Corporate Debt Maturity and Output Price Dynamics

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Abstract

This paper examines firms' optimal choices of debt maturity and their influences on pricing behaviors. To explore the link between firms' debt maturity structures and pricing behavior, we leverage both a credit supply shock and a monetary policy shock. Using novel datasets, we present new evidence demonstrating that a heightened level of short-term debt ratio leads to sharp increases in firms' output prices. The observed connection between short-term debt ratio and pricing behavior suggests that firms strategically sought to increase revenue to mitigate rollover risk when facing imminent debt repayment. Overall, our analysis highlights the important role played by debt maturity as a determinant influencing firms' pricing decisions.

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1 Introduction

Pricing decisions, like decisions on investment and financing, are inarguably one of the most important decisions for firms. Therefore, the determinants of product pricing by firms have long intrigued researchers in corporate finance and macroeconomics. The research on firms' pricing behaviors is important not only because it has significant implications on the overall economy but of significant interest to policymakers who closely monitor inflation to target the optimal federal funds rate.

One natural question that arises from this is: what factors drive firms' pricing decisions? Prior research has highlighted financial constraints as one of the important factors that affect a firm's pricing behaviors. For instance, Ge (2022) examines the impact of financial constraints on insurance companies with both life and property & casualty (P&C) divisions. His findings reveal that when one division experiences losses from disasters, these companies opt to raise premiums to alleviate financial burdens. Moreover, many other studies also provide evidence that markup is countercyclical (e.g., Chavalier and Scharfstein, 1996; Lundin et al., 2009; Nekarda and Ramey, 2020; Ravn et al., 2006).

Most previous studies investigating the relationship between financial constraints and firms' pricing behaviors have primarily focused on the perspective of cash flow on a firm's balance sheet. However, this approach often assumes that firms rely solely on one source of financing, such as equity issuance, thereby overlooking the roles played by different characteristics of financing from distinct sources. As emphasized in various studies (e.g., Choi et al., 2018; Colla et al., 2020; He and Milbradt, 2016; Huang et al., 2016) firms actively manage the composition of their debt structure. They engage in this active management of funding sources due to strong incentives aimed at avoiding liquidity shortages and rollover risk. Considering this active management of debt structure is important for a comprehensive understanding of the link between financial constraints and firms' pricing behaviors.

This paper aims to examine the impact of firms' debt maturity structures on their pricing behaviors, using both empirical and theoretical approaches. By analyzing both aspects, we seek to shed light on the implications of debt maturity structure in output price dynamics. In our empirical analysis, we use data from various sources, including product prices, funding sources, debt maturity structure, and balance sheet information. Since debt maturity structure is a consequence of a firm's strategic choice and they are endogenous to various characteristics of firms, we use two exogenous shocks to investigate the relationship between a firm's maturity structure and product pricing. First, we use credit supply shock during a financial crisis to study whether firms have different pricing strategies dependent on their debt maturity structures. To construct firm-level credit supply shock, we follow Kim (2020), who uses Dealscan data which records firms' borrowing activities in the syndicated loan market. We then use event study methodology to study the heterogenous responses of firm product pricing dependent on their debt maturity structures. Strikingly, we find that firms who are carrying more short-term, which matures within one year, tend to increase prices more because of the rollover risk they face.

Second, we use a high-frequency monetary policy shock to investigate whether the type of interest in a firm's borrowing, in addition to their short-term debt, plays a role in their pricing behaviors. Generally, a firm's borrowing can be categorized into one of the following types: 1) fixed-rate, 2) floating-rate, and 3) zero coupon. The Capital IQ database provides information on the type of interest associated with each borrowing incidence. The interest type is crucial because it is directly linked to the federal funds rate targeted by the Fed. Consequently, a firm's debt burden fluctuates significantly based on the federal funds rate. To explore this relationship, we use a monetary policy shock to examine whether firms with a higher proportion of short-term floating-rate debt have stronger incentives to increase the prices of their products. Using the local projection methodology with a monetary policy shock, our findings reveal that firms with a higher proportion of short-term floating-rate debt exhibit stronger motivations to increase the prices of their products.

As next steps, we aim to conduct my theoretical analysis in which we will build a dynamic heterogeneous firm model that incorporates the firm's endogenous choice of debt maturity and makes pricing decisions in their customer markets. More importantly, we will incorporate a customer market similar to Ravn et al. (2006) and Gilchrist et al. (2017) to allow firms to accumulate or consume their customer base based on how they set the product price. In terms of firms' financial sources, we will combine two types of debt 1) short-term debt, which should be repaid immediately within one period, and 2) long-term debt, which should be repaid only a proportion of its principal within one period and could be consistently rolled over. Firms can also decide on whether they fulfill their debt obligations or default on their debt repayment obligations. This approach is similar to Gomes et al. (2016), Jungherr and Schott (2022), and Jungherr et al. (2022) in which they allow firms decisions on default on financial resources which have different debt repayment schedules.

Our paper contributes to the extensive literature investigating the determinants of firms' pricing decisions. In particular, it advances the research on the influence of a firm's financial status on its pricing behavior by highlighting the crucial role played by the short-term debt ratio. To the best of our knowledge, this is the first study to empirically establish the link between firms' debt maturity structure and pricing behaviors using a large-scale dataset. The findings of this paper enhance our understanding of the mechanisms governing firms' pricing decisions, which is particularly relevant considering the significant shortening of the average debt maturity during financial crisis periods. By shedding light on this relationship, our research adds valuable insights to the field and contributes to the broader understanding of pricing dynamics in the context of firms' financial positions.

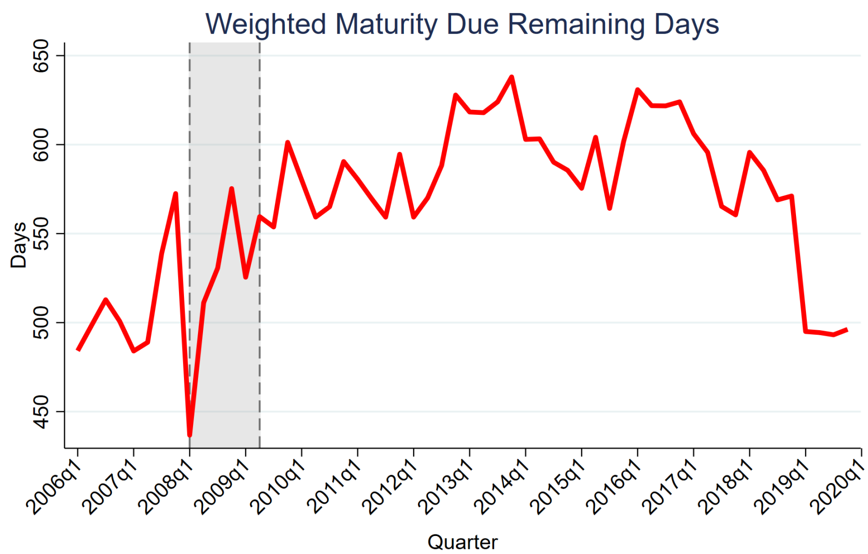
2 Background

The debt maturity structure has large variation not only among different firms at a given point in time but also within individual firms over time. The financial crisis of 2008 presents a valuable opportunity to investigate this relationship as it caused a significant shock to firms' debt maturity profiles. This section provides background information on how the financial crisis impacted firms' debt maturity structure, offering insights into the changes and challenges that emerged during that period.

Financial Crisis and Firms' Debt Maturity Structure The financial crisis refers to a period of severe economic disruption characterized by a widespread and prolonged downturn in various financial markets and economic activities. During such crises, banks and financial institutions often become more cautious in extending long-term loans to borrowers due to heightened default risk and uncertainty in the economic environment. As a consequence, there is a significant shift in the debt maturity structure of firms, leading to substantial fluctuations. Firms experience changes in the composition of their debt, with a reduction in long-term debt and a relative increase in short-term debt to cope with the constraints on obtaining long-term financing.

Figure 1 illustrates the trends in firms' average debt maturity, measured in remaining days. Notably, during the first quarter of 2008, there was a significant decline in the average debt maturity, which can be attributed to banks' heightened caution in extending long-term loans during that period. A comparable pattern is also presented in the share of short-term debt ratio. Appendix Figure A1 displays the trends in the proportion of short-term debt among firms. During

Figure 1: Trend in Firms' Average Debt Maturity (Remaining Days)



Notes: This figure presents the trends in the average debt maturity measured in remaining days. The shaded area represents the period of recessions defined by NBER.

the crisis, there was a noticeable and sharp increase in the share of debt due within one year. This highlights how the financial crisis caused a significant shift in firms' debt maturity structure.

3 Data

In this section, we describe in detail the sources of data to investigate the relationship between debt maturity profile and product pricing empirically.

3.1 Capital IQ Data

S&P Capital IQ database records extensive information on companies' debt capital structure. The data provides item-level information, which includes a description of the debt, the start date of the debt, the period end date (the ending date of the financial reporting period), debt seniority level, outstanding amounts, maturity dates, interest rate, interest rate type, among many others.

First, we drop observations with missing gvkey and period end date (the ending date of the financial reporting period). These two variables are important in merging Capital IQ data with

Compustat data. One of the caveats in Capital IQ data is that a lot of observations have the period end date, which is not the actual ending date of the financial reporting period. In order to minimize the error of the recorded period end date in Capital IQ data, we modified the period end date in Capital IQ to the ending date of the financial reporting period in Compustat within ± 30 days of the window. For those variables that can not be matched within these windows, we use ± 15 days of the window to approximate the period end date and the nearest possible date of the financial reporting period.

Second, since the Capital IQ data records outstanding amounts in the original currency, we also converted the amounts to USD dollars using IBES monthly exchange rate. Third, the observations in Capital IQ data not only contain the actual amount of outstanding debt but also contain the maximum credit limit for each item that can be drawn by the borrower as illustrated in Appendix Table A2. To avoid duplicated loan amounts, we exclude item observations that recorded the maximum credit limit for each loan item. Additionally, as the Capital IQ data contains numerous duplicated entries, we employ information on loan amounts, loan types, and maturity dates to eliminate these duplicates. To validate this cleaning process, we cross-checked the total loan amount obtained from Capital IQ data with the data from Compustat. We find that the information obtained from Capital IQ data could accurately replicate the total debt amount from Compustat, with only minor errors.

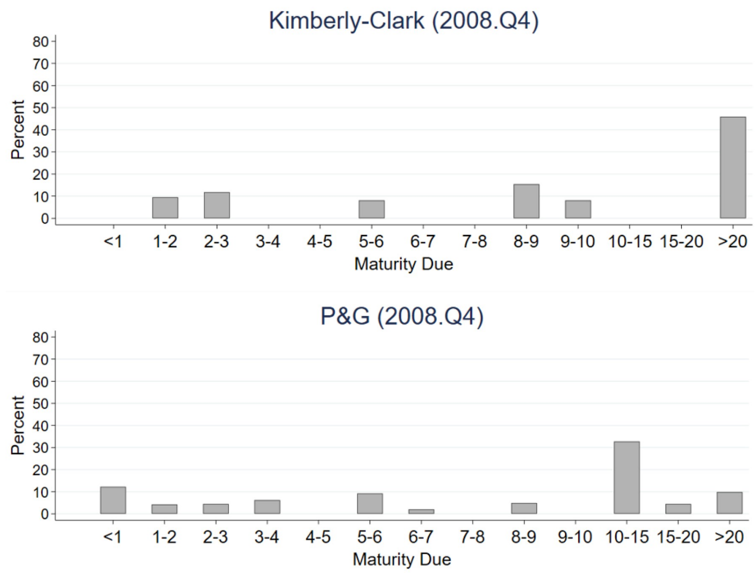
3.2 Nielsen Retail Scanner & GS1 Data

The source of product pricing information is Nielsen Retail Scanner data. The data record point-of-sale information of weekly pricing, product details, and some store-related variables obtained from participating retail stores in all US markets. Each year there are approximately 30,000 to 50,000 participating stores, and the categories of these stores include convenience stores, drug stores, food stores, mass merchandisers, and liquor stores. The earliest year of Nielsen Retail Scanner data goes back to 2006, and we use the year from 2006 to 2019 in my analysis.

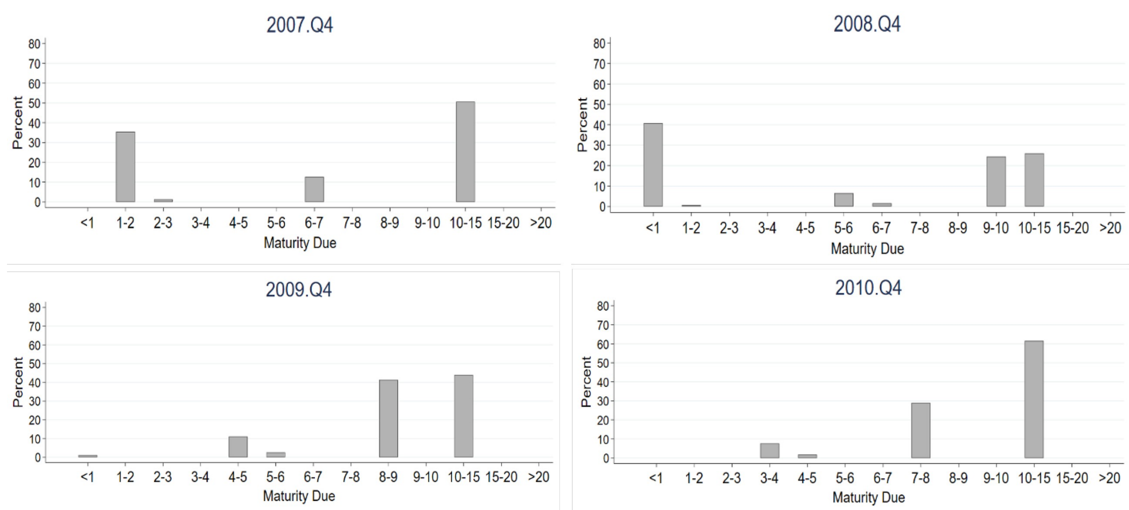
One of the most useful variables in the data is the UPC code of each product observed in the Nielsen Retailer Scanner data. UPC code is a unique identifier for each product, and it is managed by GS1 US. The producers normally register a unique UPC code for each of the products they produce through the GS1 US system. However, in the Nielsen data, only the UPC code can be observed with missing producer identification. In order to identify the producer information, we

Figure 2: Maturity Structure

(a) Maturity Structure of Kimberly-Clark and P&G



(b) Maturity Structure of J.M Smuckers



linked Nielsen data with the producer name and location information using GS1 US data through the UPC code.

