR(1) Beta shock	Beta(0.5,0.2)	0.922	[	0.877	–	0.947	]
ρ_β	AR(1) Beta shock	Beta(0.5,0.2)	0.508	[	0.358	–	0.645	]
ρ_p	AR(1) P Mark-up shock	Beta(0.5,0.2)	0.733	[	0.579	–	0.875	]
ρ_w	AR(1) W Mark-up shock	Beta(0.5,0.2)	0.203	[	0.0477	–	0.378	]
θ_p	MA(1) P shock	Beta(0.5,0.2)	0.248	[	0.0318	–	0.512	]
θ_w	MA(1) W shock	Beta(0.5,0.2)	0.165	[	0.0268	–	0.308	]
σ_z	Stdev TFP Growth Shock	InvGamma2(0.5,1)	0.602	[	0.526	–	0.685	]
σ_g	Stdev G Shock	InvGamma2(0.5,1)	0.159	[	0.137	–	0.182	]
σ_i	Stdev MP Shock	InvGamma2(0.1,1)	0.122	[	0.105	–	0.14	]
$\sigma_{\bar{\tau}}$	Stdev Fin. Shock Trend	InvGamma2(0.5,1)	0.134	[	0.101	–	0.17	]
$\sigma_{\tilde{\tau}}$	Stdev Fin. Shock Cycle	InvGamma2(0.5,1)	0.126	[	0.1245	–	0.1481	]
σ_{sg}	Stdev Dispersion Shock	InvGamma2(0.5,1)	0.0732	[	0.0505	–	0.0971	]
σ_β	Stdev Beta Shock	InvGamma2(0.5,1)	2.59	[	1.81	–	3.48	]
σ_p	Stdev P Mark-up Shock	InvGamma2(0.1,1)	0.331	[	0.262	–	0.397	]
σ_w	Stdev W Mark-up Shock	InvGamma2(0.1,1)	0.146	[	0.117	–	0.18	]
$\sigma_{ME_{sp}}$	Stdev ME Spread	InvGamma2(0.05,0.05)	0.0344	[	0.0101	–	0.0797	]
$\sigma_{ME_{fgs}}$	Stdev ME FGS	InvGamma2(0.05,0.05)	0.121	[	0.107	–	0.138	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis-Hasting algorithm. Acceptance rate 23%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.

Table 12: Posterior Variance Decomposition - Model with Technology Dispersion Shocks

	TFP	Gov't	MP	Fin.(persistent)	Fin.(transitory)	Preference	Price Mark up	Wage Mark up	Dispersion
$\Delta \log GDP_t$	**14.6**	**3.6**	**15.0**	**19.0**	**0.9**	**15.3**	**16.4**	**10.4**	**2.3**
	[8.6 - 22.7]	[2.5 - 5.0]	[9.2 - 19.8]	[14.3 - 25.3]	[0.3 - 1.6]	[11.0 - 19.9]	[10.6 - 21.7]	[4.9 - 15.6]	[0.0 - 5.2]
$\Delta \log I_t$	**9.2**	**0.1**	**20.3**	**26.1**	**1.4**	**2.1**	**22.5**	**12.7**	**2.9**
	[4.2 - 14.4]	[0.0 - 0.1]	[14.0 - 27.5]	[19.4 - 33.4]	[0.5 - 2.5]	[0.5 - 4.2]	[14.7 - 29.2]	[5.9 - 19.1]	[0.0 - 6.8]
$\Delta \log C_t$	**13.6**	**0.1**	**0.9**	**1.1**	**0.0**	**80.3**	**1.2**	**1.5**	**0.2**
	[6.8 - 21.1]	[0.0 - 0.2]	[0.3 - 2.0]	[0.3 - 2.2]	[0.0 - 0.1]	[70.2 - 88.6]	[0.4 - 2.1]	[0.5 - 2.7]	[0.0 - 0.6]
$\Delta \log w_t$	**9.4**	**0.0**	**0.4**	**0.5**	**0.0**	**0.9**	**13.5**	**74.2**	**0.1**
	[4.8 - 14.8]	[0.0 - 0.0]	[0.0 - 1.1]	[0.1 - 1.3]	[0.0 - 0.0]	[0.0 - 2.5]	[8.4 - 19.1]	[65.6 - 82.6]	[0.0 - 0.2]
π_t	**3.3**	**0.2**	**9.3**	**37.2**	**0.3**	**4.3**	**28.5**	**12.1**	**2.8**
	[1.5 - 6.0]	[0.1 - 0.3]	[5.3 - 14.3]	[28.0 - 44.3]	[0.0 - 0.6]	[2.1 - 7.4]	[19.6 - 37.8]	[6.9 - 17.6]	[0.0 - 6.8]
R_t^B	**0.8**	**0.2**	**40.2**	**35.5**	**0.4**	**4.5**	**8.9**	**4.4**	**3.0**
	[0.2 - 1.4]	[0.1 - 0.4]	[31.6 - 50.4]	[27.2 - 44.4]	[0.0 - 0.9]	[1.6 - 7.6]	[4.2 - 13.5]	[1.9 - 7.6]	[0.0 - 7.5]
$\log L_t$	**3.9**	**1.0**	**12.5**	**17.0**	**0.7**	**6.6**	**31.4**	**22.8**	**2.0**
	[2.2 - 6.1]	[0.7 - 1.5]	[7.6 - 18.9]	[10.9 - 23.3]	[0.2 - 1.3]	[3.9 - 9.5]	[20.1 - 41.4]	[11.4 - 35.0]	[0.0 - 4.6]
Sp_t	**2.5**	**0.1**	**5.2**	**11.3**	**37.5**	**1.0**	**23.4**	**4.0**	**12.6**
	[1.2 - 4.3]	[0.0 - 0.1]	[2.1 - 9.0]	[5.7 - 17.0]	[27.3 - 47.6]	[0.3 - 2.1]	[14.4 - 34.1]	[2.0 - 6.4]	[5.7 - 20.7]
FGS_t	**0.5**	**0.3**	**1.2**	**30.3**	**17.0**	**0.2**	**5.4**	**1.0**	**43.6**
	[0.3 - 0.8]	[0.2 - 0.4]	[0.6 - 2.0]	[21.6 - 39.1]	[11.0 - 24.4]	[0.0 - 0.3]	[3.0 - 7.9]	[0.6 - 1.6]	[32.6 - 54.0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Mode values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm. Acceptance rate 23%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.
Values are percentages. Rows may not sum up to 100% due to rounding error. Computed used parameter estimates in table 11.

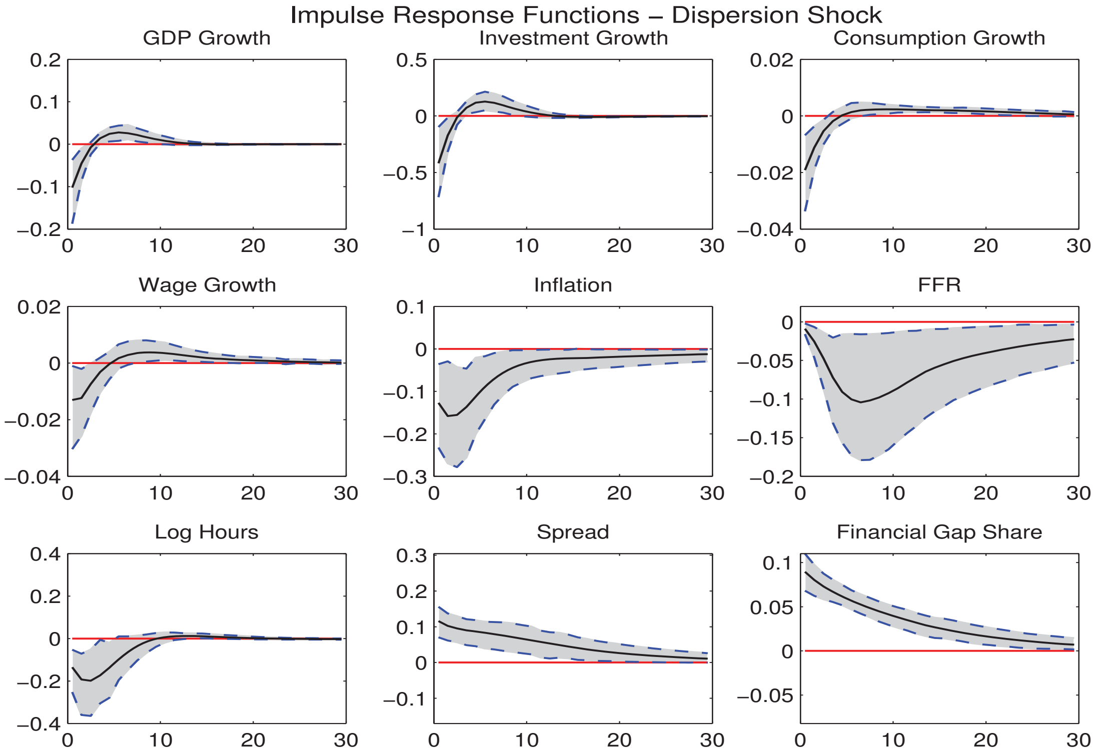

Figure 20: Impulse responses to a one standard deviation dispersion shock $\sigma_{A,t}$. The shaded areas represent 90 percent posterior credible sets around the posterior median.

