Monetary Surprises, Debt Structure and Credit Misallocation

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1 Abstract

How does firm dynamically adjust its capital and debt structure in response to interest rate risk? I document a new fact that, at the aggregate level, a tightening monetary policy is associated with a rise in bank debt and a decline in market debt, which is not driven by cyclicality. Using micro-data, I find that financially unconstrained firms substitute loans for corporate bonds while financially constrained firms have a higher probability of issuing new equity. I develop a dynamic, heterogeneous firm model to quantitatively explain these patterns. Loan (bond) is modeled as risk-free (defaultable) debt. Firms trade-off higher intermediation cost of loan against default risk of bond for the optimal debt structure. An unanticipated interest rate hike raises default risk (cost of market debt). Firms with default risk and unbinding collateral constraint substitute loan for bond and therefore credit is reallocated from constrained firms to unconstrained firms. This generates credit misallocation and it raises the dispersion of marginal product of capital. The economic mechanism emphasizes that the firm's preserved debt financing flexibility is an important determinant of firms' adjustment in response to interest rate risk. The model solutions quantitatively match the data.

Measurement of Monetary Surprises

1. Measured as the surprise component of changes in the current month's federal funds futures rate in narrow windows around FOMC announcement.

$$\epsilon_t^m = \tau(t) \times (ffr_{t+\Delta_+} - ffr_{t+\Delta_-})$$

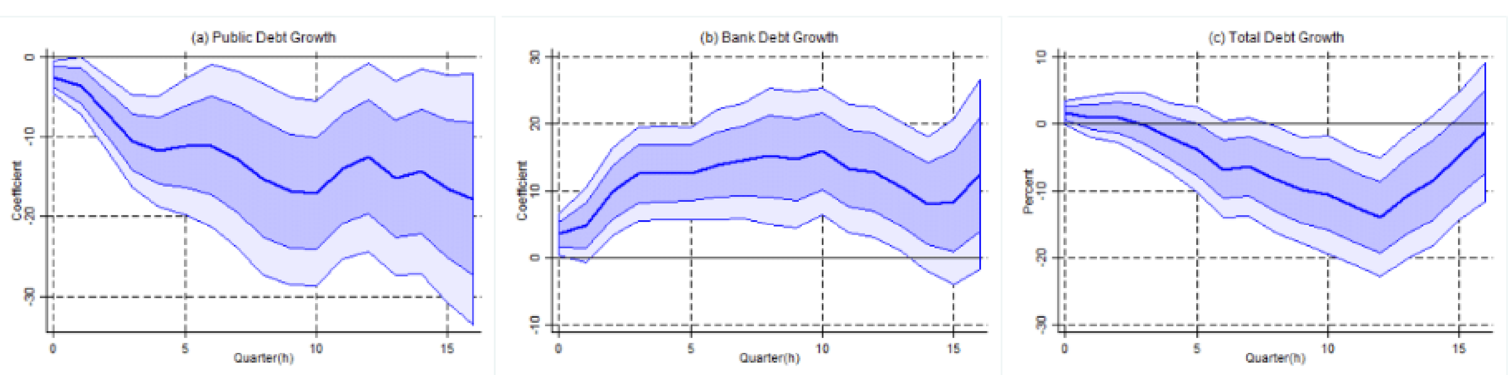
2. High-frequency, even-study approach (Gurkaynak, Sack and Swanson (2005) and Gorodnichenko and Weber (2016))
3. Cost of capital channel (current rate) matters more than the information channel (future rate) by controlling for Greenbook forecast revisions

2 Empirical Evidence

- Sample period: 1990Q1-2008Q4; Data source: Flow of Fund, St Louis Fed, Compustat, FISD, DealScan
- Main results: following an unexpected policy rate hike
  - Aggregate loan share increases while aggregate bond share decreases
  - Financially unconstrained firms tend to borrow more from bank; Financially constrained firms tend to issue more equity
  - Future expected stock return and cash holding go up

Aggregate result: Jorda (2005)-style local projection

Figure 1: Dynamic Effects of Monetary Shocks



Firm-level results

Regression specification:

$$y_{i,t+1} = \alpha_i + \beta Shock_t + \Gamma_1' Z_{i,t-1} + \Gamma_2' Y_{t-1} + \epsilon_{i,t+1}$$

where $Z_{i,t-1}$ are the firm-level controls and Y_{t-1} are the macro controls including forecast revisions.