Figure 3: Description of Data

(a) Illustration of UPC Code of KitKat

Example Image of a Product In Nielsen Retailer Scanner Data

(a) Front Image (b) Back Image With UPC

Notes: The figure presents the real image for a product with UPC code "003400008752" in the Nielsen Retailer Scanner Database

(b) UPC Code Company Prefix Match Result

Some Key Nielsen Retailer Scanner Variables of a Product With UPC Code "003400008752"

Date	UPC	Brand Descrpt.	Total Sales($)	Unit Price($)	Size Amt	Size Unit	Type Descrpt.	Product Descrpt.
2010.Q1	003400008752	Hershey‘s Kitkat	2,654,020	2.94	10.78	OZ	Milk	Chololate Milk Bar
2010.Q2	003400008752	Hershey‘s Kitkat	2,416,430	3.19	10.78	OZ	Milk	Chololate Milk Bar
2010.Q3	003400008752	Hershey‘s Kitkat	4,303,352	2.86	10.78	OZ	Milk	Chololate Milk Bar
2010.Q4	003400008752	Hershey‘s Kitkat	15,983,677	2.49	10.78	OZ	Milk	Chololate Milk Bar

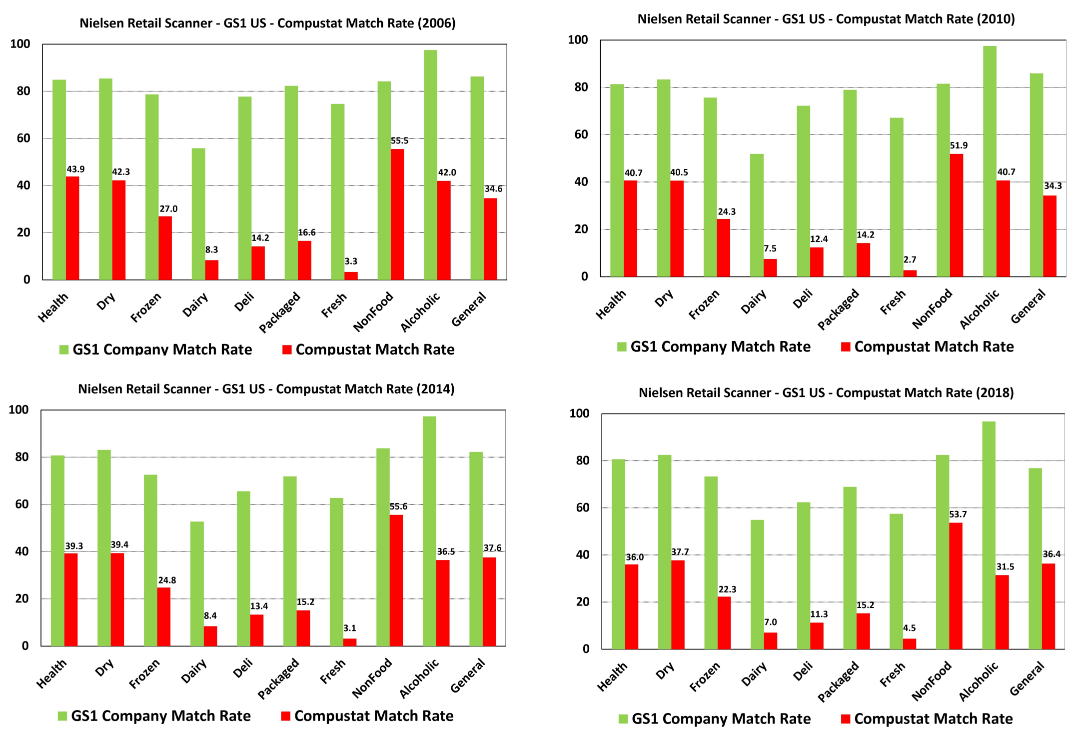
Some Key GS1 Data Variables of a Product With UPC Code "003400008752"

Date	Company Name	UPC	UPC Company Prefix	Company Address	Company City	Company State
2010.Q1	The Hershey Company	003400008752	0034000	19 E CHOCOLATE AVE	Hershey	PA
2010.Q2	The Hershey Company	003400008752	0034000	19 E CHOCOLATE AVE	Hershey	PA
2010.Q3	The Hershey Company	003400008752	0034000	19 E CHOCOLATE AVE	Hershey	PA
2010.Q4	The Hershey Company	003400008752	0034000	19 E CHOCOLATE AVE	Hershey	PA

UPC code consists of 13 digits of the number, and each UPC code can identify a unique product registered by the producer through the GS1 US system. Among the 13 digits of the number, the first 6 to 11 digits are company prefix that corresponds to the producer who registered UPC codes to their products through the GS1 system. Since the company prefix can vary from 6 to 11 digits and there are no common rules for each of the UPC. For each UPC code, I checked that only one of the numbers from all possible company prefixes could be matched to unique producer information for the validity of the matching.

GS1 data hub provides the producer's name, city, and address information. We use this information to link Nielsen data to Compustat data and Capital IQ data through fuzzy matching. To find a correct match between the producer in GS1 and Compustat, we first use company name information in both of the data and calculate the name matching score to find some potential match combinations between the two data sets. After this, we also used address information in both of the data and calculated the address matching score to find potential matches between GS1 and Compustat. Finally, we make use of all of the name-matching scores, address-matching scores, and city information to find the final match between the two data sets. I also manually checked the validity of the matching in the final step of the matching. The matching rate of is shown in the Figure 4.

Figure 4: Matching Rate Between Nielsen & GS1



Finally, using the matched sample we can construct the store-by-product-group price index. The store-by-product-group price index $P^S_{j,t,y}$ at quarter t and year y for product group j for each store is computed as:

$$P^L_{j,t,y} = P^L_{j,t-1,y} \times \frac{\sum_{i \in j} p_{i,t} q_{i,y-1}}{\sum_{i \in j} p_{i,t-1} q_{i,y-1}} \tag{1}$$

Similarly, the store-by-firm-by-product-group price index $P^S_{f,j,t,y}$ is constructed as:

$$P^L_{f,j,t,y} = P^L_{f,j,t-1,y} \times \frac{\sum_{i \in j} p_{f,i,t} q_{f,i,y-1}}{\sum_{i \in j} p_{f,i,t-1} q_{f,i,y-1}} \tag{2}$$

The store level price index is computed in both of chain method and Tornqvist method:

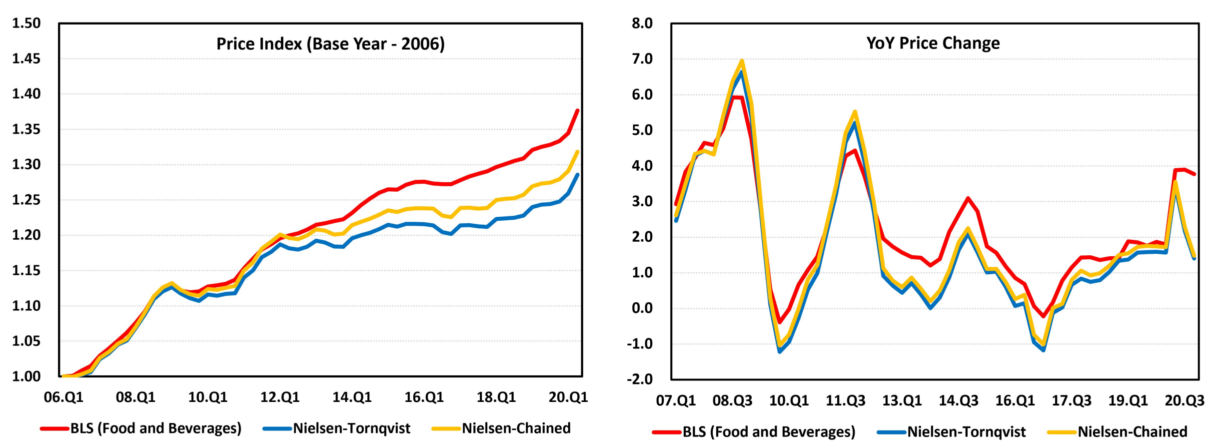
$$\frac{P_t}{P_{t-1}} = \sum_{j=1}^{N} s_{j,y-1} \left(\frac{P^S_{j,t,y}}{P^S_{j,t-1,y}} \right)$$
$$\frac{P_t}{P_{t-1}} = \prod_{j=1}^{N} \left(\frac{P^S_{j,t,y}}{P^S_{j,t-1,y}} \right)^{\frac{s_{j,t}+s_{j,t-1}}{2}} \tag{3}$$

The store-firm level price index is computed in both of chain method and Tornqvist method:

$$\frac{P_{f,t}}{P_{f,t-1}} = \sum_{j=1}^{N} s_{f,j,y-1} \left(\frac{P^S_{f,j,t,y}}{P^S_{f,j,t-1,y}} \right)$$
$$\frac{P_{f,t}}{P_{f,t-1}} = \prod_{j=1}^{N} \left(\frac{P^S_{f,j,t,y}}{P^S_{f,j,t-1,y}} \right)^{\frac{s_{f,j,t}+s_{f,j,t-1}}{2}} \tag{4}$$

To check the validity of the constructed price data, we compare the CPI index that I construct from Nielsen Retail Scanner data to the official CPI index from Bureau of Labor Statistics (BLS). Figure 5 shows that the constructed CPI index from Nielsen Retail Scanner data closely replicates the official index from BLS which shows the representativeness of the scanner data.

Figure 5: Price Index Comparisons



Notes: This figure plots the price index constructed from Nielsen Retail Scanner data using chained method and Tornqvist method. The index is constructed from store-firm level data using store sales as weights. The BLS price index is plotted using the series: Food and beverages in U.S. city average, all urban consumers.

3.3 Compustat Data

Firms' financial information is sourced from Compustat data, which comprises comprehensive records of public firms' balance sheet and statement of income data. Following the established standards in the literature, we drop observations with missing gvkey and date. We include only US established firms in my analysis. We merged Capital IQ with Compustat data using gvkey as the identifier. In the Compustat dataset, some firms have more than four observations in a year due to fiscal year changes. In such cases, we keep observations that correspond to the current fiscal year to maintain consistency in the analysis.

4 Empirical Analysis

4.1 Descriptive Analysis

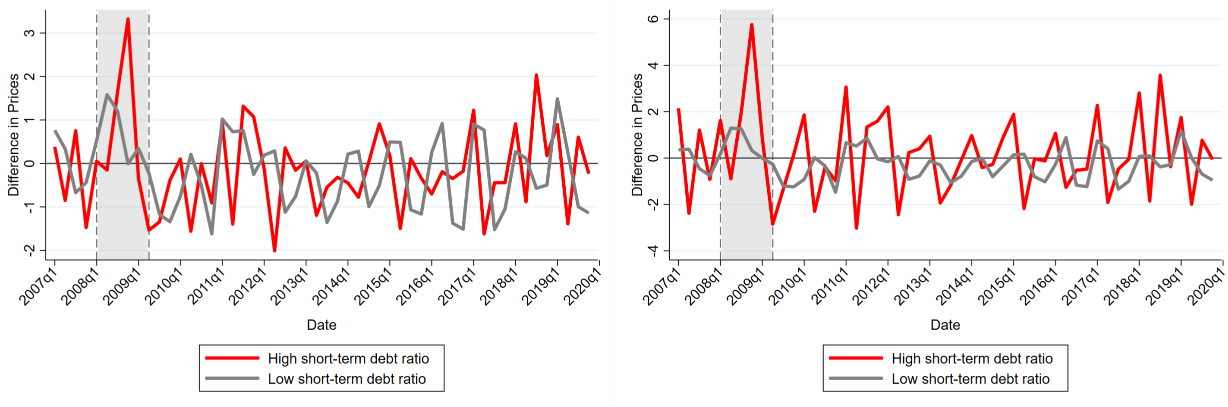
In this section, we present the heterogeneity in the dynamics of output prices based on the firm's baseline debt ratio. Figure 6 illustrates the trends in price outputs for firms with high short-term debt ratios in the baseline period (in red) and firms with low short-term ratios (in gray). Two different thresholds are used to define high versus lower debt ratios. Panel (a) uses a threshold of 75%, defining firms with short-term ratios exceeding 75% of their total debt as having a high debt ratio. In contrast, panel (b) uses a threshold of 90%.