K Robustness Estimates

K.1 Estimation on Alternative Financial Observables

Table 13 and 14 report parameter estimates and variance decomposition results for the model estimated on a financing gap share series that does not consider dividend payments as unavoidable commitments of corporations, as described in section 1.[37] If dividend payments are not considered to be an unavoidable commitment to shareholders, then the average degree of dependence of corporate firms on the financial system is lower. Accordingly, the average financing gap share in the sample drops to around 25%, compared to 35% in the baseline calculations in equation (2) and (4) (see table 2). The estimation on the financing gap measure that excludes dividends confirms the main result from the variance decomposition in table 4: financial intermediation shocks account for a large fraction of business cycle fluctuations in output and investment growth. For both variables the importance of financial shocks in explaining output growth fluctuations is moderately reduced with respect to the baseline. Under a more conservative definition of the financing gap share, corporate investment is less dependent on the financial system and the transmission of financial intermediation

[37] The estimation is performed using the FGS_{EXDIV} plotted in figure 1 as a blue dashed line, instead of the FGS black solid line in the baseline case. The relative parameter estimates are reported in table 13.

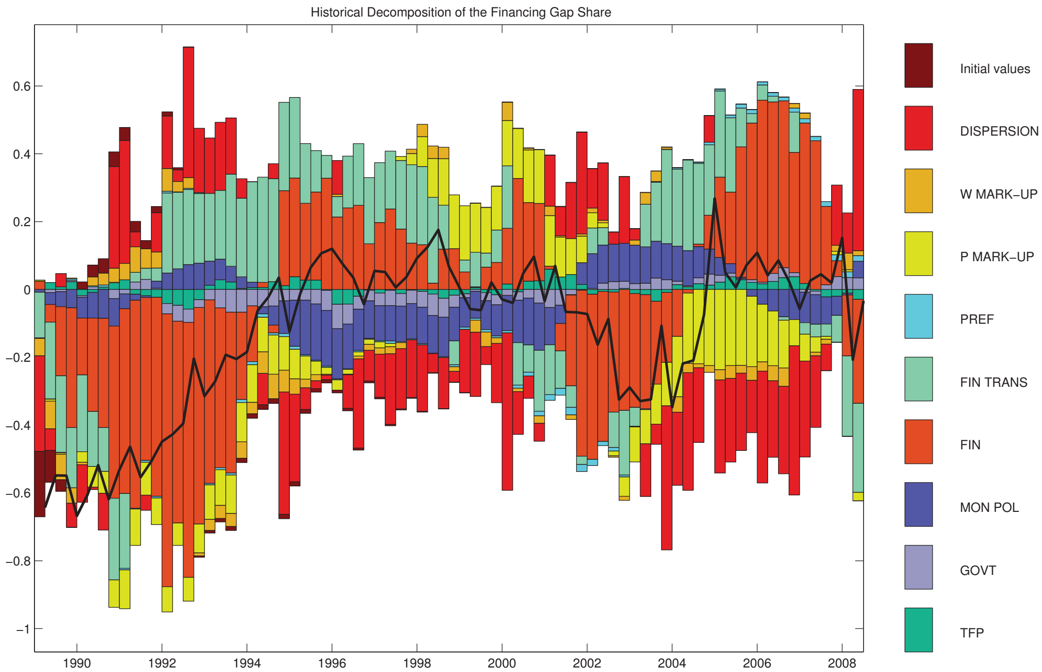

Figure 21: Historical shock decomposition for the cyclical variation of the Financing Gap Share.

shocks to real activity is partially dampened.

Tables 15 and 16 in the online appendix report the parameter estimates and variance decomposition results of the estimation of the model performed substituting the BBB corporate spread series with the EBP from Gilchrist and Zakrajsek (2012) in the set of observables.[38] Data on corporate yields and corporate spreads (like the BBB series used in the baseline estimation of the model) respond both to changes in the expected compensation for default losses on corporate debt as well as to the evolution of aggregate financial conditions. Gilchrist and Zakrajsek (2012) empirically separate the excess bond premium (EBP) from the default compensation using firm-level corporate yield data and show that the economy-wide EBP is related to measures of financial system distress. The variance decomposition results obtained by estimating the model on the EBP supports the main result from table 4: financial intermediation shocks account for 21% of business cycle fluctuations in output growth and 31% in investment growth. By construction the dynamics of the EBP do not account for one source of variation of corporate spreads, namely the time-variation in the compensation for expected default losses on corporate obligations. Nonetheless, the estimation of the model on the EBP shows a prominent role for financial intermediation shocks in explaining U.S. business

[38]The parameter estimates are reported in table 15.

cycle fluctuations.[39]

[39] As an additional robustness check and to verify the empirical results included in a previous version of this paper, I have also estimated the model on speculative grade B-rated corporate spreads instead of using the BBB spread series used in the baseline exercise and in the literature. Since lower-rated securities are subject to higher expected default losses, especially in downturns, the use of speculative grade corporate spreads exacerbates the mismatch between the data and the model, in which financing spreads move in response to financial intermediation disturbances and not in response to default risk. Variance decomposition results for the estimation on B-rated corporate bond spreads are in line with the other sets of estimates reported here. The full set of results is available upon request.

Baseline Model - FGS EX Dividends

Table 13: Calibrated Values, Priors and Posterior Estimates for the Model Parameters - Estimated with FGS EX Dividends

Parameter	Description	Prior	Mode	[	5%[2]		95%[2]	]
γ	SS Output Growth	Calibrated	0.5	[	–	–	–	]
$(\beta^{-1}-1)\times 100$	Discount Factor	Gamma(0.75,0.05)	0.0892	[	0.0283	–	0.155	]
δ	Capital Depreciation	Calibrated	0.025	[	–	–	–	]
ν	Inverse Frisch	Gamma(2,0.75)	1.7	[	0.792	–	2.92	]
h	Habit	Beta(0.5,0.2)	0.857	[	0.803	–	0.907	]
l_{ss}	Labor Supply	Calibrated	0	[	–	–	–	]
η	Labor Share	Beta(0.6,0.10)	0.774	[	0.763	–	0.784	]
λ_p	Price Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_p	Calvo Prices	Beta(0.75,0.15)	0.794	[	0.755	–	0.832	]
ι_p	Index Prices	Beta(0.50,0.15)	0.0907	[	0.0156	–	0.183	]
λ_w	Wage Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_w	Calvo Wages	Beta(0.75,0.15)	0.882	[	0.835	–	0.933	]
ι_w	Index Wages	Beta(0.50,0.15)	0.164	[	0.0627	–	0.275	]
μ_A	Mean Idiosyn. Technology	Calibrated	0	[	–	–	–	]
σ_A	Std. Idiosyn. Technology	Gamma(0.1,0.04)	0.00668	[	0.0061	–	0.00732	]
FGS_{ss}	FGS Steady State	Calibrated	0.715	[	0.632	–	0.797	]
θ	Collateral Constr.	Collateral Constr.	0	[	0	–	0	]
Bs_{ss}	Liquidity over GDP	Calibrated	0.02	[	–	–	–	]
gs_{ss}	Govt. Spend. over GDP	Calibrated	0.17	[	–	–	–	]
$\tau_{q_{ss}}\times 100$	SS Intermediation Cost	Gamma(2,0.4)	2.27	[	2.27	–	2.27	]
θ_I	IAC	Gamma(4,2)	0.901	[	0.649	–	1.18	]
π_{ss}	SS inflation	Normal(0.5,0.1)	0.386	[	0.275	–	0.492	]
ρ_i	Taylor Rule inertia	Beta(0.85,0.1)	0.864	[	0.837	–	0.892	]
ϕ_π	Taylor Rule inflation	Normal(0.7,0.05)	0.408	[	0.329	–	0.49	]
ϕ_{DY}	Taylor Rule GDP growth	Normal(0.125,0.1)	0.161	[	0.0812	–	0.246	]
φ_B	Fiscal Rule - Debt	Normal(0.5,0.2)	0.565	[	0.273	–	0.839	]
ρ_z	AR(1) TFP growth shock	Beta(0.5,0.2)	0.317	[	0.317	–	0.317	]
ρ_g	AR(1) G shock	Beta(0.5,0.2)	0.94	[	0.913	–	0.966	]
$\rho_{\bar{\tau}}$	AR(1) Fin. shock Pers.	Beta(0.5,0.2)	0.988	[	0.984	–	0.991	]
$\omega_{\tilde{\tau}}$	AR(1) Fin. shock Trans.	Beta(0.5,0.2)	0.737	[	0.666	–	0.803	]
ρ_β	AR(1) Beta shock	Beta(0.5,0.2)	0.527	[	0.373	–	0.666	]
ρ_p	AR(1) P Mark-up shock	Beta(0.5,0.2)	0.746	[	0.638	–	0.852	]
ρ_w	AR(1) W Mark-up shock	Beta(0.5,0.2)	0.221	[	0.0345	–	0.424	]
θ_p	MA(1) P shock	Beta(0.5,0.2)	0.353	[	0.0278	–	0.695	]
θ_w	MA(1) W shock	Beta(0.5,0.2)	0.192	[	0.0354	–	0.309	]
σ_z	Stdev TFP Growth Shock	InvGamma2(0.5,1)	0.585	[	0.513	–	0.662	]
σ_g	Stdev G Shock	InvGamma2(0.5,1)	0.16	[	0.138	–	0.182	]
σ_i	Stdev MP Shock	InvGamma2(0.1,1)	0.524	[	0.453	–	0.606	]
$\sigma_{\bar{\tau}}$	Stdev Fin. Shock Pers.	InvGamma2(0.5,1)	0.0758	[	0.0618	–	0.0896	]
$\sigma_{\tilde{\tau}}$	Stdev Fin. Shock Trans.	InvGamma2(0.5,1)	0.0726	[	0.0518	–	0.0959	]
σ_β	Stdev Beta Shock	InvGamma2(0.5,1)	2.73	[	1.84	–	3.62	]
σ_p	Stdev P Mark-up Shock	InvGamma2(0.1,1)	0.325	[	0.253	–	0.404	]
σ_w	Stdev W Mark-up Shock	InvGamma2(0.1,1)	0.103	[	0.0855	–	0.12	]
$\sigma_{ME_{sp}}$	Stdev ME Spread	InvGamma2(0.05,0.05)	0.0428	[	0.0124	–	0.0864	]
$\sigma_{ME_{fgs}}$	Stdev ME FGS	InvGamma2(0.05,0.05)	0.188	[	0.164	–	0.213	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis-Hasting algorithm.
Acceptance rate 25%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.