Table 1: Debt Financing Decisions

	Intensive margin: Δ Loan share				Extensive margin: $D = 1$ if issue loan			
	All firms							
Shock	0.013	0.050*			1.324***	1.553***		
	(0.816)	(1.832)			(5.436)	(4.921)		
Macro Controls	N	Y			N	Y		
	WW index	SA index	Size	Tangability	WW index	SA index	Size	Tangability
	Constrained firms							
Shock	0.056	-0.054	0.017	0.027	-0.302	0.448	-1.186*	1.300**
	(1.028)	(-0.903)	(0.320)	(0.600)	(-0.476)	(0.672)	(-1.741)	(2.050)
	Unconstrained firms							
Shock	0.076**	0.093***	0.086**	0.081**	2.341***	3.251***	2.556***	1.598***
	(1.994)	(2.845)	(2.406)	(2.554)	(4.288)	(5.921)	(4.794)	(2.603)
Macro & Firm Controls	Y	Y	Y	Y	Y	Y	Y	Y

Table 2: Equity Financing Decisions

	Intensive margin: Net equity Issuance				Extensive margin: Net equity Issuance			
	All firms							
Shock	4.99***	4.25*			0.547***	0.516***		
	(2.79)	(1.84)			(6.33)	(4.79)		
Macro Controls	N	Y			N	Y		
	WW index	SA index	Size	Tangability	WW index	SA index	Size	Tangability
	Constrained firms							
Shock	8.63*	7.95	8.98*	1.42	0.677***	0.589***	0.575***	0.575***
	(1.77)	(1.46)	(1.88)	(0.31)	(4.13)	(3.88)	(3.71)	(3.44)
	Unconstrained firms							
Shock	0.98	0.43	0.58	2.88*	-0.001	-0.108	-0.168	0.098
	(0.95)	(0.48)	(0.61)	(1.94)	(-0.01)	(-0.43)	(-0.70)	(0.44)
Macro & Firm Controls	Y	Y	Y	Y	Y	Y	Y	Y

3 Model

Model Assumptions

Assumption 1. (Liquidation and bankruptcy cost)
Assumption 2. (Seniority of bank lenders)
Assumption 3. (Loan issuance is more costly)
Assumption 4. (Secured loan and defaultable bond)

Environment

- Technology: DRS: $y = zk^\alpha l^\nu$ where $\alpha + \nu < 1$
- Productivity: $log(z') = \rho log(z) + \epsilon$
- Investment: Convex adjustment cost $AC(k', k) = \frac{\phi}{2}\left(\frac{k' - (1-\delta)k}{k}\right)^2 k$
- Financial Frictions (B: total debt; s: bond share)
  - Linear debt issuance cost $DIC(B', s') = \xi_0 B'(1-s') + \xi_1 B's' = \xi_0 B' + (\xi_1 - \xi_0)B's'$ $(\xi_0 > \xi_1)$
  - Proportional equity issuance cost $EIC(d) = \lambda d \mathbb{1}(d < 0)$
  - Liquidation loss $(1-\chi)(1-\delta)k$
  - Collateralized bank debt $(1+c)B'(1-s') \leq \theta(1-\delta)k'$
- Fixed target inflation rate: $\bar{\pi}$

Timing

Enter each period with state variables (z, k, B),i.e productivity,capital and total debt