Figure 6 illustrates that firms' price-setting behavior varies a lot depending on their share of the short-term debt ratio. Firms with a high proportion of short-term debt experienced a remarkably sharp increase in their output prices during the financial crisis. One possible explanation for this change is their strategic intent to increase revenue and mitigate rollover risk during the financial crisis.

This evidence provides new and valuable insights into how firms with different short-debt ratios adjust their prices during a crisis. Remarkably, to the best of my knowledge, this is the first paper to document this pricing pattern using a large-scale dataset. By shedding light on the price-setting behavior of firms with varying short-debt ratios, this research contributes to a deeper understanding of how financial conditions impact firms' pricing decisions.

Figure 6: Heterogeneity in the Dynamics in Output Prices Based on Short-term Debt Ratio

(a) Quarter-over-Quarter Price Change, Threshold: 75% (b) Quarter-over-Quarter Price Change, Threshold: 90%



4.2 Global Financial Crisis

The main specification to investigate the importance of debt maturity in a firm's price-setting behaviors during the financial crisis is as follows:

$$\Delta P_{if} = \lambda_g + \beta D_f + \theta X_f + \varepsilon_{fg}, \tag{5}$$

where we included different controls in the specification. The key coefficient of interest is β, while D_f measures the firm $f's$ maturity structure. To incorporate the debt maturity structure, we created different debt maturity bins using the maturity date information from Capital IQ. We then calculated the ratio of debt to total debt in each maturity bin. To emphasize the debt maturity channel in the firm's price setting behaviors, we control for a variety of firm characteristics, as commonly done in previous literature. In Gilchrist et al. (2017), the analysis emphasizes the liquidity channel's influence on the firm's price-setting behaviors. In contrast to their study, we aim to validate my findings by employing various alternative specifications. These specifications enable us to investigate whether the debt maturity channel retains its statistical significance even after accounting for other factors and channels.

In Table 1, we present the results that I obtain using different specifications of the model. The time horizon is in quarters, and the dependent variable is the change in prices between the pre-crisis period (2007.Q4–2008.Q2) and the post-crisis period (2008.Q4–2009.Q2). Prices are measured at the individual UPC level, denoted by ΔP_{if}, representing the price change of the product of i produced by firm f before and after the financial crisis.

Table 1: Effects of Debts with Various Maturities on Price Change

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm Size	-1.485**		-0.946	-1.017	-0.857	-0.627	-0.677	-0.345
	(0.690)		(1.112)	(1.099)	(1.090)	(0.984)	(0.918)	(1.099)
Book Leverage	0.256***		0.298***	0.275***	0.243***	0.243***	0.240***	0.283***
	(0.091)		(0.093)	(0.092)	(0.091)	(0.091)	(0.090)	(0.099)
Market Value	0.000		0.000	-0.000	-0.000	-0.000	-0.000**	-0.000
	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tobin's Q	-1.259**		-1.612***	-1.553***	-1.369***	-1.420***	-2.175***	-2.445***
	(0.547)		(0.475)	(0.457)	(0.464)	(0.519)	(0.676)	(0.677)
Cash Holding	1.201**		0.964	1.184	1.097	0.970	1.259	0.896
	(0.546)		(0.955)	(0.904)	(0.869)	(0.793)	(0.784)	(0.916)
Debt to Asset Ratio	-0.259**		-0.315**	-0.359***	-0.302**	-0.305**	-0.330***	-0.397***
	(0.111)		(0.129)	(0.121)	(0.120)	(0.122)	(0.123)	(0.138)
Liquidity		0.060	0.039	-0.172	-0.193	-0.172	-0.289**	-0.234
		(0.106)	(0.175)	(0.156)	(0.152)	(0.138)	(0.130)	(0.151)
Inventory to Sales Ratio		0.208	-0.323	-0.617	-1.232	-1.224	-1.243	-0.320
		(1.759)	(1.777)	(1.833)	(1.895)	(1.865)	(1.835)	(1.982)
Sales Growth		-3.252	-5.874	-1.541	-2.846	-0.910	12.633	14.757
		(9.037)	(14.949)	(13.757)	(13.424)	(14.728)	(13.572)	(12.705)
Cost of Goods Sold Growth		3.913	16.187	9.318	9.258	6.942	-1.226	2.007
		(8.048)	(12.862)	(12.157)	(11.190)	(13.189)	(12.311)	(13.808)
Debt Due in 1 Year				0.059***	0.072***	0.070***	0.094***	0.112***
				(0.019)	(0.020)	(0.020)	(0.020)	(0.027)
Debt Due in 1 to 2 Years					-0.056	-0.049	-0.010	-0.006
					(0.035)	(0.041)	(0.040)	(0.038)
Debt Due in 2 to 3 Years						-0.029	-0.063	-0.037
						(0.070)	(0.076)	(0.085)
Debt Due in 3 to 4 Years							0.039**	0.046**
							(0.019)	(0.021)
Debt Due in 4 to 5 Years								0.052
								(0.052)
Observations	3,861,817	3,866,459	3,781,504	3,781,504	3,781,504	3,781,504	3,781,504	3,781,504
R^2	0.362	0.347	0.364	0.369	0.371	0.371	0.374	0.375

Notes: Standard errors are two-way clustered at the firm and product group levels are in parentheses. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively. The standard errors are two-way clustered by firm and product group. The regression includes store and product group fixed effect and is weighted by total sales. Each observation is a store-by-firm-by-product-group price index. The dependent variable is the change of price index between two periods (07.Q4:08.Q2 and 08.Q4:09.Q2).

In column (1), we control for standard firm controls commonly used in the corporate finance literature, such as firm size, book leverage, Tobin's Q, cash holding, and the total debt-to-asset ratio of a firm. In column (2), we add additional controls following Gilchrist et al. (2017), such as liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. All control variables are computed as averages between the period 2007.Q4 and 2008.Q2. More detailed information on how these variables were constructed is included in Appendix Table A1.

The main results are highlighted in columns (4)–(8) of Table 1, in which the debt maturity structure is taken into account. As shown in columns (4)–(8) of Table 1, the ratio of short-term debt is statistically significant at the 1% or 5% significance level across all columns, even after controlling for various firm controls. Specifically, in column (4), the result indicates that a 1 percent point increase in short-term debt ratio, due within one year, is associated with an approximate 0.08 percent point increase in product prices. This finding aligns with my previous results in section 4, where firms with a higher short-term debt ratio showed a substantial increase in product prices compared to those with a lower short-term debt ratio. This effect becomes even more pronounced when considering other debt maturity structure variables, such as debt ratios due within 1 to 2 years, 2 to 3 years, 3 to 4 years, and 4 to 5 years.

Columns (4) and (5) reveal interesting findings, as the short-term debt ratio due within one year consistently displays a statistically significant positive relationship with the firm's price change behaviors. Strikingly, the signs of the estimated results are opposite to those of the total debt ratio, where the total debt ratio tends to decrease the firm's product prices. These contrasting signs emphasize the significance of considering the firm's debt maturity profile beyond the simple effects of its total debt ratio.

Table 2 presents the results when employing an accumulated measure of debt ratio instead of using debt maturity bins to test the robustness of my findings. The results are consistent with my previous observations, indicating that short-term debt has positive effects on a firm's price change. In particular, column (4) of Table 2 demonstrates that this positive relationship becomes less significant when we include relatively long-term debt, those due more than five years.

Table 2: Effects of Debts with Various Maturities on Price Change

	(1)	(2)	(3)	(4)	(5)
Firm Size	-1.060	-1.133	-1.235	-1.654	-1.300
	(1.097)	(1.159)	(1.185)	(1.127)	(1.114)
Book Leverage	0.273***	0.296***	0.303***	0.302***	0.337***
	(0.092)	(0.092)	(0.092)	(0.090)	(0.093)
Market Value	-0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tobin's Q	-1.547***	-1.594***	-1.623***	-2.179***	-2.403***
	(0.457)	(0.484)	(0.496)	(0.633)	(0.688)
Cash Holding	1.257	1.162	1.207	1.650	1.306
	(0.904)	(0.969)	(0.995)	(1.050)	(1.003)
Debt to Asset Ratio	-0.361***	-0.355***	-0.353***	-0.356***	-0.402***
	(0.121)	(0.128)	(0.129)	(0.128)	(0.133)
Liquidity	-0.202	-0.072	-0.053	-0.161	-0.090
	(0.158)	(0.168)	(0.176)	(0.184)	(0.176)
Inventory to Sales Ratio	-0.603	-0.051	-0.105	-0.092	0.651
	(1.839)	(1.941)	(1.933)	(1.928)	(2.019)
Sales Growth	-0.717	-3.421	-4.849	2.997	5.015
	(13.654)	(14.802)	(14.881)	(13.018)	(12.881)
Cost of Goods Sold Growth	8.581	12.568	15.024	12.735	14.767
	(12.084)	(13.248)	(12.899)	(10.740)	(11.143)
Debt Due in 1 Years	0.062***				
	(0.019)				
Debt Due in 2 Years		0.026*			
		(0.013)			
Debt Due in 3 Years			0.018		
			(0.012)		
Debt Due in 4 Years				0.034**	
				(0.015)	
Debt Due in 5 Years					0.039*
					(0.020)
Observations	3,781,504	3,781,504	3,781,504	3,781,504	3,781,504
R^2	0.369	0.366	0.365	0.367	0.367

Notes: Standard errors are two-way clustered at the firm and product group levels are in parentheses. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively. The standard errors are two-way clustered by firm and product group. The regression includes store and product group fixed effect and is weighted by total sales. Each observation is a store-by-firm-by-product-group price index. The dependent variable is the change of price index between two periods (07.Q4:08.Q2 and 08.Q4:09.Q2).

4.3 Credit Supply Shock

In this section, we use a credit supply shock during the financial crisis to study the effects of debt maturity profile on each firm's price-setting behavior. To do this, we expand the previous equation by introducing a credit supply shock measure, wherein the idiosyncratic firm-level credit supply shock is interacted with the short-term debt ratio. The specification incorporating the credit supply shock is as follows:

$$\Delta P_{if} = \lambda_g + \beta(-\Delta L_f)D_f + \theta X_f + \varepsilon_{fg} \tag{6}$$

Following the approach of Chodorow-Reich (2014) and Kim (2020), we construct the credit supply shock at the firm level. We use the failure of Lehman Brothers, which occurred on September 15, 2008. The financial crisis had a significant impact on the health of banks, leading us to define two distinct periods: the pre-Lehman period and the post-Lehman period for constructing the credit supply shock. The post-Lehman period is defined as the time between 2008.Q4 and 2009.Q2, which immediately follows Lehman's failure. On the other hand, the pre-Lehman period is selected from 2007.Q4 to 2008.Q2. To test the robustness of my findings, I also conduct a sensitivity analysis by using the period between 2006.Q4 and 2007.Q2 as an alternative pre-Lehman period for comparison.

We use Dealscan data to construct a firm-level credit supply shock. The Dealscan database contains information on firms' bank borrowings from the syndicated loan market. An example deal from Dealscan is illustrated in Appendix Figure A2, where The Procter & Gamble Company acts as the borrower, and the loan involves ten different banks serving as lead agents, co-agents, or participants. The lead agent typically handles the largest portion of the syndicated loan. Given that each syndicated loan deal involves multiple banks, we can investigate the banks with which a specific firm has established a relationship. To identify the list of banks that a particular firm had engaged with before the Lehman failure, I use the last syndicated loan that the firm borrowed before the Lehman failure and denoted it as S_f.

After identifying the list of banks that a specific firm had established a relationship with prior to the Lehman failure, the firm-level credit shock is defined in Equation 7 as follows:

$$\begin{aligned}
\Delta L_f &= \sum_{b \in S_f} \alpha_{fb,\,\text{last}}\, \Delta(\text{ Bank Health })_{-f,b} \\
\Delta(\text{ Bank Health })_{-f,b} &= \frac{\sum_{j \neq f} \alpha_{jb,\,\text{post}} \times \mathbb{1}(b \text{ lent to } j \text{ post-Lehman })}{\frac{1}{2}\sum_{j \neq f} \alpha_{jb,\,\text{pre}} \times \mathbb{1}(b \text{ lent to } j \text{ pre-Lehman })}
\end{aligned} \tag{7}$$

The firm-level credit shock is calculated as the weighted average of the changes in bank health with whom the firm had constructed a relationship through the last syndicated loan before Lehman's failure. The weight $\alpha_{fb,last}$ is determined by the proportion of the loan that a specific bank had borrowed to the firm in the last syndicated loan. By the definition of ΔL_f, a firm's credit supply shock is represented as a weighted average of the exposures to the changes in the health of the banks upon which it relied for borrowings.

The change in bank health is calculated at the bank level, measuring the extent to which a bank has reduced its borrowings after the Lehman failure. In the bank health change equation, the indicator function $\mathbb{1}$ takes a value of zero if the bank b provided loans to the firm j either in the pre-Lehman period or the post-Lehman period through a syndicated loan deal. To account for the bank's proportion in each syndicated loan deal, the weights $\alpha_{jb,post}$ and $\alpha_{jb,pre}$ are multiplied in front of the indicator function $\mathbb{1}$.