Table 14: Posterior Variance Decomposition - Sticky wages - FGS EX Dividends

	TFP	Gov't	MP	Fin.(pers.)	Fin.(trans.)	Preference	Price Mark up	Wage Mark up	ME FGS	ME Spread
$\Delta \log GDP_t$	**15.1**	**3.2**	**20.3**	**20.6**	**1.0**	**13.9**	**13.0**	**11.1**	**0.0**	**0.0**
	[9.7 - 19.8]	[2.1 - 4.3]	[15.0 - 25.9]	[16.2 - 25.5]	[0.4 - 1.6]	[9.9 - 18.1]	[8.5 - 16.8]	[6.0 - 17.1]	[0 - 0]	[0 - 0]
$\Delta \log I_t$	**10.5**	**0.1**	**26.7**	**27.1**	**1.4**	**1.4**	**17.6**	**13.3**	**0.0**	**0.0**
	[6.4 - 14.7]	[0.0 - 0.1]	[19.8 - 33.1]	[21.1 - 33.5]	[0.6 - 2.3]	[0.2 - 3.4]	[12.4 - 23.5]	[7.5 - 20.5]	[0 - 0]	[0 - 0]
$\Delta \log C_t$	**11.9**	**0.1**	**1.4**	**1.5**	**0.0**	**82.2**	**0.8**	**1.7**	**0.0**	**0.0**
	[7.1 - 16.9]	[0.0 - 0.3]	[0.5 - 2.6]	[0.6 - 2.8]	[0.0 - 0.1]	[74.9 - 89.2]	[0.4 - 1.4]	[0.6 - 2.9]	[0 - 0]	[0 - 0]
$\Delta \log w_t$	**6.7**	**0.0**	**0.4**	**0.4**	**0.0**	**0.5**	**11.0**	**80.3**	**0.0**	**0.0**
	[4.5 - 9.7]	[0.0 - 0.0]	[0.1 - 1.1]	[0.1 - 1.1]	[0.0 - 0.0]	[0.0 - 1.8]	[7.2 - 16.4]	[72.2 - 86.9]	[0 - 0]	[0 - 0]
π_t	**4.2**	**0.1**	**11.3**	**40.4**	**0.2**	**3.5**	**25.0**	**13.7**	**0.0**	**0.0**
	[1.8 - 6.7]	[0.0 - 0.2]	[6.5 - 16.5]	[34.3 - 46.5]	[0.0 - 0.4]	[1.5 - 6.2]	[17.3 - 33.7]	[9.3 - 19.0]	[0 - 0]	[0 - 0]
R_t^B	**0.9**	**0.1**	**49.4**	**34.7**	**0.3**	**3.3**	**6.3**	**4.1**	**0.0**	**0.0**
	[0.4 - 1.4]	[0.0 - 0.2]	[38.8 - 56.7]	[25.8 - 43.1]	[0.0 - 0.6]	[1.2 - 6.1]	[3.3 - 10.1]	[2.1 - 6.7]	[0 - 0]	[0 - 0]
$\log L_t$	**4.3**	**0.8**	**19.3**	**19.9**	**0.7**	**6.7**	**23.3**	**23.1**	**0.0**	**0.0**
	[2.3 - 6.1]	[0.5 - 1.1]	[12.9 - 25.7]	[13.3 - 26.2]	[0.2 - 1.3]	[4.0 - 9.7]	[16.3 - 32.4]	[12.8 - 35.5]	[0 - 0]	[0 - 0]
Sp_t	**2.3**	**0.3**	**7.4**	**15.2**	**48.8**	**0.6**	**18.6**	**3.6**	**0.0**	**0.9**
	[1.3 - 3.4]	[0.1 - 0.5]	[3.6 - 12.4]	[9.3 - 22.8]	[39.8 - 57.8]	[0.1 - 1.4]	[11.6 - 26.1]	[1.9 - 5.3]	[0 - 0]	[0.0 - 3.7]
$FGSEXDIV_t$	**1.8**	**0.4**	**5.2**	**27.3**	**13.4**	**0.4**	**15.1**	**3.7**	**31.4**	**0.0**
	[1.2 - 2.5]	[0.2 - 0.5]	[2.7 - 7.3]	[21.6 - 32.6]	[9.0 - 17.7]	[0.1 - 0.8]	[9.9 - 20.0]	[2.5 - 5.3]	[25.8 - 38.9]	[0 - 0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Mode values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm. Acceptance rate 25%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.
Values are percentages. Rows may not sum up to 100% due to rounding error. Computed used parameter estimates in table 13.

Baseline Model - Excess Bond Premium

Table 15: Calibrated Values, Priors and Posterior Estimates for the Model Parameters - Estimated with EBP

Parameter	Description	Prior	Mode	5%[2]	95%[2]
γ	SS Output Growth	Calibrated	0.5	–	–
$(\beta^{-1} - 1) \times 100$	Discount Factor	Gamma(0.75,0.05)	0.665	0.387	2.49
δ	Capital Depreciation	Calibrated	0.025	–	–
ν	Inverse Frisch	Gamma(2,0.75)	0.912	0.779	2.24
h	Habit	Beta(0.5,0.2)	0.804	0.762	0.905
l_{ss}	Labor Supply	Calibrated	0	–	–
η	Labor Share	Beta(0.6,0.10)	0.791	0.736	0.817
λ_p	Price Mark-up	Calibrated	0.15	–	–
ξ_p	Calvo Prices	Beta(0.75,0.15)	0.74	0.198	0.827
ι_p	Index Prices	Beta(0.50,0.15)	0.534	0.179	0.882
λ_w	Wage Mark-up	Calibrated	0.15	–	–
ξ_w	Calvo Wages	Beta(0.75,0.15)	0.791	0.39	0.893
ι_w	Index Wages	Beta(0.50,0.15)	0.692	0.363	4.15
μ_A	Mean Idiosyn. Technology	Calibrated	0	–	–
σ_A	Std. Idiosyn. Technology	Gamma(0.1,0.04)	0.0202	0.0136	0.856
FGS_{ss}	FGS Steady State	Calibrated	0.417	0.393	0.446
θ	Collateral Constr.	Collateral Constr.	0.612	0.178	0.757
Bs_{ss}	Liquidity over GDP	Calibrated	0.02	–	–
gs_{ss}	Govt. Spend. over GDP	Calibrated	0.17	–	–
$\tau_{q_{ss}} \times 100$	SS Intermediation Cost	Gamma(2,0.4)	3.67	0.497	5.07
θ_I	IAC	Gamma(4,2)	0.625	0.446	0.909
π_{ss}	SS inflation	Normal(0.5,0.1)	0.409	0.0208	0.661
ρ_i	Taylor Rule inertia	Beta(0.85,0.1)	0.796	0.421	0.858
ϕ_π	Taylor Rule inflation	Normal(0.7,0.05)	0.408	0.183	0.543
ϕ_{DY}	Taylor Rule GDP growth	Normal(0.125,0.1)	0.115	-0.0894	0.246
φ_B	Fiscal Rule - Debt	Normal(0.5,0.2)	0.0598	0.0317	0.736
ρ_z	AR(1) TFP growth shock	Beta(0.5,0.2)	0.345	0.187	0.496
ρ_g	AR(1) G shock	Beta(0.5,0.2)	0.945	0.91	0.979
$\rho_{\bar{\tau}}$	AR(1) Fin. shock Pers.	Beta(0.5,0.2)	0.984	0.977	0.989
$\omega_{\tilde{\tau}}$	AR(1) Fin. shock Trans.	Beta(0.5,0.2)	0.719	0.642	0.78
ρ_β	AR(1) Beta shock	Beta(0.5,0.2)	0.534	0.374	0.661
ρ_p	AR(1) P Mark-up shock	Beta(0.5,0.2)	0.791	0.621	0.902
ρ_w	AR(1) W Mark-up shock	Beta(0.5,0.2)	0.247	0.0801	0.484
θ_p	MA(1) P shock	Beta(0.5,0.2)	0.302	0.0829	0.662
θ_w	MA(1) W shock	Beta(0.5,0.2)	0.185	0.057	0.408
σ_z	Stdev TFP Growth Shock	InvGamma2(0.5,1)	0.584	0.512	0.66
σ_g	Stdev G Shock	InvGamma2(0.5,1)	0.154	0.135	0.179
σ_i	Stdev MP Shock	InvGamma2(0.1,1)	0.485	0.419	0.571
$\sigma_{\bar{\tau}}$	Stdev Fin. Shock Pers.	InvGamma2(0.5,1)	0.268	0.204	0.346
$\sigma_{\tilde{\tau}}$	Stdev Fin. Shock Trans.	InvGamma2(0.5,1)	0.0671	0.0482	0.0915
σ_β	Stdev Beta Shock	InvGamma2(0.5,1)	2.71	1.9	4.04
σ_p	Stdev P Mark-up Shock	InvGamma2(0.1,1)	0.321	0.265	0.396
σ_w	Stdev W Mark-up Shock	InvGamma2(0.1,1)	0.243	0.198	0.302
$\sigma_{ME_{sp}}$	Stdev ME Spread	InvGamma2(0.05,0.05)	0.035	0.0154	0.0884
$\sigma_{ME_{fgs}}$	Stdev ME FGS	InvGamma2(0.05,0.05)	0.117	0.0995	0.141