1. Default decision
   - If default, value = 0 and permenantly exits. Lender recovers $\chi(1-\delta)k$.
   - If continue, repay bank and market debt b and m, and an operating cost c_f.
2. Production $y = zk^\alpha l^\nu$
   - Define cash in hand $n = (1-\tau)zk^\alpha l^\nu - wl + (1-\delta)k - c_f + \tau(\delta k + cB) - (1+c)B$
3. Investment k'
   - Internal finance: cash in hand; Costly external debt finance; Costly external equity finance

Firm's Problem

$$\begin{aligned} V(z,k,B) = \mathrm{Max}_{k',B',s',l} d - EIC(d) &+ \beta \mathbb{E}[Max\{V(z',k',B'),0\}] \\ s.t \quad n = (1-\tau)zk^\alpha l^\nu - wl &+ (1-\delta)k - c_f + \tau(\delta k + cB/\bar{\pi}) - (1+c)B/\bar{\pi} \\ d + k' + AC(k',k) = n &+ \frac{B'(1-s')}{1+r} + QB's' - DIC(B',s') \\ (1+c)B'(1-s') &\leq \theta(1-\delta)k' \\ Q(z,k',B',s') = \mathbb{E}[\beta\{(1-D)(1+c) &+ Dmin\{\frac{\chi(1-\delta)k' - B'(1-s')/\bar{\pi}}{B's'/\bar{\pi}}, 1+c\}\}] \end{aligned}$$

Bond price $Q(z, k', B', s')$ is pinned down by risk neutral financial intermediary break even condition.

Optimal Debt Structure

Within each period, given states $(z_{i,t}, k_{i,t+1}, B_{i,t+1}; \beta_t)$, firms choose their optimal debt composition $s_{i,t+1}$ by solving a static maximization problem. The objective function is

$$\begin{aligned} Max\ Obj = Max_{s_{i,t+1}} & \frac{B_{i,t+1}(1-s_{i,t+1})}{1+r_t} + Q_{i,t}B_{i,t+1}s_{i,t+1} - DIC(B_{i,t+1}, s_{i,t+1}) \\ s.t\ \ 1 - & \frac{\theta(1-\delta)k_{i,t+1}}{B_{i,t+1}(1+c)} \leq s_{i,t+1} \leq 1 \end{aligned}$$

The lower bound of $s_{i,t+1}$ comes from the collateral constraint. The first-order condition with respect to the optimal bond share $s_{i,t+1}$ is

$$\frac{\partial Obj}{\partial s_{i,t+1}} = \xi_0 - \xi_1 + \left(Q_{i,t} - \frac{1+c}{1+r_t}\right) + \frac{\partial Q_{i,t}}{\partial s_{i,t+1}} s_{i,t+1}$$

No default risk

For $\forall$ $(z_{i,t}, k_{i,t+1}, B_{i,t+1}; \beta_t)$ such that $Q_{i,t} = \frac{1+c}{1+r_t}$ $\forall s_{i,t+1}$, $s^*_{i,t+1} = 1$, i.e, for those firms that do not default, they choose bond debt only.

With default risk

For $(z_{i,t}, k_{i,t+1}, B_{i,t+1}; \beta_t)$ such that $Q_{i,t} < \frac{1+c}{1+r_t}$

- $s^*_{i,t+1} = \hat{s}_t \leq 1$, if $1 - \frac{\theta(1-\delta)k_{i,t+1}}{B_{i,t+1}(1+c)} < \hat{s}$
- $s^*_{i,t+1} = 1 - \frac{\theta(1-\delta)k_{i,t+1}}{B_{i,t+1}(1+c)}$, if $1 - \frac{\theta(1-\delta)k_{i,t+1}}{B_{i,t+1}(1+c)} \geq \hat{s}_t$

where $\hat{s}_t = \frac{(\xi_0 - \xi_1) + (Q_{i,t} - \frac{1+c}{1+r_t})}{-\frac{\partial Q_{i,t}}{\partial s_{i,t+1}}}$ such that $\frac{\partial obj}{\partial s_{i,t+1}}|_{s_{i,t+1} = \hat{s}_t} = 0$.

i.e, for those firms with default risk, the optimal debt composition is $s^*_{i,t+1} = \frac{(\xi_0 - \xi_1) + (Q_{i,t} - \frac{1+c}{1+r_t})}{-\frac{\partial Q_{i,t}}{\partial s_{i,t+1}}}$ for financially unconstrained firms (collateral constraint does not bind) and $s^*_{i,t+1} = 1 - \frac{\theta(1-\delta)k_{i,t+1}}{B_{i,t+1}(1+c)}$ for financially constrained firms.