The bank health equation focuses on quantifying the total number of firms that bank b has provided loans to. The equation involves two summations: one in the numerator, which considers all the firms that bank b extended loans to in the syndicated loan market during the pre-Lehman period, and another in the denominator, which includes all the borrowers to whom bank b provided loans during specific time intervals (2007.Q4 to 2008.Q2 & 2006.Q4 to 2007.Q2). We multiply the denominator by $\frac{1}{2}$ to account for the differences in the length of quarters for the two periods. We exclude firm f from the summation when measuring the credit supply shock in order to prevent the measure of credit supply shock to firm f is compounded by neglecting the demand side of the loan. By excluding firm f from the calculation of bank health change, we focus solely on the pure credit supply shock to firm f without attributing any changes in the number of loans provided by bank b to firm f solely to fluctuations in firm $f's$ credit demand. This ensures a more accurate assessment of the credit supply shock experienced by firm f.

Table 3 presents the estimation results of Equation 7, incorporating the credit supply shock constructed as described above. Additionally, we interacted this shock with different maturities of the debt, as shown in Equation 7. Comparing these results with those in Table 1, we find notable differences. Columns (4)–(8) reveal a positive relationship between the firm's price change and the short-term debt ratio due in 1 year. In particular, although the coefficient of the short-term debt due in 1 year interacted with the credit supply shock is not statistically significant in column (4), it becomes statistically significant when other debt maturities are included. In columns (5) to (8), it is evident that a one standard deviation increase in the credit supply shock interacted with

1 percentage point increase of the short-term debt ratio due in one year generally leads to a rise in the firm's product price by approximately 0.5 to 0.9 percentage points. These results indicate a meaningful impact of the credit supply shock and short-term debt ratio on the firm's price dynamics.

Table 3: Effects of Debts with Various Maturities on Price Change (Credit Supply Shock)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm Size	-1.485**		-1.413	-0.122	-1.354	-1.348	-2.187**	-2.454**
	(0.690)		(1.151)	(1.318)	(1.264)	(1.222)	(1.094)	(1.093)
Book Leverage	0.256***		0.251***	0.208**	0.241***	0.319***	0.257***	0.342***
	(0.091)		(0.080)	(0.103)	(0.089)	(0.105)	(0.086)	(0.079)
Market Value	0.000		-0.000	-0.000**	-0.000	-0.000	-0.000	-0.000
	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tobin's Q	-1.259**		-1.063*	-1.978**	-1.816**	-2.488***	-3.170***	-3.603***
	(0.547)		(0.593)	(0.782)	(0.786)	(0.839)	(0.777)	(0.728)
Cash Holding	1.201**		1.618*	0.788	1.689*	2.075**	2.655***	2.661***
	(0.546)		(0.957)	(1.035)	(0.936)	(0.937)	(0.876)	(0.925)
Debt to Asset Ratio	-0.259**		-0.264**	-0.310**	-0.312***	-0.439***	-0.410***	-0.528***
	(0.111)		(0.108)	(0.126)	(0.113)	(0.145)	(0.116)	(0.111)
Liquidity		0.363*	0.178	0.103	0.025	0.007	0.088	0.143
		(0.190)	(0.204)	(0.188)	(0.173)	(0.154)	(0.190)	(0.170)
Inventory to Sales Ratio		-0.183	0.568	-1.996	-0.178	-1.385	-1.120	0.006
		(1.831)	(1.648)	(2.068)	(1.707)	(1.763)	(1.735)	(1.767)
Sales Growth		-2.381	-11.849	0.266	4.409	15.770	47.641***	50.795***
		(10.169)	(17.642)	(16.558)	(15.521)	(16.953)	(13.746)	(12.656)
Cost of Goods Sold Growth		2.604	21.529	9.940	5.392	-0.658	-27.645**	-25.818*
		(9.682)	(16.906)	(16.810)	(16.399)	(15.219)	(13.313)	(13.992)
Shock X Liquidity		-0.957*	-0.738	-0.658	-0.922	-1.176*	-2.494***	-2.606***
		(0.526)	(0.585)	(0.502)	(0.565)	(0.604)	(0.741)	(0.747)
Shock X Debt Due in 1 Year				0.557*	1.062***	1.254***	1.249***	1.226***
				(0.321)	(0.392)	(0.408)	(0.415)	(0.399)
Shock X Debt Due in 1 to 2 Years					-0.406**	-1.174**	-0.814*	-0.667
					(0.192)	(0.525)	(0.432)	(0.474)
Shock X Debt Due in 2 to 3 Years						1.160	0.634	0.433
						(0.723)	(0.587)	(0.647)
Shock X Debt Due in 3 to 4 Years							0.244**	0.192*
							(0.109)	(0.115)
Shock X Debt Due in 4 to 5 Years								0.323***
								(0.111)
Observations	3,861,817	3,793,559	3,708,820	3,708,820	3,708,820	3,708,820	3,708,820	3,708,820
R^2	0.362	0.358	0.371	0.376	0.379	0.380	0.387	0.388

Notes: Standard errors are two-way clustered at the firm and product group levels are in parentheses. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively. The standard errors are two-way clustered by firm and product group. The regression includes store and product group fixed effect and is weighted by total sales. Each observation is a store-by-firm-by-product-group price index. The dependent variable is the change of price index between two periods (07.Q4:08.Q2 and 08.Q4:09.Q2).

In Table 4, we explore an alternative measure of accumulated debt ratio due in two years, three years, four years, and five years. The results reveal an intriguing pattern: the effects of debt ratio interacted with the credit supply shock on price change show a positive relationship when the debts are due in less than two years, but the sign becomes negative when the debts are due in three years or more. This finding suggests that debts that are due in the near future (within one or two years) serve as a motivation for firms to increase their product prices. This observation indicates that the debt maturity structure significantly influences a firm's price-setting behaviors. One possible explanation for this pattern is that firms are sensitive to their maturity profiles when determining their pricing strategies. Firms with a higher proportion of short or medium-term debt due within the one-year or two-year window tend to increase product prices to boost their revenue and mitigate rollover risks. The strategic adjustment of prices allows these firms to address their upcoming debt obligations more effectively.

In essence, the findings highlight how firms take into account their debt maturity profiles strategically, adapting their pricing decisions to manage rollover risk and optimize their financial positions. The observed relationship between debt maturity structure and price-setting behavior underscores the importance of considering the interplay between debt characteristics and firm decisions in understanding pricing dynamics.

In addition to this, we investigate the dynamic impact of a firm's pricing behavior by utilizing the global financial crisis as an exogenous shock to the firm's refinancing conditions on the financial market. As we explained previously, the constructed idiosyncratic firm-level credit supply shock measures the exposure of a firm to banks' health deterioration of which its has close tie with. As previously mentioned, the constructed idiosyncratic firm-level credit supply shock quantifies a firm's vulnerability to the deteriorating health of banks with which it has a close relationship. In the existing literature, numerous papers have explored how, due to switching costs, firms may face challenges in transitioning to other banks when the banks they have established close relationships with encounter financial difficulties. Taking these facts into account, we estimate a difference-in-differences model which takes the following form:

$$\begin{aligned} 100 * \left(\frac{P_{fjt} - P_{fjt-4}}{P_{fjt-4}}\right) = \sum_{t \neq 2008.Q2} \gamma_t \left(-L_f\right) \times 1\{\text{ShortTerm\_Debt}^{Pre} > \text{Cutoff}\}_f \times \mathbf{1_t} \\ \alpha_t(-L_f) + \sigma_f + \delta_t + \kappa' X_{ft} + \varepsilon_{fjt} \qquad (8) \end{aligned}$$

Each observation in Equation 8 is the year-over-year price change of individual firm f for product group j during quarter t. We divide firms into the treated group and the control group based on the average short-term debt ratio for each firm during the pre-financial-crisis period, spanning from 2007.Q4 to 2008.Q2. Specifically, the treated group consists of firms with a baseline short-term debt ratio above a specific threshold. $\mathbf{1_t}$ refers to time dummies and $(-L_f)$ indicates the firm-level idiosyncratic credit supply shock. The equation includes firm fixed effects

(σ_f) and time fixed effects (δ_t). We also control for the firm-level time-varying covariates which include: firm size, book leverage, market value, Tobin's Q, total debt ratio, cash holding, and liquidity. In the estimation, standard errors are clustered at the firm and product group level.

Figure 7: Heterogeneous Effect of Credit Supply Shock

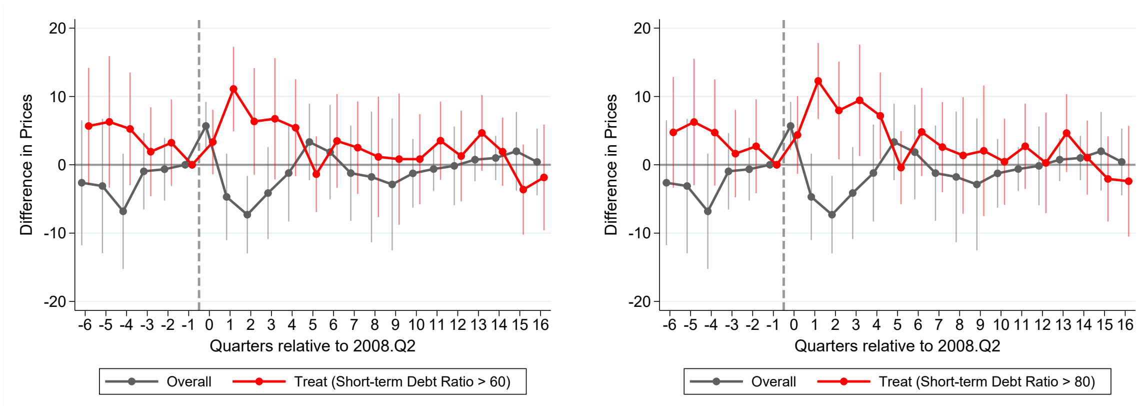


Figure 7 clearly shows the difference of price response to credit supply shock depending on the ratio of firm's short-term debt ratio. The gray line shows how the shock affects price over time, while the red line shows the effect of the shock on prices among the treatment group relative to the control group. This pattern highlights the differential effect of the shock depending on firms' short-term debt ratio. This indicates that firms with high levels of short-term debt find themselves compelled to either maintain or raise their product prices in order to boost their revenues and mitigate the risk of default. This emphasizes the channel in which firms, when confronted with the choice between risking customer attrition by raising prices and increasing revenue to avoid default, opt to prioritize revenue generation to fulfill their imminent debt obligations. For the robustness check, we use different threshold of short-term debt ratio for the treated group. Figure A7 shows that the channel is still valid with different threshold of short-term debt ratio.

4.4 Monetary Policy Shock

In this section, we investigate the influence of debt maturity profiles on a firm's price-setting behaviors using monetary policy shocks. As a firm's debt burdens are sensitive to changes in borrowing interest rates, analyzing the firm's response to debts with different maturities becomes relevant, and monetary policy shocks serve as a valuable source of exogenous variation in this context.

Table 4: Effects of Debts with Various Maturities on Price Change (Credit Supply Shock)

	(1)	(2)	(3)	(4)	(5)
Firm Size	-0.122	-0.723	-0.909	-1.619	-1.514
	(1.318)	(1.233)	(1.249)	(1.144)	(1.117)
Book Leverage	0.208**	0.236**	0.242***	0.200**	0.280***
	(0.103)	(0.091)	(0.090)	(0.085)	(0.072)
Market Value	-0.000**	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tobin's Q	-1.978**	-1.510**	-1.515**	-2.185***	-2.591***
	(0.782)	(0.726)	(0.696)	(0.763)	(0.699)
Cash Holding	0.788	1.175	1.292	1.977**	1.819*
	(1.035)	(0.996)	(1.003)	(0.984)	(0.963)
Debt to Asset Ratio	-0.310**	-0.309**	-0.311**	-0.281**	-0.394***
	(0.126)	(0.123)	(0.122)	(0.111)	(0.099)
Liquidity	0.103	0.082	0.076	0.094	0.241
	(0.188)	(0.184)	(0.197)	(0.211)	(0.220)
Inventory to Sales Ratio	-1.996	-0.546	-0.617	-1.288	0.447
	(2.068)	(1.897)	(1.910)	(2.302)	(1.819)
Sales Growth	0.266	-8.592	-10.152	18.291	27.805**
	(16.558)	(17.426)	(17.220)	(15.527)	(13.389)
Cost of Goods Sold Growth	9.940	18.676	21.250	-1.408	-3.321
	(16.810)	(16.655)	(16.154)	(14.495)	(13.400)
Shock X Liquidity	-0.658	-0.503	-0.499	-1.370**	-1.758**
	(0.502)	(0.523)	(0.537)	(0.681)	(0.687)
Shock X Debt Due in 1 Years	0.557*				
	(0.321)				
Shock X Debt Due in 2 Years		0.078			
		(0.074)			
Shock X Debt Due in 3 Years			0.059		
			(0.052)		
Shock X Debt Due in 4 Years				0.102	
				(0.064)	
Shock X Debt Due in 5 Years					0.099*
					(0.051)
Observations	3708820	3708820	3708820	3708820	3708820
R^2	0.376	0.373	0.373	0.376	0.378

Notes: Standard errors are two-way clustered at the firm and product group levels are in parentheses. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively. The standard errors are two-way clustered by firm and product group. The regression includes store and product group fixed effect and is weighted by total sales. Each observation is a store-by-firm-by-product-group price index. The dependent variable is the change of price index between two periods (07.Q4:08.Q2 and 08.Q4:09.Q2).