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 Posterior percentiles from 3 chains of 100,000 draws generated using a Random walk Metropolis-Hasting algorithm. Acceptance rate 17%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.

Table 16: Posterior Variance Decomposition - Sticky wages - Excess Bond Premium

	TFP	Gov't	MP	Fin.(pers.)	Fin.(trans.)	Preference	Price Mark up	Wage Mark up	ME FGS	ME Spread
$\Delta \log GDP_t$	**10.3**	**11.0**	**7.7**	**21.4**	**1.0**	**16.4**	**20.4**	**8.2**	**0.0**	**0.0**
	[5.7 - 14.9]	[7.4 - 15.0]	[5.5 - 10.3]	[13.8 - 31.9]	[0.5 - 1.6]	[7.6 - 26.7]	[8.4 - 36.7]	[3.0 - 13.6]	[0 - 0]	[0 - 0]
$\Delta \log I_t$	**5.6**	**3.7**	**11.2**	**31.1**	**1.6**	**3.1**	**29.5**	**10.4**	**0.0**	**0.0**
	[2.6 - 8.7]	[1.9 - 5.7]	[7.6 - 15.1]	[19.4 - 43.6]	[0.8 - 2.5]	[0.4 - 8.3]	[12.9 - 49.0]	[3.6 - 17.3]	[0 - 0]	[0 - 0]
$\Delta \log C_t$	**11.6**	**0.1**	**0.6**	**1.4**	**0.0**	**82.2**	**2.0**	**1.5**	**0.0**	**0.0**
	[6.5 - 18.0]	[0.0 - 0.2]	[0.3 - 0.9]	[0.6 - 2.5]	[0.0 - 0.0]	[74.5 - 88.7]	[0.3 - 5.0]	[0.7 - 2.7]	[0 - 0]	[0 - 0]
$\Delta \log w_t$	**8.3**	**0.1**	**0.4**	**0.9**	**0.0**	**1.7**	**25.4**	**61.2**	**0.0**	**0.0**
	[4.1 - 13.3]	[0.0 - 0.3]	[0.1 - 0.8]	[0.1 - 2.2]	[0.0 - 0.1]	[0.1 - 5.0]	[14.5 - 39.4]	[49.5 - 72.6]	[0 - 0]	[0 - 0]
π_t	**3.8**	**8.9**	**3.8**	**35.6**	**0.2**	**5.4**	**30.0**	**8.6**	**0.0**	**0.0**
	[1.6 - 6.4]	[4.0 - 12.6]	[1.5 - 6.1]	[20.9 - 50.6]	[0.0 - 0.4]	[1.2 - 11.3]	[13.3 - 51.3]	[3.9 - 14.0]	[0 - 0]	[0 - 0]
R_t^B	**0.8**	**10.7**	**20.2**	**43.0**	**0.3**	**7.2**	**11.0**	**3.2**	**0.0**	**0.0**
	[0.2 - 1.6]	[5.8 - 15.7]	[16.0 - 24.9]	[27.3 - 57.4]	[0.0 - 0.7]	[1.7 - 14.6]	[1.7 - 26.0]	[1.0 - 5.9]	[0 - 0]	[0 - 0]
$\log L_t$	**4.0**	**5.1**	**5.2**	**15.7**	**0.6**	**6.7**	**41.2**	**17.2**	**0.0**	**0.0**
	[2.1 - 6.4]	[2.9 - 7.7]	[2.9 - 7.7]	[7.9 - 25.5]	[0.2 - 1.0]	[1.5 - 11.8]	[18.7 - 61.7]	[5.7 - 31.8]	[0 - 0]	[0 - 0]
EBP_t	**1.2**	**1.7**	**1.8**	**17.4**	**50.3**	**1.1**	**22.7**	**2.2**	**0.0**	**0.1**
	[0.5 - 2.0]	[0.8 - 2.6]	[0.8 - 2.9]	[10.7 - 24.1]	[37.5 - 60.4]	[0.1 - 3.0]	[9.0 - 42.6]	[0.7 - 3.8]	[0 - 0]	[0.1 - 0.1]
FGS_t	**0.8**	**2.1**	**0.5**	**35.7**	**13.2**	**0.2**	**10.3**	**1.2**	**34.6**	**0.0**
	[0.5 - 1.0]	[1.2 - 3.0]	[0.3 - 0.7]	[28.9 - 43.2]	[10.5 - 16.2]	[0.0 - 0.4]	[3.6 - 20.0]	[0.6 - 2.0]	[27.2 - 41.2]	[0 - 0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Mode values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm. Acceptance rate 17%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.
Values are percentages. Rows may not sum up to 100% due to rounding error. Computed used parameter estimates in table 15.

Table 17: Comparison of Selected Statistics - Model with Sticky Wages vs. Model with Flexible Wages

Statistics	Data	Flexible Wages	Sticky Wages
Marginal Likelihood	$--$	-454	-420
StDev Real Wage Growth	1.24%	2.4%	0.94%
StDev Hours Worked	4.98%	2.9%	3.52%

Standard deviations of selected observable variables. Standard deviations are expressed in terms of the volatility of GDP growth in the data and in the model. Source: Haver Analytics. Sample period: 1989:Q1 - 2008:Q2. Moments computed over 1,000 randomly-selected accepted draws for each model specification. For each draw, I simulate 1 samples of length equal to the sample period in the data (178 periods, burning the first 100 observations). The table reports the median moments for the 1,000 parameter draws. Marginal Likelihood computed by means of a Laplace approximation.

K.2 Estimation under Assumption of Flexible Wages

Table 18: Calibrated Values, Priors and Posterior Estimates for the Model Parameters