4 Model Solution

Figure 4 shows optimal equity value, investment rate, debt issuance and bond price of the firms with average productivity under high rate and low rate. Figure 5 shows more details about debt financing for firms with average productivity but with different level of leverage. In terms of total debt issuance, firms with lower leverage first increase their debt issuance when their capital stock is lower while they gradually reduce debt issuance when their capital stock is high enough. This is because debt is more valuable for low leverage firms due to lower default risk. Firms' debt payment is relatively low when firms have a large amount of capital stock to generate enough internal funds to finance their future investment. As a result, they do not need a large amount of new debt issuance. Low leverage firms rely on a little amount of loan issuance when they have a lower level of capital stock (higher default risk) but zero when they have enough capital stock. Loan issuance is higher in bad state when interest rate is high due to the substitution effect between loan and bond. In panel (b), debt issuance is increasing in capital stock for firms with high leverage. A large amount of debt payment will significantly reduce the internal funds available generated from production activities regardless of the amount of capital stock they have and therefore, firms have to rely heavily on debt financing given the shortage of internal financing and costly external equity financing.

Figure 4: Value and Policy functions

This figure plots the perceived value of equity (top left panel), the policy for the investment-to-capital ratio (top right panel), the policy for issuing new (total) debt (bottom left panel), and the price of bond debt (bottom right panel) as functions of capital. The two lines correspond to firms with identical current idiosyncratic productivity levels and leverage levels, but in the economy with different interest rates. The blue solid line refers to a realization of good state (low rate), and the red dashed line refers to a realization of bad state (high rate).

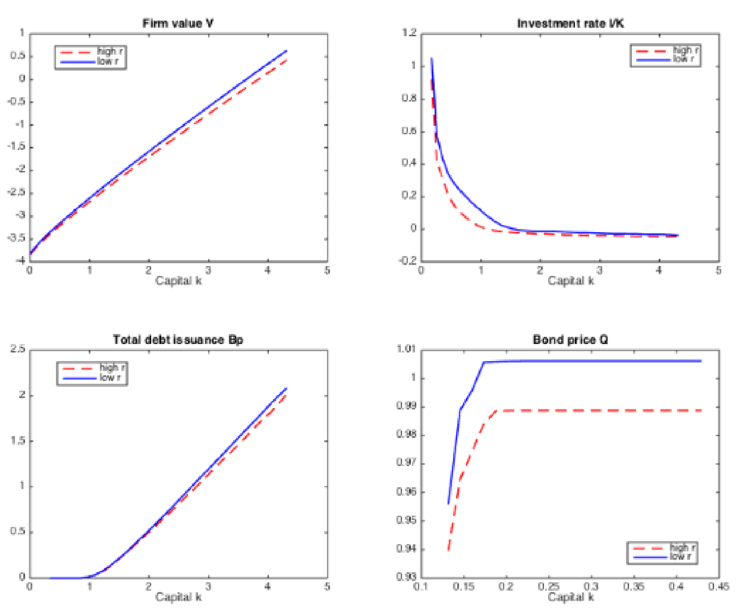
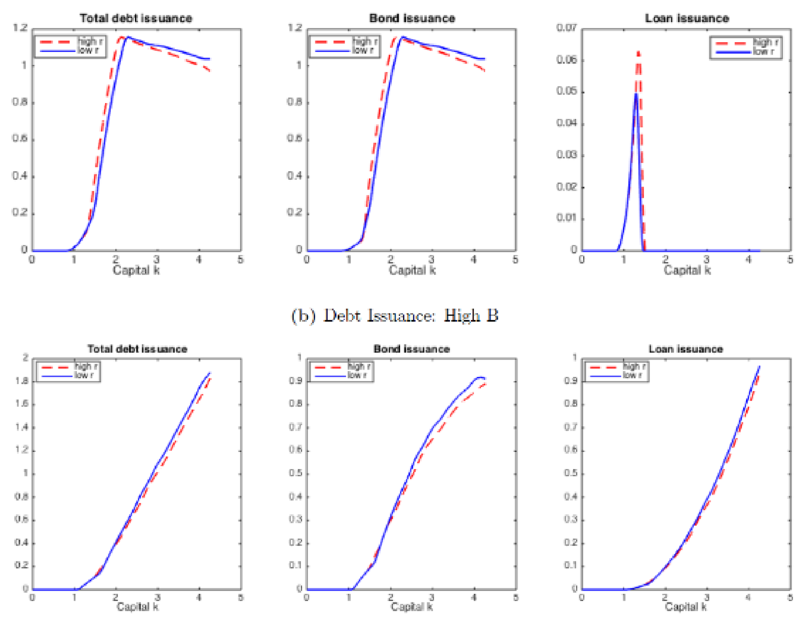