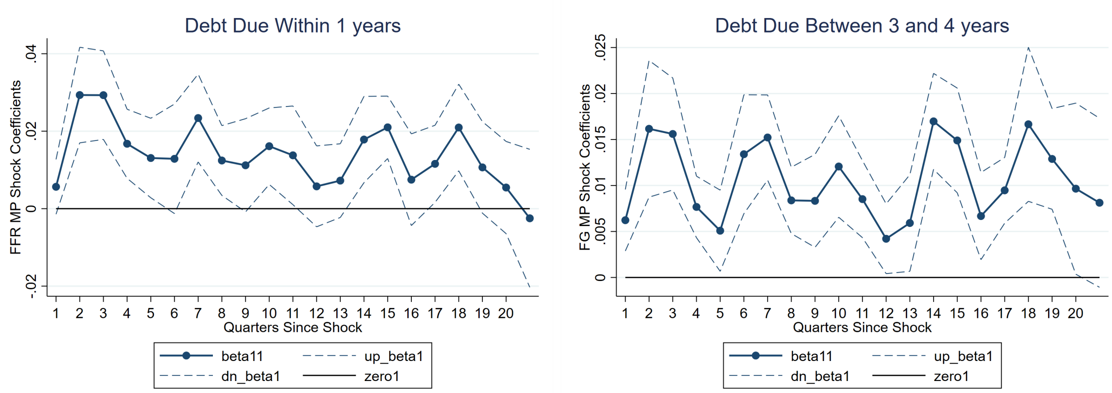
First, we use the monetary policy proposed by Swanson (2021) which extends the approach of Gürkaynak et al. (2005). Both of the papers use factor model to extract the unexpected component of change in federal funds rate, forward guidance, large scale asset purchase (LSAP). This approach offers the advantage of decomposing a monetary policy shock into distinct components that can impact the asset prices of various maturities. Because various announcements of monetary policy have asymmetric effects on asset prices with varying horizons, it is essential to distinguish each component of monetary policy to analyze its unique impacts on debt burdens with differing maturities.

We follow Jordà (2005) to estimate the impacts of monetary policy shock on the firm's price change using local projection method.

$$\sum_{h=0}^{H} \log \frac{P_{fjt+h}}{P_{fjt-1}} = \beta_1^h \,\text{Debt}_{ft}\, \varepsilon_t^{\text{MP}} + \alpha_j^h + \alpha_t^h + \alpha_f^h + \varepsilon_t^{\text{MP}} + \Gamma_1^h X_{ft-1} + \varepsilon_{it} \tag{9}$$

The dependent variable is log price change of product group j produced by firm f between time $t+h$ and $t-1$. $\varepsilon_t^{\text{MP}}$ denotes the monetary policy shock. I focus on two types of monetary policy shock constructed by Swanson (2021): the target component, and the path component. The target component of monetary policy shock is the surprise of change in federal funds rate, and the path component of monetary policy shock is the surprise of change in forward guidance. Hence, the target component of monetary policy shock is more closely related to the debt burden with short-term maturities and the path component of monetary policy shock is more closely related to the debt burden with medium-term or long-term debt maturities. In the regression, the product group FEs (α_j^h), time FEs (α_t^h), and firm FEs (α_f^h) are included. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. β_1^h is main coefficient of interest in this estimation.

Figure 8: Response of Price to Target & Path of Monetary Policy Shock



In the left panel of 8, the contractionary monetary policy shock in target component has immediate response to price change for firms with high ratio of short-term debt maturing within 1 year. Compared to this, the contractionary monetary policy shock in path component has more impacts on price change for firms with more debt burdens maturing in the medium-term.

Figure 9: Response of Price to Target & Path of Monetary Policy Shock

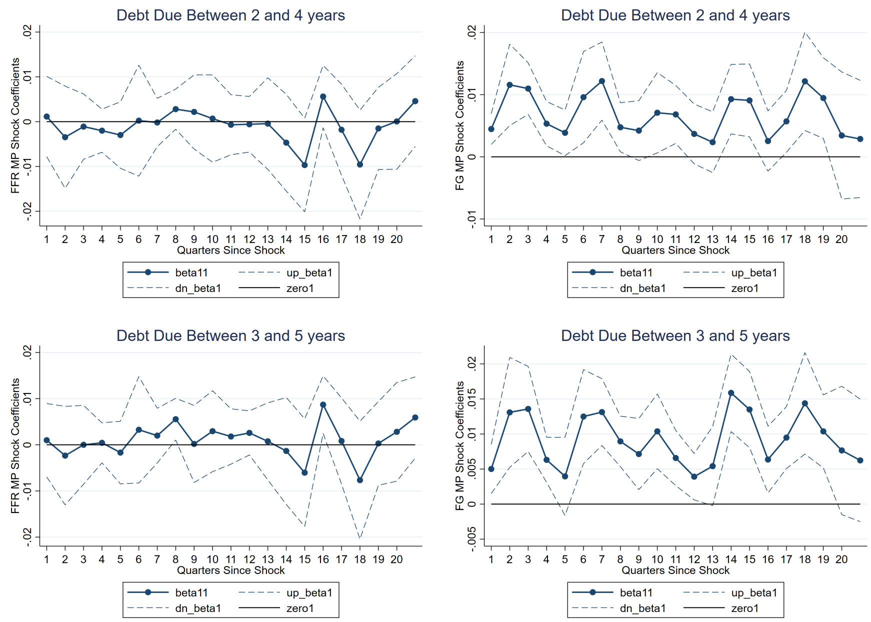


Figure 9 also shows the similar story. The first row of the figure shows that target component of monetary policy attributes to price increases only to firms with elevated level of debt burden maturing in medium-term or long-term. In comparison, the second row of Figure 9 shows that the path component of monetary policy attributes to price increases only to firms with high level of debt budern maturing in short-term. This finding is interesting because it shows the different response of the firm's price change depending on their debt burdens of different maturities.

For the robustness check, we use different measure of monetary policy shock. To measure the exogenous changes in monetary policy, we adopt a high-frequency approach that leverages the fluctuations of Federal Funds futures around the narrow window of Federal Open Market Committee (FOMC) announcements (Kuttner 2001; Gürkaynak et al. 2005; Gorodnichenko and Weber 2016; Nakamura and Steinsson 2018; Eichenbaum et al. 2022). This method allows us to derive the monetary policy shock from Federal Funds futures, which plays a central role in the analysis. The model specification is as follows:

$$\varepsilon_t = \frac{D}{D-t}\left(y_{t+\Delta^+} - y_{t-\Delta^-}\right), \tag{10}$$

where the variable t represents the time of the Federal Open Market Committee (FOMC) announcement release. To capture the effects of the announcement, I consider two short time windows, denoted as $t-\Delta^-$ and $t+\Delta^+$, which respectively correspond to a period shortly before and after the meeting. Typically, these windows are set at either 15 minutes or 30 minutes before and after the announcement, as commonly seen in the literature. I use both time windows in my analysis. The narrowness of this window selection ensures that the constructed monetary policy shock is solely based on the unexpected components of the FOMC announcements, uncontaminated by other factors that might influence Federal Funds futures. To account for the exact date of the FOMC announcement within a given month, we multiply the factor $\frac{D}{D-t}$ at the front of Equation 10. Here, D represents the total number of days in that month, while t denotes the specific day of the FOMC meeting within that month. This adjustment helps to accurately reflect the temporal aspect of the announcement and its impact on the monetary policy shock. Furthermore, to create a quarterly-level aggregate monetary policy shock, we sum up all the monetary policy shocks within a quarter. This aggregation allows for a broader perspective on the overall monetary policy effects during the specific quarter under consideration. By employing these adjustments and aggregations, we can effectively analyze the dynamics of the monetary policy shocks and their relationships with a firm's debt maturity profiles and pricing behaviors.

We use the local projection approach, following Jordà (2005), to examine the response of price changes to monetary policy shocks. The model specification is as follows:

$$\begin{aligned}\sum_{h=0}^{H} \log \frac{P_{it+h}}{P_{it-1}} = &+ \beta_1^h \text{ Debt } 1_{it}\varepsilon_t^{\text{MP}} + \beta_2^h \text{ Debt } 2_{it}\varepsilon_t^{\text{MP}} + \beta_3^h \text{ Debt } 3_{it}\varepsilon_t^{\text{MP}} \\ &+ \beta_4^h \text{ Debt } 4_{it}\varepsilon_t^{\text{MP}} + \beta_5^h \text{ Debt } 5_{it}\varepsilon_t^{\text{MP}} + \alpha_g^h + \alpha_t^h + \alpha_{\text{firm}}^h + \varepsilon_t^{\text{MP}} + \Gamma_1^h X_{ft} + \varepsilon_{it},\end{aligned} \tag{11}$$

where we interact the monetary policy shock with different debt maturity due dates to investigate whether firms increase their product prices as the loan's due date approaches. In the equation, Debt1_{it} represents the ratio of debt due within one year, while Debt2_{it} represents the ratio of debt due between one and two years. Similarly, the variables Debt3_{it}, Debt4_{it}, and Debt5_{it} are defined accordingly. We control for X_{ft}, which includes basic firm characteristics, as well as fixed effects for firm, product-group, and time.

In Appendix Figure A5, we present the price change responses to various debt maturities, and the corresponding coefficients β_1^h, β_2^h, β_3^h, β_4^h, and β_5^h are displayed in subsequent panels. Notably, in panel (a) of the figure, a distinct price increase is observed in response to debts that are due within one year. Moreover, firms consistently raise their product prices as the due date of the debt approaches in two years and three years. While the response may appear somewhat muted in the pattern of β_4^h, firms still initiate a price increase starting from the 4th year as the due date of the debt due in 5 years approaches, as shown in panel (e).

In the Capital IQ data, we can also observe whether the debt is fixed-rate or floating-rate. Using this information, we run the above specification using only debts of the floating-rate type. The rationale behind this choice is that floating-rate debt is directly linked to the federal funds rates set by monetary policy, potentially resulting in firms' price changes being more responsive to short-term floating-rate debts. The observed pattern is presented in Appendix Figure A6, where the fluctuations are noticeably more dynamic when compared to Figure A5. Of particular interest is panel (b) of the figure, which clearly demonstrates a pattern indicating that firms gradually increase their product pricing as the due date of the debt that matures within two years approaches. This trend is also observable in the case of debts due in three years and five years.

5 Quantitative Model

5.1 Households

We assume there exist a representative household who consumes a variety of differentiated consumption goods indexed by $i \in [0, 1]$. The representative household's objective is to maximize its expected utilities

$$E_0 \sum_{t=0}^{\infty} \beta^t U(X_t, L_t) \tag{12}$$

where X_t is a composite of habit-adjusted consumption of a continuum of differentiated goods. It is expressed in the constant elasticity of substitution (CES) aggregation

$$X_t = \left[\int_0^1 \left(c_{i,t} - \theta m_{i,t-1} \right)^{1-1/\eta} di \right]^{1/(1-1/\eta)} \tag{13}$$

where $c_{i,t}$ is differentiated consumption goods, $m_{i,t-1}$ is stock of external habit, which can be interpreted as customer capital that producer of goods i accumulated. We denote the price of product i as $p_{i,t}$ in terms of aggregate consumption. By solving consumption expenditure minimizing problem of $\int_0^1 P_{i,t} c_{i,t} di$ subject to constraint $X_t = \left[\int_0^1 \left(c_{i,t} - \theta m_{i,t-1} \right)^{1-1/\eta} di \right]^{1/(1-1/\eta)}$, we can derive the demand for product i which is

$$c_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\eta} X_t + \theta m_{i,t-1} \tag{14}$$

in which $P_t \equiv \left[\int_0^1 P_{it}^{1-\eta} di\right]^{\frac{1}{1-\eta}}$ is aggregate price index.

(Evolution of Customer Base) Given the demand function for individual product i, firms can attract additional consumers by undercutting product prices. The mechanism we need to build is that, due to the existence of consumption inertia, firms can enjoy the persistent positive effects on their product demand by reducing their product pricing or providing discounts. In order to incorporate this channel in our model, we assume the following law of motion of evolution of customer base

$$m_{i,t} = \rho m_{i,t-1} + (1-\rho)c_{i,t} \tag{15}$$

The evolution of customer base indicates that the household's current consumption is weighted sum of all of its past consumption. The parameter ρ captures the speed of customer base depreciation. There are four sources of income which can be used to finance the household's consumption: (i) labor income from hours worked, (ii) investment in firms' stocks, (iii) purchase of firms' short-term bonds, (iv) purchase of firms' long-term bonds. The details on the financial instruments will be introduced in the subsequent sections. The household's budget constraint is

$$\mathcal{X}_t + \mathcal{B}_{t+1}^S + \mathcal{B}_{t+1}^L + \mathcal{Q}_t = \mathcal{W}_t \mathcal{L}_t + \mathcal{R}_t^S \mathcal{B}_t^S + \mathcal{R}_t^L \mathcal{B}_t^L + \mathcal{R}^{stock} \mathcal{Q}_{t-1} \tag{16}$$

where $\mathcal{R}_t^S$, $\mathcal{R}_t^L$, $\mathcal{R}^{stock}$ are returns on short-term bond, long-term bond, and stocks which will be defined in the subsequent sections. $\mathcal{W}_t \mathcal{L}_t = W_t \int_i L_{i,t}$ is the household's total labor income, $\mathcal{B}_{t+1}^S = \int_i Q_{i,t}^S B_{i,t+1}^S$ is the total investment in short-term debt, $\mathcal{B}_{t+1}^L = \int_i Q_{i,t}^L B_{i,t+1}^L$ is the total investment in long-term debt, and $\mathcal{Q}_t = \int_i Q_{i,t}$ is total stock holdings. From the household's optimization problem, the stochastic discount factor is given as $\Lambda_{t,t+1} = \beta \frac{U'(C_{t+1})}{U'(C_t)}$.