Parameter	Description	Prior	Mode	[	5%[2]		95%[2]	]
γ	SS Output Growth	Calibrated	0.5	[	–	–	–	]
$(\beta^{-1}-1)\times 100$	Discount Factor	Gamma(0.75,0.05)	0.288	[	0.167	–	0.413	]
δ	Capital Depreciation	Calibrated	0.025	[	–	–	–	]
ν	Inverse Frisch	Gamma(2,0.75)	1.43	[	0.897	–	2.03	]
h	Habit	Beta(0.5,0.2)	0.778	[	0.694	–	0.855	]
l_{ss}	Labor Supply	Calibrated	0	[	–	–	–	]
η	Labor Share	Beta(0.6,0.10)	0.769	[	0.754	–	0.784	]
λ_p	Price Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_p	Calvo Prices	Beta(0.75,0.15)	0.726	[	0.668	–	0.783	]
ι_p	Index Prices	Beta(0.50,0.15)	0.0792	[	0.0188	–	0.147	]
λ_w	Wage Mark-up	Calibrated	0.15	[	–	–	–	]
μ_A	Mean Idiosyn. Technology	Calibrated	0	[	–	–	–	]
σ_A	Std. Idiosyn. Technology	Gamma(0.1,0.04)	0.00943	[	0.00825	–	0.0107	]
FGS_{ss}	FGS Steady State	Calibrated	0.35	[	–	–	–	]
θ	Collateral Constr.	Collateral Constr.	0.702	[	0.616	–	0.79	]
Bs_{ss}	Liquidity over GDP	Calibrated	0.02	[	–	–	–	]
gs_{ss}	Govt. Spend. over GDP	Calibrated	0.17	[	–	–	–	]
$\tau_{q_{ss}}\times 100$	SS Intermediation Cost	Gamma(2,0.4)	2.63	[	2.27	–	3.04	]
θ_I	IAC	Gamma(4,2)	0.385	[	0.269	–	0.512	]
π_{ss}	SS inflation	Normal(0.5,0.1)	0.396	[	0.285	–	0.514	]
ρ_i	Taylor Rule inertia	Beta(0.85,0.1)	0.796	[	0.752	–	0.837	]
ϕ_π	Taylor Rule inflation	Normal(0.7,0.05)	0.424	[	0.346	–	0.511	]
ϕ_{DY}	Taylor Rule GDP growth	Normal(0.125,0.1)	0.158	[	0.0542	–	0.253	]
φ_B	Fiscal Rule - Debt	Normal(0.5,0.2)	0.55	[	0.277	–	0.883	]
ρ_z	AR(1) TFP growth shock	Beta(0.5,0.2)	0.181	[	0.0761	–	0.285	]
ρ_g	AR(1) G shock	Beta(0.5,0.2)	0.946	[	0.918	–	0.972	]
$\rho_{\bar{\tau}}$	AR(1) Fin. shock Pers.	Beta(0.5,0.2)	0.984	[	0.978	–	0.988	]
$\omega_{\tilde{\tau}}$	AR(1) Fin. shock Trans.	Beta(0.5,0.2)	0.726	[	0.665	–	0.79	]
ρ_β	AR(1) Beta shock	Beta(0.5,0.2)	0.602	[	0.468	–	0.728	]
ρ_p	AR(1) P Mark-up shock	Beta(0.5,0.2)	0.77	[	0.668	–	0.87	]
ρ_w	AR(1) W Mark-up shock	Beta(0.5,0.2)	0.94	[	0.876	–	1	]
θ_p	MA(1) P shock	Beta(0.5,0.2)	0.2	[	0.0222	–	0.416	]
θ_w	MA(1) W shock	Beta(0.5,0.2)	0.0781	[	0.0161	–	0.146	]
σ_z	Stdev TFP Growth Shock	InvGamma2(0.5,1)	0.594	[	0.514	–	0.675	]
σ_g	Stdev G Shock	InvGamma2(0.5,1)	0.157	[	0.136	–	0.181	]
σ_i	Stdev MP Shock	InvGamma2(0.1,1)	0.558	[	0.466	–	0.657	]
$\sigma_{\bar{\tau}}$	Stdev Fin. Shock Pers.	InvGamma2(0.5,1)	0.0871	[	0.0713	–	0.105	]
$\sigma_{\tilde{\tau}}$	Stdev Fin. Shock Trans.	InvGamma2(0.5,1)	0.124	[	0.084	–	0.166	]
σ_β	Stdev Beta Shock	InvGamma2(0.5,1)	1.87	[	1.27	–	2.52	]
σ_p	Stdev P Mark-up Shock	InvGamma2(0.1,1)	1.53	[	1.24	–	1.86	]
σ_w	Stdev W Mark-up Shock	InvGamma2(0.1,1)	0.121	[	0.102	–	0.14	]
$\sigma_{ME_{sp}}$	Stdev ME Spread	InvGamma2(0.05,0.05)	0.0324	[	0.0113	–	0.0603	]
$\sigma_{ME_{fgs}}$	Stdev ME FGS	InvGamma2(0.05,0.05)	0.166	[	0.142	–	0.19	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 N stands for Normal, B Beta, Γ Gamma and Inv. Γ Inverse-Gamma1 distribution.
2 Posterior percentiles from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm.
Acceptance rate 19%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.

Table 19: Baseline Model with Flexible Wages: Posterior Variance Decomposition

	TFP	Gov't	MP	Fin.(pers.)	Fin.(trans.)	Preference	Price Mark up	Wage Mark up	ME FGS	ME Spread
$\Delta \log GDP_t$	**22.1**	**3.7**	**13.0**	**10.7**	**1.6**	**14.2**	**14.1**	**18.9**	**0.0**	**0.0**
	[13.8 - 30.5]	[2.4 - 5.0]	[7.9 - 18.8]	[5.9 - 14.9]	[0.8 - 2.4]	[9.3 - 19.3]	[9.6 - 19.0]	[11.3 - 26.3]	[0 - 0]	[0 - 0]
$\Delta \log I_t$	**14.8**	**0.4**	**18.6**	**15.4**	**2.5**	**7.1**	**21.2**	**18.5**	**0.0**	**0.0**
	[8.1 - 21.1]	[0.1 - 0.7]	[12.6 - 26.6]	[9.3 - 21.1]	[1.4 - 3.7]	[2.5 - 11.6]	[14.7 - 27.9]	[12.3 - 25.4]	[0 - 0]	[0 - 0]
$\Delta \log C_t$	**11.6**	**0.3**	**0.4**	**0.3**	**0.0**	**81.6**	**0.4**	**3.8**	**0.0**	**0.0**
	[6.3 - 17.5]	[0.1 - 0.6]	[0.0 - 0.9]	[0.0 - 0.7]	[0.0 - 0.0]	[74.5 - 90.3]	[0.1 - 0.8]	[0.8 - 9.4]	[0 - 0]	[0 - 0]
$\Delta \log w_t$	**2.3**	**0.7**	**28.9**	**21.7**	**2.0**	**3.2**	**11.4**	**27.5**	**0.0**	**0.0**
	[1.2 - 4.4]	[0.1 - 1.4]	[20.7 - 36.8]	[17.2 - 27.1]	[1.0 - 3.3]	[1.2 - 5.7]	[7.0 - 16.8]	[15.5 - 39.6]	[0 - 0]	[0 - 0]
π_t	**1.9**	**0.4**	**25.8**	**47.4**	**1.6**	**5.5**	**8.5**	**8.1**	**0.0**	**0.0**
	[0.7 - 3.4]	[0.1 - 0.7]	[17.7 - 34.1]	[40.2 - 53.6]	[0.6 - 2.8]	[3.4 - 8.3]	[3.8 - 13.6]	[2.7 - 12.4]	[0 - 0]	[0 - 0]
R_t^B	**1.0**	**0.2**	**41.8**	**47.2**	**1.4**	**5.5**	**0.9**	**1.0**	**0.0**	**0.0**
	[0.5 - 1.7]	[0.1 - 0.4]	[33.2 - 51.9]	[38.1 - 55.8]	[0.5 - 2.6]	[3.4 - 8.1]	[0.1 - 2.0]	[0.4 - 1.9]	[0 - 0]	[0 - 0]
$\log L_t$	**3.9**	**1.4**	**5.8**	**4.9**	**0.7**	**7.4**	**26.6**	**48.4**	**0.0**	**0.0**
	[2.2 - 5.8]	[0.9 - 1.9]	[3.0 - 9.3]	[2.4 - 7.7]	[0.3 - 1.2]	[4.5 - 10.4]	[17.3 - 37.9]	[32.4 - 61.6]	[0 - 0]	[0 - 0]
Sp_t	**0.7**	**0.1**	**1.5**	**26.7**	**59.4**	**0.8**	**8.1**	**1.1**	**0.0**	**0.5**
	[0.4 - 1.1]	[0.0 - 0.2]	[0.4 - 2.9]	[20.0 - 33.6]	[51.1 - 66.9]	[0.4 - 1.3]	[3.3 - 13.8]	[0.5 - 1.7]	[0 - 0]	[0.0 - 1.8]
FGS_t	**0.5**	**0.2**	**4.0**	**25.2**	**19.0**	**0.5**	**9.5**	**1.5**	**39.0**	**0.0**
	[0.2 - 0.7]	[0.1 - 0.3]	[2.1 - 6.2]	[20.5 - 31.0]	[13.6 - 24.5]	[0.3 - 0.9]	[5.7 - 14.0]	[0.6 - 2.5]	[30.1 - 47.3]	[0 - 0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Mode values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm. Acceptance rate 19%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.
Values are percentages. Rows may not sum up to 100% due to rounding error. Computed used parameter estimates in table 18.

K.3 Estimation on Sample Period that ends in 2012:Q4

Table 20: Calibrated Values, Priors and Posterior Estimates for the Model Parameters