Figure 5: Loan/Bond Issuance

Figure 5 shows more details about debt financing for firms with average productivity but carrying different level of debt (different level of leverage). Panel (a) presents total debt issuance, bond issuance and loan issuance separately for firms with lower debt burden (lower leverage). Panel (b) presents debt issuance decisions for firms with average productivity but higher level of debt.

(a) Debt Issuance: Low B



(b) Debt Issuance: High B

5 Model Implication

5.1 Cross-sectional Determination of Debt Structure

- By credit rating: This model implies that firms with very high default risk take bank debt only, firms with median default risk take both bank and market debt simultaneously and firms with very low or no default risk only issue bond debt.
- By size and age: This model also implies that, in the cross section, large firms are bond-financed firms and they payout dividend. Firms of median size depend on the mix of loans and bonds. Small firms are predicted to be highly bank-dependent.

5.2 Dynamic Capital, Debt Structure and Interest Risk

Table 3: Capital, Debt Structure and Interest Rate Risk

	(1)	(2)	(3)	(4)
	Panel A: All firms			
	Loan Ratio$_{i,t+1}$	ΔLoan Ratio$_{i,t+1}$	Leverage$_{i,t+1}$	
Shock	0.001*	0.058***	-0.006***	
	(1.81)	(9.02)	(-3.64)	
Obs	198956	38159	198956	
Adjusted R^2	0.396	0.042	0.875	
Panel B:	Constrained	Unconstrained	Constrained	Unconstrained
	Loan Ratio$_{i,t+1}$		ΔLoan Ratio$_{i,t+1}$	
Shock	-0.002***	0.001***	0.033***	0.118***
	(-2.90)	(3.98)	(7.82)	(5.47)
Obs	31000	167825	29534	8024
Adjusted R^2	0.567	0.119	0.111	0.113