5.2 Heterogeneous Firm Producers

Each firm $i \in [0,1]$ produces differential goods using labor as input and linear production technology. The production function of firm i at period t is given by

$$y_{i,t} = Al_{i,t} \tag{17}$$

where $y_{i,t}$ is firm produced differentiated good, A denotes constant productivity and $l_{i,t}$ is labor input. Then the firm's operating profit $\Pi_{i,t}$ can be expressed as

$$\Pi_{i,t} = p_{i,t}y_{i,t} - w_t l_{i,t} = (p_{i,t} - \frac{w_t}{A})y_{i,t} \tag{18}$$

where prices for differentiated goods $p_{i,t}$ and wages for labor w_t are both expressed in time t composite good X_t. From the market clearing condition of each differentiated good, we can further express the operating profit $\Pi_{i,t}$ as

$$\Pi_{i,t} = (p_{i,t} - \frac{w_t}{A})y_{i,t} = (p_{i,t} - \frac{w_t}{A})\left[(\frac{p_{i,t}}{P_t})^{-\eta}X_t + \theta m_{i,t-1}\right] \tag{19}$$

Firms can optimally set $p_{i,t}$ to maximize their profits given the nominal aggregate price index $P_t \equiv \left[\int_0^1 P_{it}^{1-\eta}di\right]^{1/(1-\eta)}$, demand for composite good X_t, and the firm's accumulated customer capital $m_{i,t-1}$.

5.3 Debt Financing

Firms have access to financial market and they can finance their operations from two types of debt, short-term bond issuance and long-term bond issuance.

(Short-term Debt) A short-term debt is a promise to pay one unit of composite good along with coupon c after one-period. At the beginning of each period t, the amount of short-term debt outstanding is denoted by $B^S_{i,t}$. The firm need to make the debt payment $(1 + c)B^S_{i,t}$ at the beginning of next period $t + 1$.

(Long-term Debt) A long-term debt is a promise to pay a fraction $\gamma \in (0, 1)$ of the principal along with coupon c after one-period. At the beginning of each period t, the amount of long-term debt outstanding is denoted by $B^L_{i,t}$. In the next period $t+1$, a fraction $(1-\gamma)$ of the bond remains outstanding. The amount of outstanding long-term debt at the beginning of period t is $(1-\gamma)B^L_{i,t}$.

(Debt Issuance Cost) Debt issuance is costly. We assume that there is a linear issuance cost ζ per unit of short-term debt and long-term debt. The functional form for debt issuance cost is given by

$$DIC(B^S_{i,t+1}, B^L_{i,t+1}) = \zeta\left(B^S_{i,t+1} + \ max\{B^L_{i,t+1} - (1-\gamma)B^L_{i,t}, 0\}\right)^2 \tag{20}$$

5.4 Equity Value

Equity holders of firms have the right to collect the firms' dividends as long as the firms are in operation. The dividend is the sum of firm's operating profit $\Pi_{i,t}$ net of debt obligations. Also, the dividend is subject to cash-flow shock which are proportional to the firm's customer capital $m_{i,t-1}$. The dividend can be written by

$$\begin{aligned} d_{i,t} = \Pi_{i,t} - (1+c)B^S_{i,t} - (1+\gamma)B^L_{i,t} - \sigma z_{i,t} m_{i,t-1} + Q^S_{i,t}B^S_{i,t+1} + Q^L_{i,t}(B^L_{i,t+1} - (1-\gamma)B^L_{i,t}) \\ - \zeta \left(B^S_{i,t+1} + \ max\{B^L_{i,t+1} - (1-\gamma)B^L_{i,t}, 0\} \right)^2 \end{aligned}$$

where $p_{i,t} = (p_{i,t} - \frac{w_t}{A}) \left[(\frac{p_{i,t}}{P_t})^{-\eta} X_t + \theta m_{i,t-1} \right]$ and $z_{i,t}$ is an idiosyncratic firm specific cash-flow shock which follows i.i.d standard normal distribution.

The objective of managers of the firm is to maximize the value of firm to its share holders. The value firms to its shareholder can be expressed as

$$\begin{aligned} V\left(z_{i,t}, m_{i,t-1}, B^S_{i,t}, B^L_{i,t}\right) &= \max_{\mathfrak{D}_{i,t}} \left[0, V^C(z_{i,t}, m_{i,t-1}, B^S_{i,t}, B^L_{i,t})\right] \\ &= \max_{\mathfrak{D}_{i,t}} \Bigg\{ 0, \max_{p_{i,t}, B^S_{i,t+1}, B^L_{i,t+1}} \underbrace{(p_{i,t} - \frac{w_t}{A}) \left[(\frac{p_{i,t}}{P_t})^{-\eta} X_t + \theta m_{i,t-1} \right]}_{\text{operating profit}} - \underbrace{(1+c)B^S_{i,t} - (1+\gamma)B^L_{i,t}}_{\text{repayment of debt}} - \underbrace{\sigma z_{i,t} m_{i,t-1}}_{\text{cash-flow shock}} \\ &\quad + \underbrace{Q^S_{i,t}B^S_{i,t+1} + Q^L_{i,t}(B^L_{i,t+1} - (1-\gamma)B^L_{i,t})}_{\text{new debt issuance}} - \underbrace{\zeta \left(B^S_{i,t+1} + \ max\{B^L_{i,t+1} - (1-\gamma)B^L_{i,t}, 0\} \right)^2}_{\text{debt issuance cost}} \\ &\quad + E_t \left[\Lambda_{t,t+1} V\left(z_{i,t+1}, m_{i,t}, B^S_{i,t+1}, B^L_{i,t+1}\right) \right] \Bigg\} \end{aligned} \tag{21}$$

where $m_{i,t} = \rho m_{i,t-1} + (1-\rho) C_{i,t} = \rho m_{i,t-1} + (1-\rho) \left[(\frac{p_{i,t}}{P_t})^{-\eta} X_t + \theta m_{i,t-1} \right]$ and the firm is subject to flow of funds constraint $d_{i,t} \geq 0$

5.5 Timing

The timing of events is given as follows:

(i) **(Default Decision)** Each firm starts period t with cash-flow shock, customer capital, outstanding short-term debt, and long-term debt $(z_{i,t}, m_{i,t-1}, B^S_{i,t}, B^L_{i,t})$. At the beginning, the firm compare the continuation value with 0. If the continuation value is smaller than 0 then the firm decides to default.

(ii) **(Price Setting and Financing Decision)** If the firm does not decide to default, then the firm sets its optimal price and chooses methods of debt financing. The firm can issue both of short-term debt and long-term debt. After its financing decision, then it moves on to the next period $t+1$.

5.6 Debt Pricing

The firm's creditors are risk neutral. They invest in firm's short-term debt and long-term debt as long as the break-even condition of the debt is satisfied. The short-term debt and long-term debt have equal seniority. If the firm chooses to default, we assume the creditors can take over the firm and collect the profits obtained by setting the price level which can preserve the firm's previous customer capital $m_{i,t-1}$. In addition to the collected profits, the creditor can have a claim to the enterprise's unlevered future value. The bankruptcy also entails a one time $\xi\%$ of the firm value. The lenders' zero-profit conditions give the debt pricing kernel as below:

$$
\begin{aligned}
&Q^S_{i,t}(z_{i,t}, m_{i,t-1}, B^S_{i,t+1}, B^L_{i,t+1}) \\
&= E_t\Lambda_{t,t+1}\int_{z_{i,t+1}}\left\{(1-\mathbb{D}_{i,t+1})(1+c)+\mathbb{D}_{i,t+1}\frac{(1-\xi)}{B^S_{i,t+1}+B^L_{i,t+1}}\left[\overline{\Pi_{i,t}}+V(z_{i,t+1}, m_{i,t-1}, 0, 0))\right]\right\}d(z_{i,t+1}) \\
&Q^L_{i,t}(z_{i,t}, m_{i,t-1}, B^S_{i,t+1}, B^L_{i,t+1}) \\
&= E_t\Lambda_{t,t+1}\int_{z_{i,t+1}}\left\{(1-\mathbb{D}_{i,t+1})(\gamma+c+(1-\gamma)Q^L_{i,t+1})+\mathbb{D}_{i,t+1}\frac{(1-\xi)}{B^S_{i,t+1}+B^L_{i,t+1}}\right. \\
&\qquad\qquad\qquad\qquad\qquad\qquad \left.\times\left[\overline{\Pi_{i,t}}+V(z_{i,t+1}, m_{i,t-1}, 0, 0)\right]\right\}d(z_{i,t+1})
\end{aligned}
$$

where $\overline{\Pi_{i,t}} = (P_t\left[\frac{X_t}{(1-\theta)m_{i,t-1}}\right]^{1/\eta} - \frac{W}{A})m_{i,t-1}$

5.7 Numerical Solutions

We first reformulate the value functions with simplified notations:

$$
\begin{aligned}
&V\left(m, B^S, B^L, z\right) = \max_{\mathcal{D}}\left[0, V^C(m, B^S, B^L, z)\right] \\
&= \max_{\mathcal{D}}\left\{0, \max_{p, B^{S'}, B^{L'}}(p-\frac{w}{A})\left[(\frac{p}{P})^{-\eta}X+\theta m\right]-(1+c)B^S-(c+\gamma)B^L-\sigma m z\right. \\
&\qquad +Q^S B^{S'}+Q^L(B^{L'}-(1-\gamma)B^L)-\zeta\left(B^{S'}+\ max\{B^{L'}-(1-\gamma)B^L, 0\}\right)^2 \\
&\qquad \left.+E\left[\Lambda V\left(z', m', B^{S'}, B^{L'}\right)\right]\right\}
\end{aligned} \tag{22}
$$

where $m^{'} = \rho m + (1-\rho)C = \rho m + (1-\rho)\left[(\frac{p}{P})^{-\eta}X + \theta m\right]$, and the threshold of a firm's idiosyncratic cash-flow shock for default satisfies

$$V^C(m, B^S, B^L, z^*) = 0$$

$$\max_{p, B^{S'}, B^{L'}} (p - \frac{w}{A})\left[(\frac{p}{P})^{-\eta}X + \theta m\right] - (1+c)B^S - (1+\gamma)B^L - \sigma m z^* + Q^S B^{S'} +$$

$$Q^L(B^{L'} - (1-\gamma)B^L) - \zeta\left(B^{S'} + \ max\{B^{L'} - (1-\gamma)B^L, 0\}\right)^2 + E\left[\Lambda V\left(z^{'}, m^{'}, B^{S'}, B^{L'}\right)\right] = 0$$

Now the problem to solve can be expressed as

Firm Eqity Value $\quad V(m, B^S, B^L, z) = \max\left[V_D(m, B^S, B^L, z),\ V_C(m, B^S, B^L, z)\right]$

Default $\quad V_D(m, B^S, B^L, z) = 0$

Continuation

$$\begin{aligned} V_C(m, B^S, B^L, z) = & \max_{p, B^{S'}, B^{L'}} (p - \frac{w}{A})\left[(\frac{p}{P})^{-\eta}X + \theta m\right] - (1+c)B^S - (1+\gamma)B^L \\ & - \sigma m z + Q^S B^{S'} + Q^L(B^{L'} - (1-\gamma)B^L) - \zeta\left(B^{S'} + \ max\{B^{L'} - (1-\gamma)B^L, 0\}\right)^2 \\ & + \beta\sum_{z^{'}} \Lambda f(z^{'}) V(z^{'}, m^{'}, B^{S'}, B^{L'}) \end{aligned} \tag{23}$$

In order the to express the firm problem in collocation notations, We first define vectors of state variables to vectorize the state variables in the model. We define $\mathbb{S} = [\vec{s_1}, \vec{s_2}, \vec{s_3}, \vec{s_4}]$ in which

$$\begin{aligned} \vec{s_1} &= \mathbf{1}_{N_S \times N_L \times N_z} \otimes \vec{m} \\ \vec{s_2} &= \mathbf{1}_{N_L \times N_z} \otimes (\vec{B^S} \otimes \mathbf{1}_{N_m}) \\ \vec{s_3} &= \mathbf{1}_{N_z} \times (\vec{B^L} \otimes \mathbf{1}_{N_m \times N_S}) \\ \vec{s_4} &= \vec{z} \times \mathbf{1}_{N_m \times N_S \times N_L} \end{aligned} \tag{24}$$

We express the value function of firms using collocation methods, note that $E[V(\mathbb{S})] = \Phi(\mathbb{S})\vec{c^e}$ and $V_C(\mathbb{S}) = \Phi(\mathbb{S})\vec{c}$, in which

$$\begin{aligned}\Phi(\mathbb{S})\vec{c} = \max_{\vec{p},\vec{B}^{S'},\vec{B}^{L'}} (\vec{p} - \frac{w}{A}) \left[(\frac{\vec{p}}{P})^{-\eta}X + \theta\vec{m}\right] - (1+c)\vec{B}^S - (c+\gamma)\vec{B}^L - \sigma\vec{m}\odot\vec{z} \\ + \vec{Q}^S \odot \vec{B}^{S'} + \vec{Q}^L \odot (\vec{B}^{L'} - (1-\gamma)\vec{B}^L) - \zeta\left(\vec{B}^{S'} + \ max\{\vec{B}^{L'} - (1-\gamma)\vec{B}^L, 0\}\right)^2 \\ + \Lambda\Phi([\vec{m}', \vec{B}^{S'}, \vec{B}^{L'}], \vec{z})\vec{c^e}\end{aligned}$$

$$\begin{aligned}\Phi(\mathbb{S})\vec{c^e} &= (\mathbf{1}_{N_z} \otimes f') \otimes \mathbf{I}_{N_m \times N_s \times N_L} \max\{\vec{\mathbb{O}},\ \Phi(s)\vec{c}\} \\ &= (\mathbf{1}_{N_z} \otimes f') \otimes \mathbf{I}_{N_m \times N_s \times N_L} [\mathbf{I}(s) \odot \mathbb{O} + (\mathbf{1}_N - \mathbf{I}(s)) \odot \Phi(s)\vec{c}]\end{aligned} \tag{25}$$

We solve for the steady-state equilibrium using value function iteration with collocation methods. I discretize the state space $\mathbb{S} = (\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z})$ into $N_m \times N_{B^S} \times N_{B^L} \times N_z$ grid points.