Parameter	Description	Prior	Mode	[	5%[2]		95%[2]	]
γ	SS Output Growth	Calibrated	0.5	[	–	–	–	]
$(\beta^{-1}-1)\times 100$	Discount Factor	Gamma(0.75,0.05)	0.237	[	0.0699	–	0.353	]
δ	Capital Depreciation	Calibrated	0.025	[	–	–	–	]
ν	Inverse Frisch	Gamma(2,0.75)	1.52	[	0.583	–	2.64	]
h	Habit	Beta(0.5,0.2)	0.926	[	0.901	–	0.944	]
l_{ss}	Labor Supply	Calibrated	0	[	–	–	–	]
η	Labor Share	Beta(0.6,0.10)	0.804	[	0.789	–	0.821	]
λ_p	Price Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_p	Calvo Prices	Beta(0.75,0.15)	0.878	[	0.836	–	0.923	]
ι_p	Index Prices	Beta(0.50,0.15)	0.195	[	0.0796	–	0.387	]
λ_w	Wage Mark-up	Calibrated	0.15	[	–	–	–	]
ξ_w	Calvo Wages	Beta(0.75,0.15)	0.989	[	0.986	–	0.993	]
ι_w	Index Wages	Beta(0.50,0.15)	0.172	[	0.0679	–	0.251	]
μ_A	Mean Idiosyn. Technology	Calibrated	0	[	–	–	–	]
σ_A	Std. Idiosyn. Technology	Gamma(0.1,0.04)	0.0269	[	0.0235	–	0.0358	]
FGS_{ss}	FGS Steady State	Calibrated	0.35	[	–	–	–	]
θ	Collateral Constr.	Collateral Constr.	0.65	[	0.514	–	0.696	]
Bs_{ss}	Liquidity over GDP	Calibrated	0.02	[	–	–	–	]
gs_{ss}	Govt. Spend. over GDP	Calibrated	0.17	[	–	–	–	]
$\tau_{q_{ss}}\times 100$	SS Intermediation Cost	Gamma(2,0.4)	3.19	[	2.4	–	3.65	]
θ_I	IAC	Gamma(4,2)	2.53	[	1.69	–	3.27	]
π_{ss}	SS inflation	Normal(0.5,0.1)	0.354	[	0.259	–	0.528	]
ρ_i	Taylor Rule inertia	Beta(0.85,0.1)	0.919	[	0.902	–	0.941	]
ϕ_π	Taylor Rule inflation	Normal(0.7,0.05)	0.511	[	0.46	–	0.61	]
ϕ_{DY}	Taylor Rule GDP growth	Normal(0.125,0.1)	0.119	[	0.0162	–	0.18	]
φ_B	Fiscal Rule - Debt	Normal(0.5,0.2)	0.244	[	0.176	–	0.252	]
ρ_z	AR(1) TFP growth shock	Beta(0.5,0.2)	0.439	[	0.319	–	0.597	]
ρ_g	AR(1) G shock	Beta(0.5,0.2)	0.941	[	0.919	–	0.965	]
$\rho_{\bar{\tau}}$	AR(1) Fin. shock Pers.	Beta(0.5,0.2)	0.994	[	0.992	–	0.996	]
$\omega_{\tilde{\tau}}$	AR(1) Fin. shock Trans.	Beta(0.5,0.2)	0.76	[	0.672	–	0.826	]
ρ_β	AR(1) Beta shock	Beta(0.5,0.2)	0.454	[	0.303	–	0.566	]
ρ_p	AR(1) P Mark-up shock	Beta(0.5,0.2)	0.981	[	0.96	–	0.99	]
ρ_w	AR(1) W Mark-up shock	Beta(0.5,0.2)	0.0651	[	0.0137	–	0.147	]
θ_p	MA(1) P shock	Beta(0.5,0.2)	0.119	[	0.0501	–	0.646	]
θ_w	MA(1) W shock	Beta(0.5,0.2)	0.102	[	0.0119	–	0.193	]
σ_z	Stdev TFP Growth Shock	InvGamma2(0.5,1)	0.669	[	0.588	–	0.749	]
σ_g	Stdev G Shock	InvGamma2(0.5,1)	0.176	[	0.154	–	0.199	]
σ_i	Stdev MP Shock	InvGamma2(0.1,1)	0.11	[	0.0986	–	0.126	]
$\sigma_{\bar{\tau}}$	Stdev Fin. Shock Pers.	InvGamma2(0.5,1)	0.229	[	0.198	–	0.308	]
$\sigma_{\tilde{\tau}}$	Stdev Fin. Shock Trans.	InvGamma2(0.5,1)	0.0268	[	0.0156	–	0.0396	]
σ_β	Stdev Beta Shock	InvGamma2(0.5,1)	5.87	[	4.29	–	7.27	]
σ_p	Stdev P Mark-up Shock	InvGamma2(0.1,1)	0.316	[	0.261	–	0.356	]
σ_w	Stdev W Mark-up Shock	InvGamma2(0.1,1)	0.191	[	0.157	–	0.23	]
$\sigma_{ME_{sp}}$	Stdev ME Spread	InvGamma2(0.05,0.05)	0.0203	[	0.0115	–	0.0693	]
$\sigma_{ME_{fgs}}$	Stdev ME FGS	InvGamma2(0.05,0.05)	0.142	[	0.119	–	0.153	]

Standard deviations of the shocks are scaled by 100 for the estimation with respect to the model.
1 N stands for Normal, B Beta, Γ Gamma and Inv. Γ Inverse-Gamma1 distribution.
2 Posterior percentiles from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm.
Acceptance rate 24%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.

Table 21: Baseline Model with Sticky Wages: Posterior Variance Decomposition

	TFP	Gov't	MP	Fin.(pers.)	Fin.(trans.)	Preference	Price Mark up	Wage Mark up	ME FGS	ME Spread
$\Delta \log GDP_t$	**10.9**	**2.8**	**10.3**	**39.7**	**0.2**	**14.9**	**16.4**	**2.9**	**0.0**	**0.0**
	[5.4 - 18.0]	[1.9 - 3.8]	[6.2 - 14.2]	[29.3 - 50.2]	[0.0 - 0.4]	[10.8 - 19.6]	[7.6 - 24.6]	[1.0 - 5.3]	[0 - 0]	[0 - 0]
$\Delta \log I_t$	**6.9**	**0.0**	**14.3**	**45.7**	**0.4**	**0.2**	**28.3**	**2.8**	**0.0**	**0.0**
	[2.8 - 11.7]	[0.0 - 0.0]	[8.7 - 19.2]	[35.1 - 58.2]	[0.1 - 0.8]	[0.1 - 0.4]	[18.0 - 41.9]	[0.7 - 5.2]	[0 - 0]	[0 - 0]
$\Delta \log C_t$	**11.9**	**0.0**	**2.7**	**18.2**	**0.0**	**61.4**	**1.4**	**1.9**	**0.0**	**0.0**
	[5.8 - 20.4]	[0.0 - 0.0]	[1.0 - 4.7]	[10.1 - 27.2]	[0.0 - 0.0]	[50.2 - 73.8]	[0.0 - 3.4]	[0.7 - 3.3]	[0 - 0]	[0 - 0]
$\Delta \log w_t$	**6.4**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**21.8**	**71.2**	**0.0**	**0.0**
	[2.9 - 10.6]	[0.0 - 0.0]	[0.0 - 0.1]	[0.0 - 0.6]	[0.0 - 0.0]	[0.0 - 0.1]	[12.0 - 30.6]	[61.8 - 81.8]	[0 - 0]	[0 - 0]
π_t	**8.4**	**0.0**	**0.3**	**14.1**	**0.0**	**0.2**	**68.5**	**7.6**	**0.0**	**0.0**
	[3.7 - 13.4]	[0.0 - 0.0]	[0.0 - 0.6]	[8.3 - 19.1]	[0.0 - 0.0]	[0.0 - 0.4]	[56.5 - 80.5]	[3.1 - 13.1]	[0 - 0]	[0 - 0]
R_t^B	**3.7**	**0.0**	**42.1**	**12.2**	**0.0**	**0.3**	**36.6**	**3.9**	**0.0**	**0.0**
	[1.3 - 6.1]	[0.0 - 0.0]	[26.5 - 54.5]	[6.0 - 18.6]	[0.0 - 0.0]	[0.0 - 0.8]	[23.3 - 49.7]	[1.5 - 6.7]	[0 - 0]	[0 - 0]
$\log L_t$	**9.4**	**0.7**	**10.8**	**41.0**	**0.2**	**7.5**	**24.4**	**4.1**	**0.0**	**0.0**
	[6.3 - 13.3]	[0.5 - 0.9]	[6.3 - 15.1]	[30.0 - 52.8]	[0.0 - 0.4]	[4.9 - 11.3]	[12.4 - 35.9]	[1.4 - 7.7]	[0 - 0]	[0 - 0]
$Spread_t$	**3.2**	**0.0**	**6.2**	**8.7**	**45.9**	**0.1**	**31.6**	**1.9**	**0.0**	**0.3**
	[1.5 - 5.2]	[0.0 - 0.1]	[2.8 - 10.1]	[3.2 - 17.0]	[32.1 - 59.3]	[0.0 - 0.2]	[16.2 - 47.0]	[0.9 - 2.9]	[0 - 0]	[0.0 - 1.2]
FGS_t	**1.0**	**0.1**	**0.7**	**21.3**	**4.3**	**0.0**	**4.9**	**1.1**	**65.9**	**0.0**
	[0.5 - 1.6]	[0.1 - 0.2]	[0.4 - 1.1]	[16.3 - 27.2]	[2.4 - 6.6]	[0.0 - 0.0]	[2.2 - 7.4]	[0.6 - 1.7]	[59.0 - 73.1]	[0 - 0]

Variance Decomposition of the observables, periodic component with cycles between 6 and 32 quarters. Mode values and 90% confidence intervals reported. Posterior percentiles obtained from 3 chains of 100,000 draws generated using a Random Walk Metropolis algorithm. Acceptance rate 24%. Burning period: initial 20,000 draws. Statistics computed over 1,000 randomly sampled accepted draws.
Values are percentages. Rows may not sum up to 100% due to rounding error. Computed used parameter estimates in table 20.