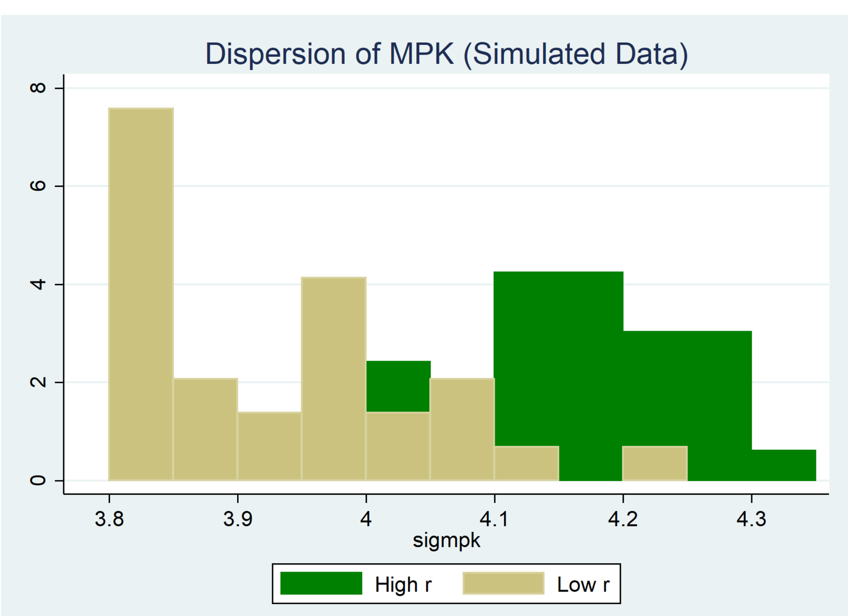
5.3 Credit and Capital Reallocation

The analysis above implies that bank credit flows from constrained firms to unconstrained firms with preserve debt financing flexibility following a tightening monetary policy. Below I show the ratio of total loan of unconstrained firms to total loan of constrained firms in different economies using the simulated data. The ratio is 0.18 in the high interest rate environment, which is higher than 0.17 in the low interest rate environment. Given that constrained firms are mostly more productive firms, credit misallocation is more severe in bad times. The shortage of external financing raises the dispersion of marginal product of capital (MPK), as shown in the histogram below. The dispersion of marginal product of capital on average is larger under high rate.

Table 4: Credit allocation

Loan Ratio: $\frac{unconstrained}{constrained}$

	High r	Low r
Mean	0.181	0.170
Std	0.029	0.057



5.4 Real Effects

In this section, I discuss this debt structure channel and model implications on investment, borrowing and firm value. I do the following regression analysis:

$$y_{i,t+1} = \alpha_i + \beta\epsilon_t^m + \gamma\epsilon_t^m \times LoanRatio_{i,t-1} + \Gamma' Z_{i,t-1} + \epsilon_{i,t+1}$$

Table 5: Real Effect of the Debt Structure Channel

	(1)	(2)	(3)	(4)	(5)	(6)
	Investment Rate$_{i,t+1}$		Market-to-Book$_{i,t+1}$		Borrowing$_{i,t+1}$	
Shock	-0.013***	-0.0136***	-0.031***	-0.032***	-0.010**	-0.010**
	(-5.67)	(-5.64)	(-11.24)	(-10.93)	(-1.88)	(-1.77)
Shock $\times$ Loan Ratio (lag)		0.004**		0.008***		-0.001
		(3.05)		(3.38)		(-0.20)
Obs	198956	198956	198956	198956	198956	198956
Adjusted R^2	0.275	0.276	0.509	0.510	0.739	0.740

The coefficient of interest is γ, which reflects the transmission of monetary shock through this debt structure channel. On average, firms cut down investment and borrowing following a policy rate hike and therefore, the firm value measured by market-to-book ratio declines. The interaction term between shock and loan ratio indicates that firms with higher loan ratio are less responsive to the shocks on investment and firm value since they have less exposure to the interest rate risk. On the other hand, they are more responsive in terms of borrowing but the interaction term is not statistically significant.

Conclusions

- I show that firms substitute loans for corporate bonds as a response to an unanticipated interest rate hike on both intensive and extensive margin, especially among financially unconstrained firms. On average, a positive monetary shock is associated with an increase in firms' risk and future excess return.
- I develop a dynamic, heterogeneous firm model to explain how firms optimally choose their capital and debt structure in the face of investment opportunities and changes in interest rate.
- In this model, firms trade-off between tax benefit and the overall cost of debt financing, which determines the optimal capital structure. Within debt financing, firms trade-off between higher intermediation cost for loans and default risk for bonds for optimal debt structure.
- The model also has interesting implications on cross-sectional debt structure and credit misallocation. It also points out a debt structure channel of monetary policy.
- Overall, the main findings in this paper can be potentially helpful to policymakers in terms of the policy effects on credit reallocation and financial stability.