Start Outer Loop

1. We first normalize the aggregate price index $P = 1$, and start with the guess of equilibrium wage rate W^n.

Start Inner Loop

(a) We guess $E[V(\mathbb{S})]^m$ which is equivalent to guessing the coefficient vector $\vec{c^e}^m$. In addition to this, we also guess the pricing kernel for short-term debt and long-term debt $Q^{S,m}$, $Q^{L,m}$. This means that we are iterating the values functions and bond price functions simultaneously.

(b) Given the guess of $E[V(\mathbb{S})]^m$, $Q^{S,m}$, $Q^{L,m}$, we can now solve for the firm's maximization problem which solves for $\vec{p}^{*,m}$, $\vec{B}^{S',*,m}$, and $\vec{B}^{L',*,m}$

(c) After solving the firm's maximization problem, we can compute $V_C^m(\mathbb{S}) = \Phi(\mathbb{S})\vec{c^m}$

(d) Now update $E[V(\mathbb{S})]^{m+1} = \Phi(\mathbb{S})\vec{c^e}^m$, $Q^{S,m+1}$, $Q^{L,m+1}$, and iterate steps (a)-(d) until

$$\left|E[V(\mathbb{S})]^{m+1} - E[V(\mathbb{S})]^m\right| < \varepsilon, \quad \left|Q^{S,m+1} - Q^{S,m}\right| < \varepsilon, \quad \left|Q^{L,m+1} - Q^{L,m}\right| < \varepsilon$$

2. Starting from $\mu_0(\mathbb{S})$, we simulate firms for sufficient periods until the distribution reaches steady state distribution.

3. Compare the market clearing condition of aggregate labor market, and aggregate consumption

$$L_t = \int_i l_i(m, B^S, B^L, z; W, X) di, \quad 1 = \left[\int_i p_i^{1-\eta} di \right]^{\frac{1}{1-\eta}}$$

4. Stop the outer-loop if the market clearing conditions are satisfied, otherwise repeat the outer-loop.

We explain the details of the solution algorithm for simultaneous iteration of value functions and pricing kernels to speed up the computation in Appendix B.

6 Conclusion

In this paper, we study the importance of debt maturity profiles in firms' price setting behaviors. We find that firms adjust their product pricing strategies differently based on their varying debt maturity structures. Specifically, firms with a high proportion of debt that is due within one or two years tend to increase their product prices as a means to increase their revenues. This finding implies that firms strategically adjust their product pricing to fulfill their debt obligations and mitigate rollover risk.

This is the first paper that investigates the relationship between a firm's product pricing and its debt maturity profile. The findings of this paper are particularly important, given that the average debt maturity is significantly shortened during periods of financial crisis.

Moreover, this finding holds substantial policy implications, illuminating the efficacy of the Federal Reserve's unconventional monetary policies, exemplified by the Maturity Extension Program (MEP), as a potent tool in relieving corporate debt roll-over risks. These findings underscore the instrumental role of such policies in advancing the Federal Reserve's objective of maintaining price stability within the U.S. economy.

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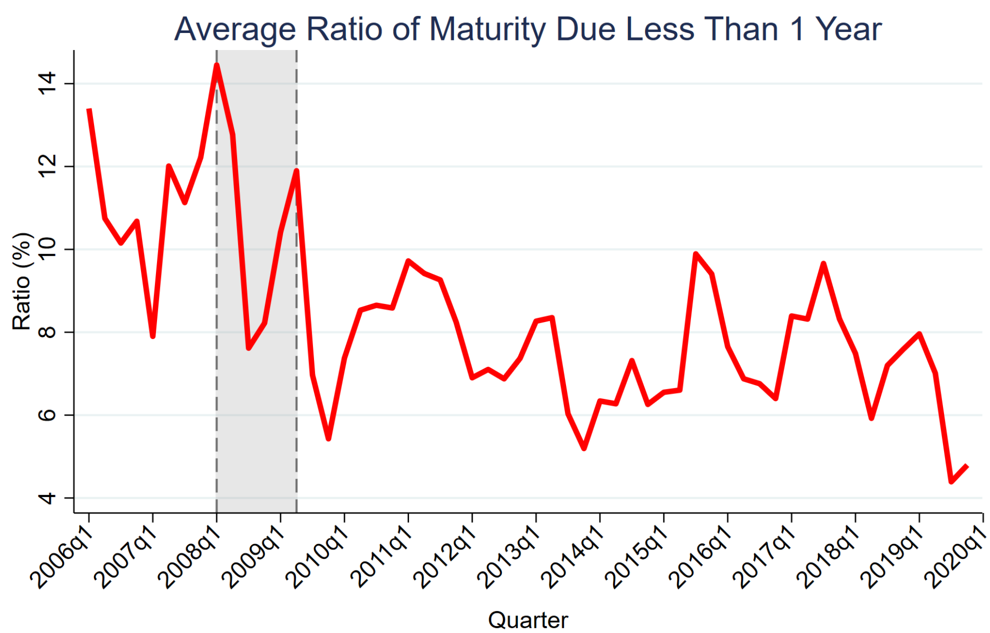
A Appendix

Figure A1: Trend in Firms' Share of Short- and Medium-Term Debt Ratio



Notes: This figure presents the trends in the proportion of short-term debt. The shaded area represents the period of recessions defined by NBER.

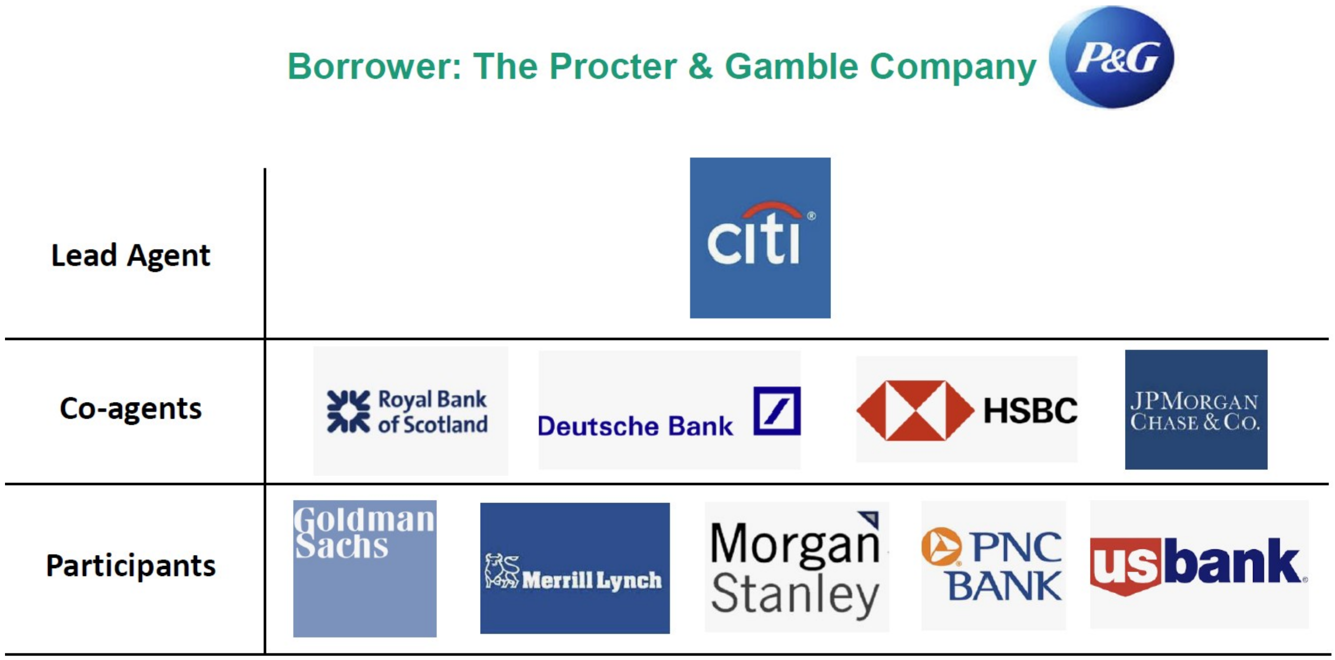
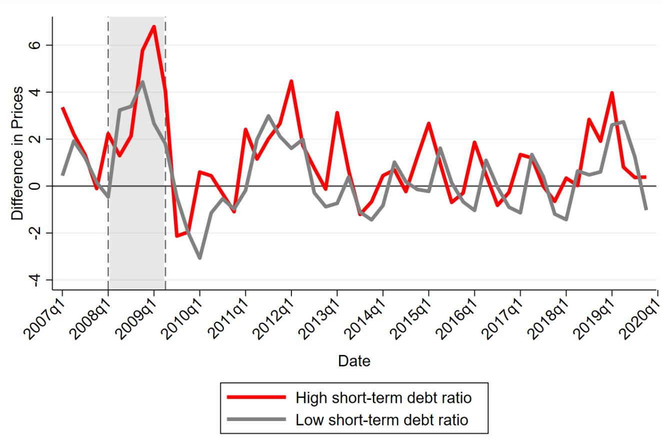