Impulse Responses to Standard Shocks

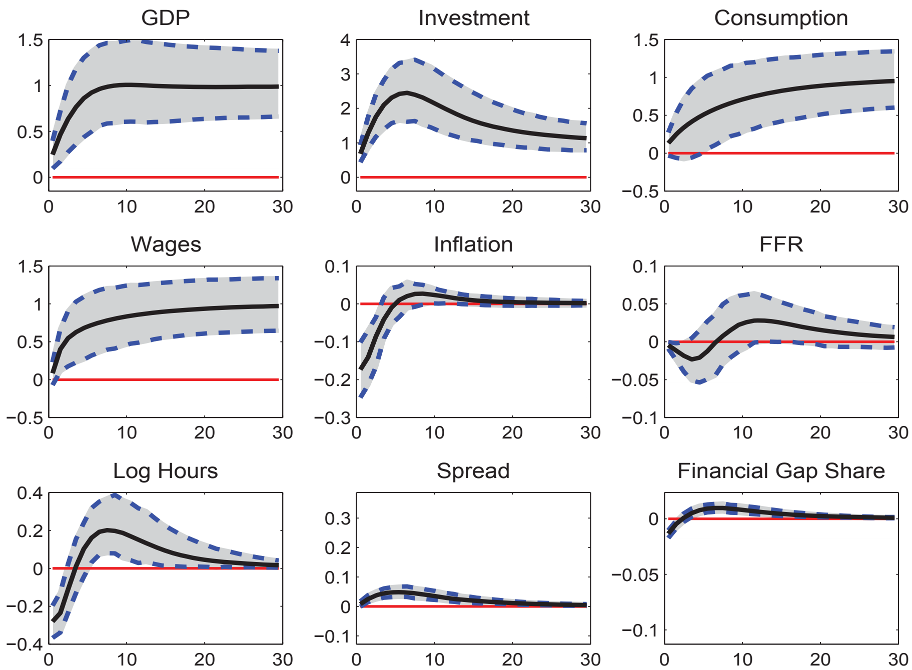

Figure 22: Impulse responses to a one standard deviation TFP shock. The shaded areas represent 90 percent posterior credible sets around the posterior median.

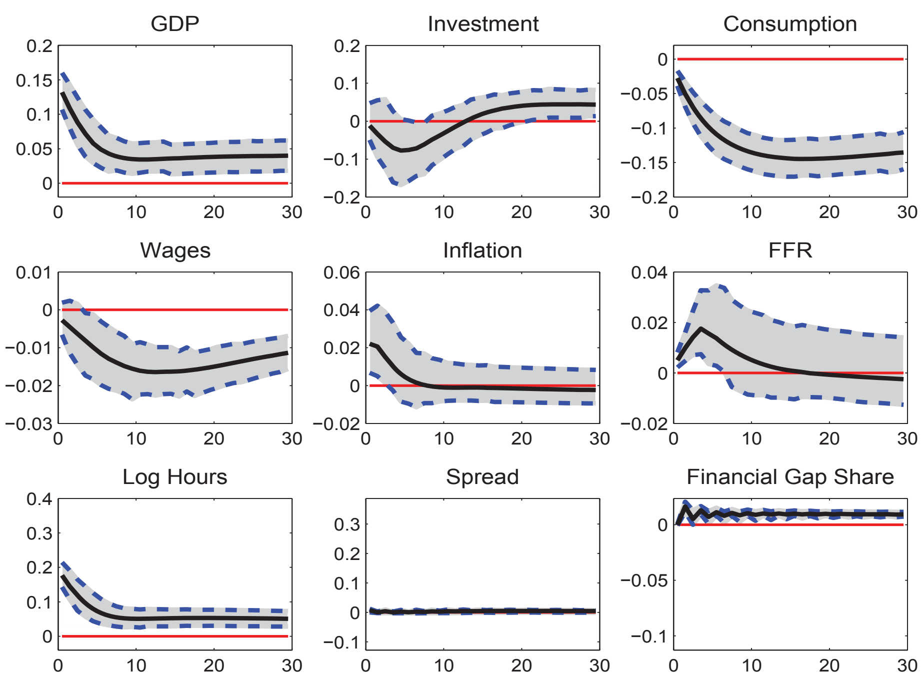

Figure 23: Impulse responses to a one standard deviation government spending shock. The shaded areas represent 90 percent posterior credible sets around the posterior median.

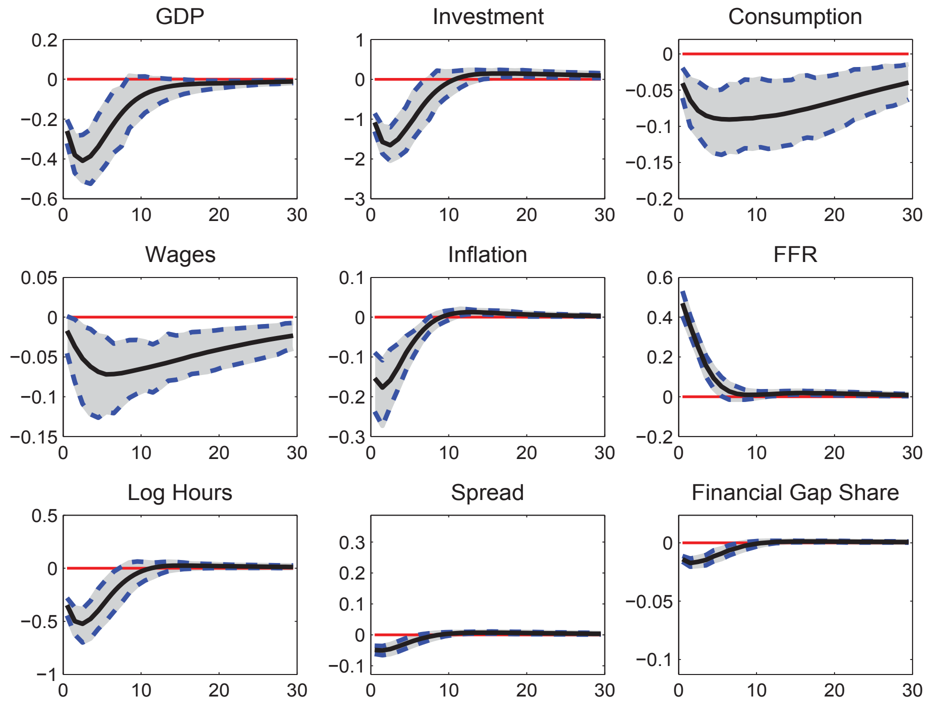

Figure 24: Impulse responses to a one standard deviation monetary policy shock. The shaded areas represent 90 percent posterior credible sets around the posterior median.

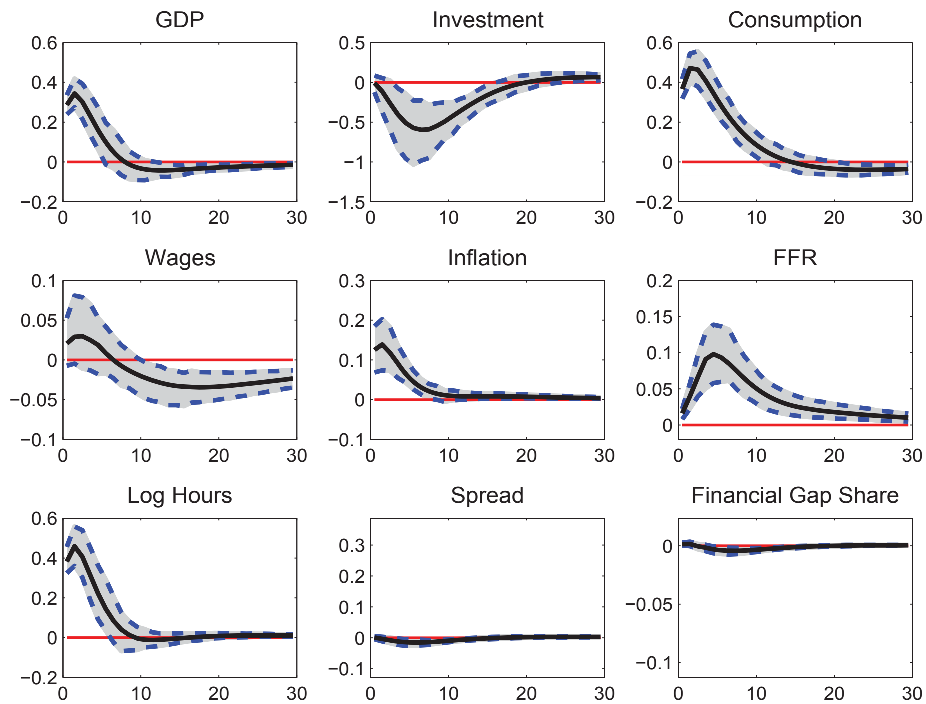

Figure 25: Impulse responses to a one standard deviation time preference shock. The shaded areas represent 90 percent posterior credible sets around the posterior median.

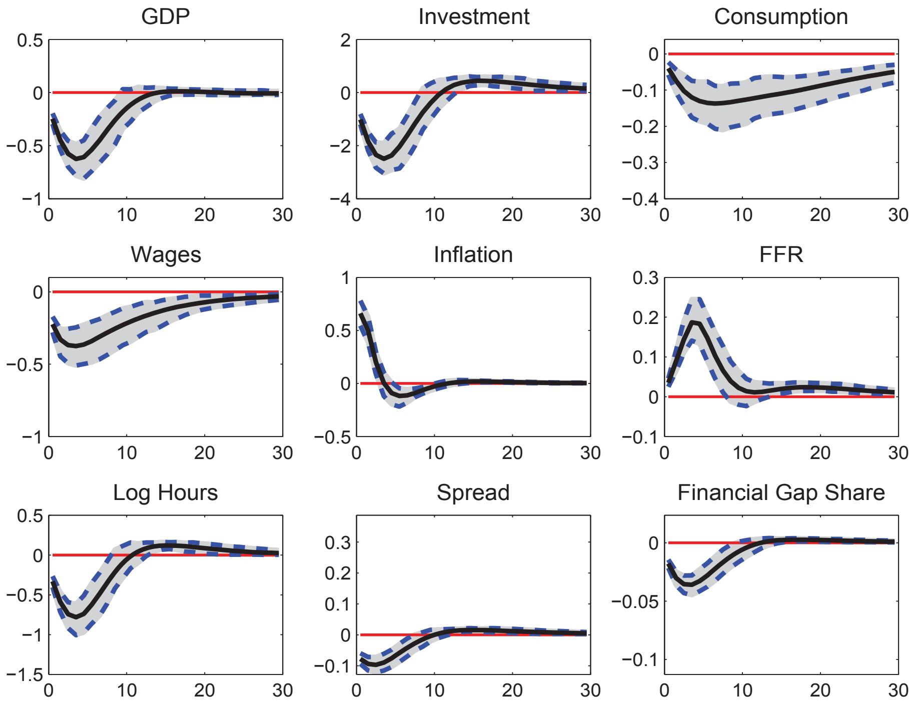

Figure 26: Impulse responses to a one standard deviation price mark-up shock. The shaded areas represent 90 percent posterior credible sets around the posterior median.

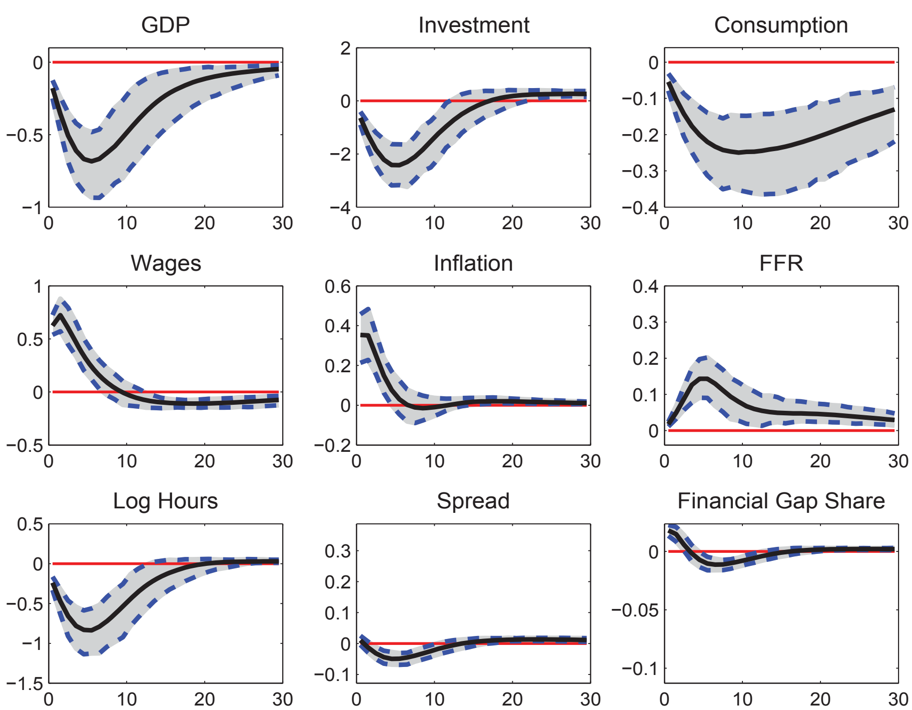

Figure 27: Impulse responses to a one standard deviation wage mark-up shock. The shaded areas represent 90 percent posterior credible sets around the posterior median.

Additional Figures

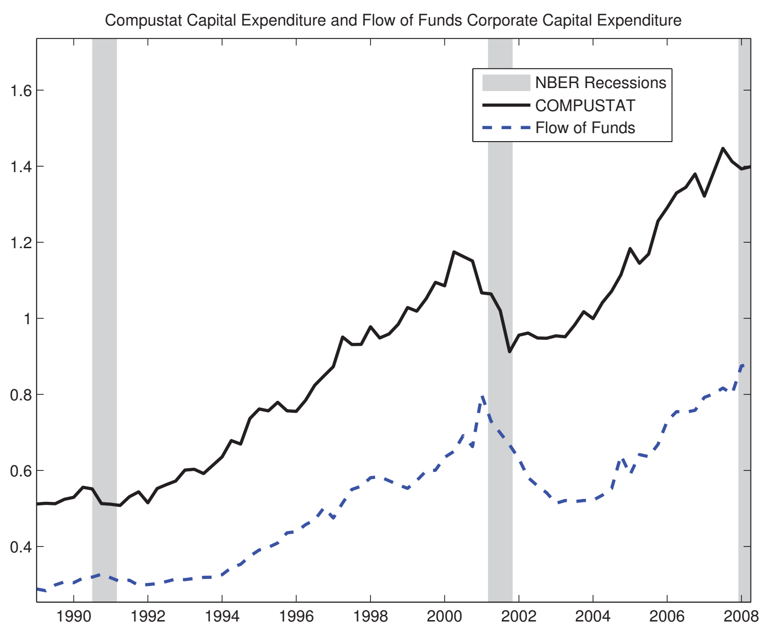

Figure 28: Comparison of capital expenditure of Compustat Firms (blue dashed line) and Non-financial Corporate Sector capital expenditure from the Flow of Funds (black solid line), annualized and seasonally adjusted, in billion of dollars. Sources: Compustat and Flow of Funds Table F.102. Sample period 1989:Q1 - 2012:Q4.

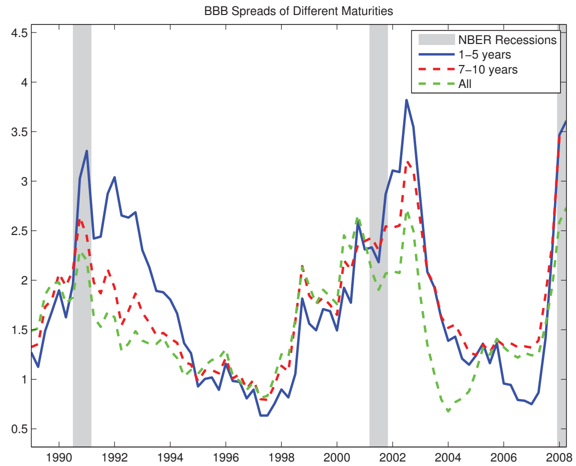

Figure 29: BBB corporate spreads - selected maturities.

Figure 30: The figure depicts BBB corporate spreads. Selected maturities: 1-5 years, 7-10 years and all maturities. Expressed in annual percentage points. Sample period: 1989:Q1 - 2008:Q2. Source: Corporate Yields from Merryll Lynch Master. Nominal Treasury Yields of 2- 7- and 10- years are used as from FRB H.15 tables

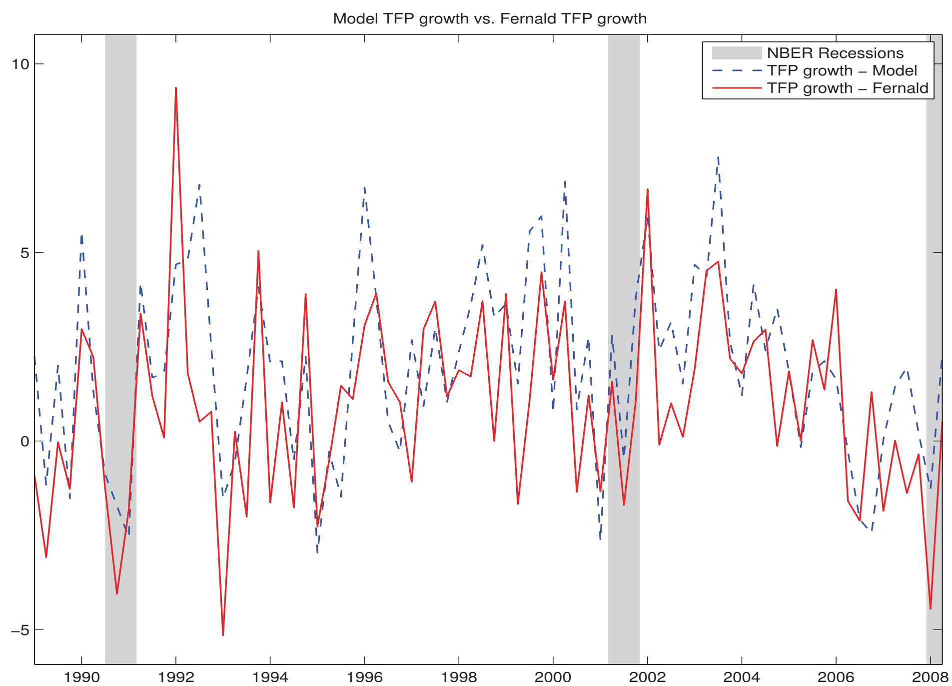

Figure 31: TFP growth estimates. Comparison between model-implied series and Fernald (2012) series, not adjusted for capital utilization.

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