Figure A2: Example of a Syndicated Loan

Figure A3: Price Change Difference With Different Maturity Group

(a) Price Change $(t-3)$, Threshold Between Two Groups: 75



(b) Price Change $(t-3)$, Threshold Between Two Groups: 90

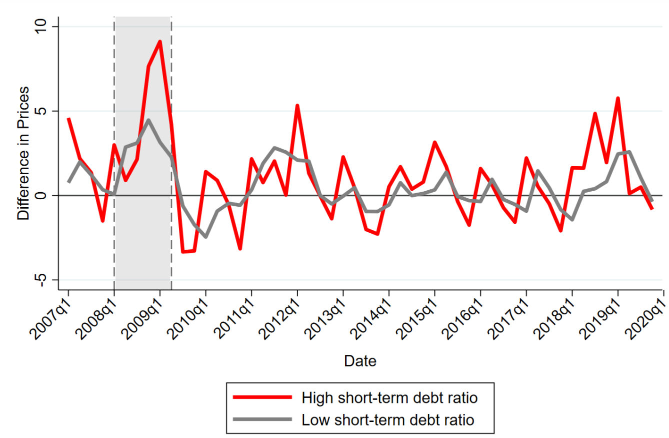


Figure A4: Price Change Difference With Different Maturity Group

(a) Year-over-Year Price Change, Threshold Between Two Groups: 75

(b) Year-over-Year Price Change, Threshold Between Two Groups: 90

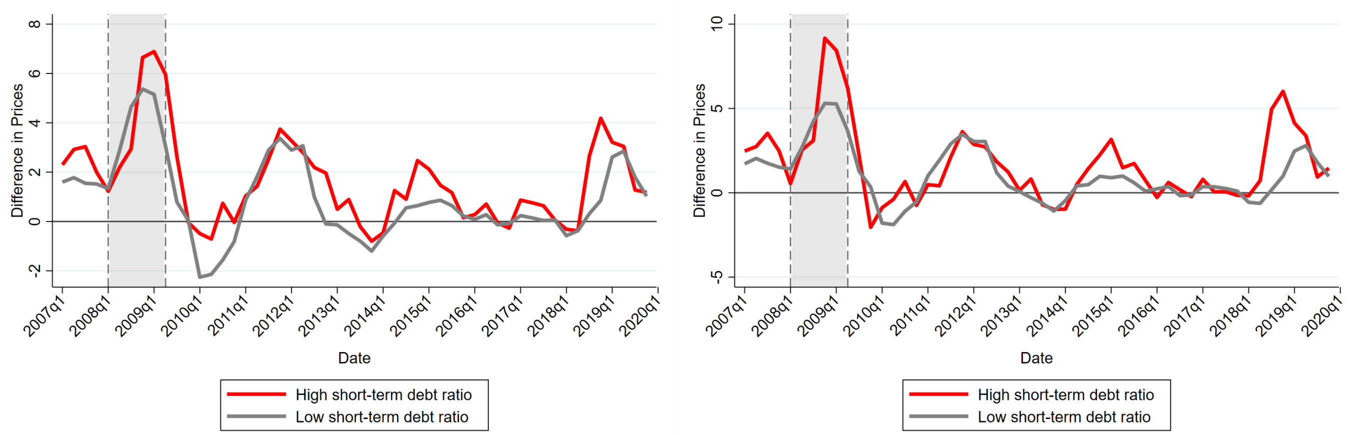


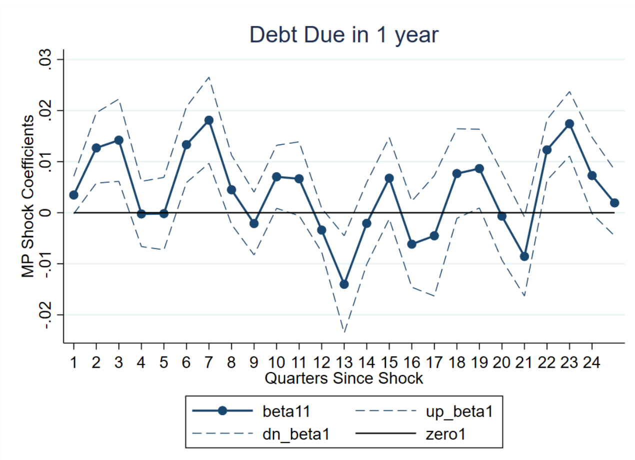
Table A1: Description of Main Variables

Variables	Construction	Source	Reference
Firm Size	$log(total\ assets_{i,t}) = log(ATQ_{i,t})$	Compustat	Alfaro et al. (2018)
Book Leverage	$\frac{total\ debt_{i,t}}{total\ debt_{i,t}+equity_{i,t}} = (\frac{DLCQ_{i,t}+DLTTQ_{i,t}}{DLCQ_{i,t}+DLTTQ_{i,t}+CEQQ_{i,t}}) \times 100$	Compustat	Alfaro et al. (2018)
Market Value	$shares\ outstanding_{i,t} \times stock\ price_{i,t} = CSHOQ_{i,t} \times PRCCQ_{i,t}$	Compustat	Alfaro et al. (2018)
Tobin's Q	$market\ value_{i,t} + total\ assets_{i,t} - equity_{i,t} = \frac{CSHOQ_{i,t} \times PRCCQ_{i,t}+ATQ_{i,t}-CEQQ_{i,t}}{ATQ_{i,t}}$	Compustat	Alfaro et al. (2018)
Cash Holding	$log(cash\ and\ short-term\ investments_{i,t}) = log(CHEQ_{i,t})$	Compustat	Alfaro et al. (2018)
Debt to Asset Ratio	$\frac{total\ debt_{i,t}}{total\ assets_{i,t}} = \frac{DLCQ_{i,t}+DLTTQ_{i,t}}{ATQ_{i,t}}$	Compustat	Alfaro et al. (2018)
Liquidity	$\frac{cash\ and\ short-term\ investments_{i,t}}{total\ assets_{i,t}} = \frac{CHEQ_{i,t}}{ATQ_{i,t}}$	Compustat	Gilchrist et al. (2017)
Inventory to Sales Ratio	$\frac{inventories_{i,t}}{sales_{i,t}} = \frac{INVTQ_{i,t}}{SALEQ_{i,t}}$	Compustat	Gilchrist et al. (2017)
Sales Growth	$log(\frac{sales_{i,t}}{sales_{i,t-4}}) = log(\frac{SALEQ_{i,t}}{SALEQ_{i,t-4}})$	Compustat	Gilchrist et al. (2017)
Cost of Goods Sold Growth	$log(\frac{cost\ of\ goods\ sold_{i,t}}{cost\ of\ goods\ sold_{i,t-4}}) = log(\frac{COGSQ_{i,t}}{COGSQ_{i,t-4}})$	Compustat	Gilchrist et al. (2017)
Debt Due in 1 Year	$\frac{firm\ level\ summation\ of\ debts\ due \leq 12\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 1 to 2 Years	$\frac{firm\ level\ summation\ of\ debts\ due>12\ months\ \&\ \leq 24\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 2 to 3 Years	$\frac{firm\ level\ summation\ of\ debts\ due>24\ months\ \&\ \leq 36\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 3 to 4 Years	$\frac{firm\ level\ summation\ of\ debts\ due>36\ months\ \&\ \leq 48\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 4 to 5 Years	$\frac{firm\ level\ summation\ of\ debts\ due>48\ months\ \&\ \leq 60\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 2 Years	$\frac{firm\ level\ summation\ of\ debts\ due \leq 24\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 3 Years	$\frac{firm\ level\ summation\ of\ debts\ due \leq 36\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 4 Years	$\frac{firm\ level\ summation\ of\ debts\ due \leq 48\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)
Debt Due in 5 Years	$\frac{firm\ level\ summation\ of\ debts\ due \leq 60\ months}{total\ debt}$	Capital IQ	Choi et al. (2018)

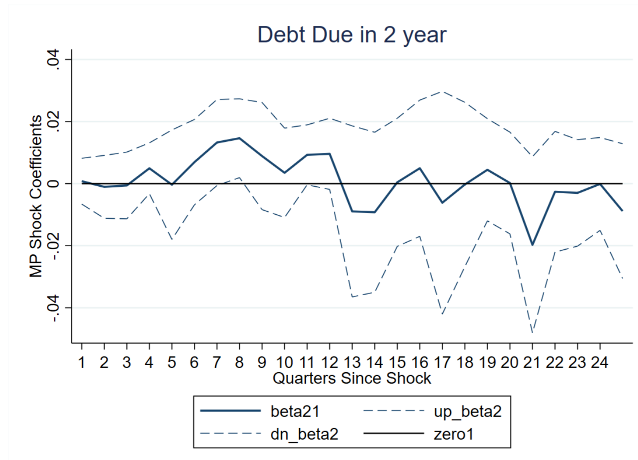
Notes: This table provides explanation on the main firm-level variables that are used in the main specifications.

Figure A5: Price Change Impulse Response to Monetary Policy Shock

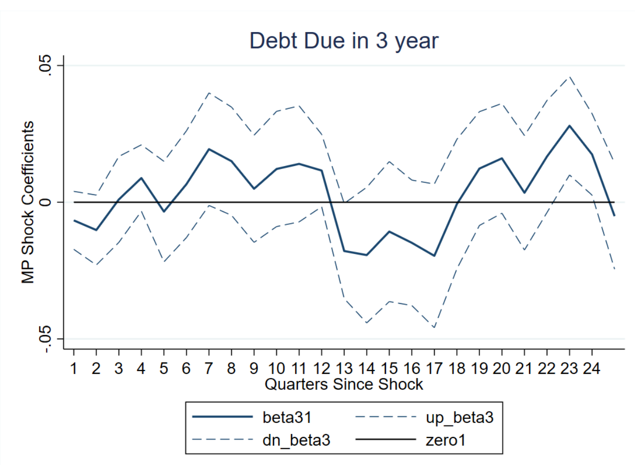
(a) Debt Due within 1 Year



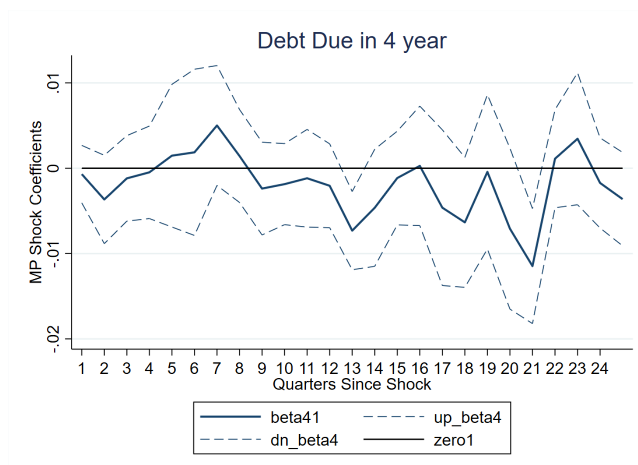
(b) Debt Due within 2 Years



(c) Debt Due within 3 Years



(d) Debt Due within 4 Years



(e) Debt Due within 5 Years

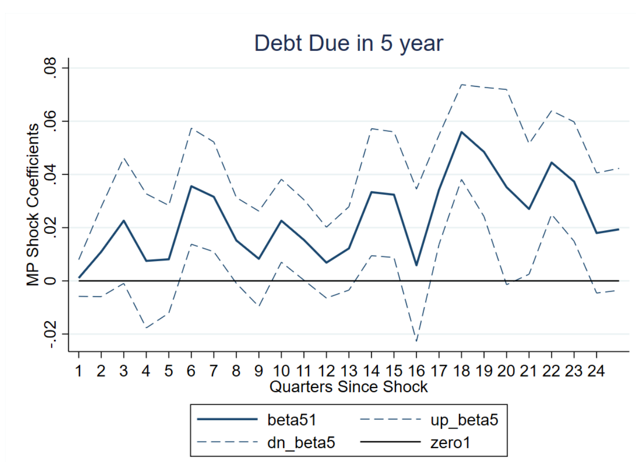
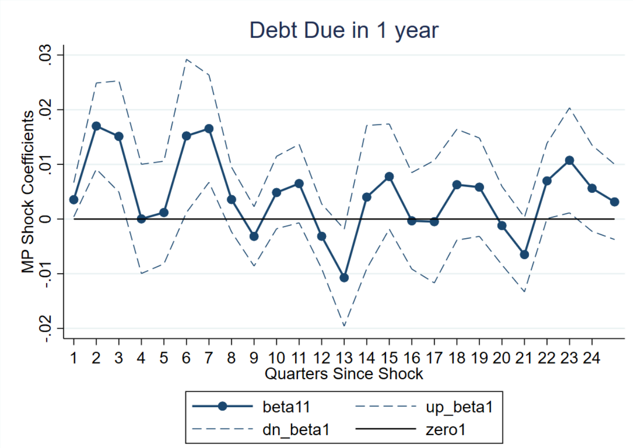
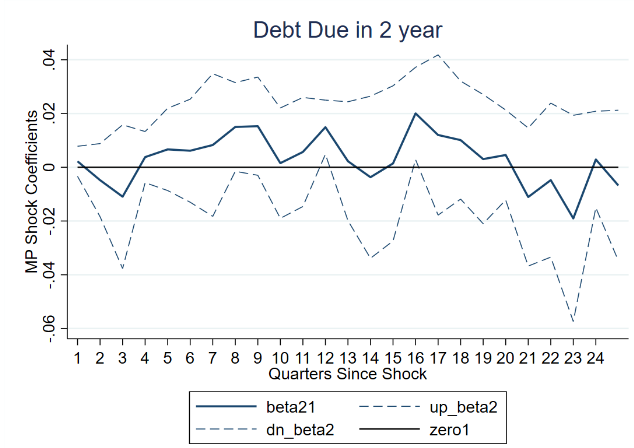


Figure A6: Price Change Impulse Response to Monetary Policy Shock

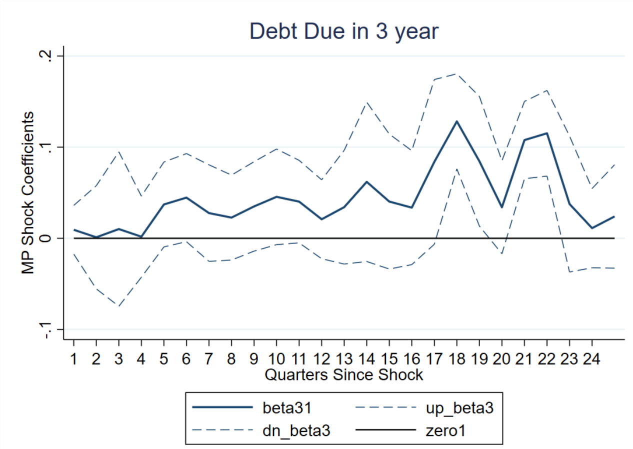
(a) Debt Due within 1 Year



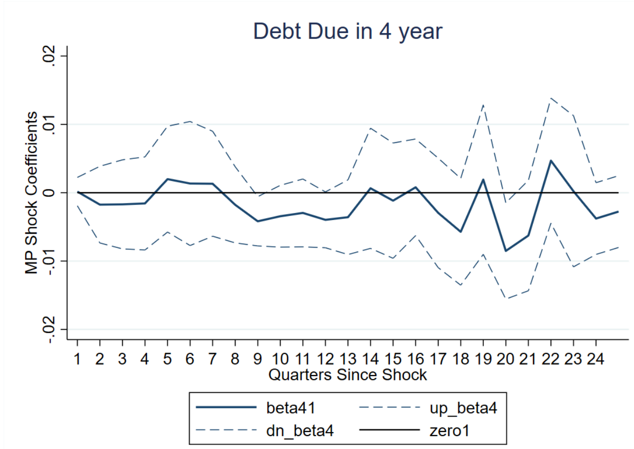
(b) Debt Due within 2 Years



(c) Debt Due within 3 Years



(d) Debt Due within 4 Years



(e) Debt Due within 5 Years

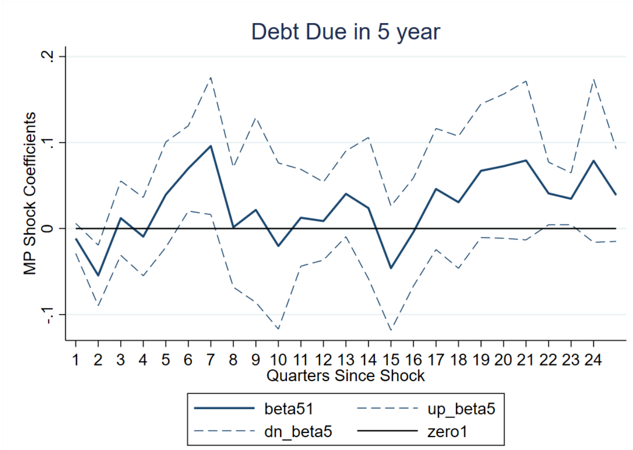
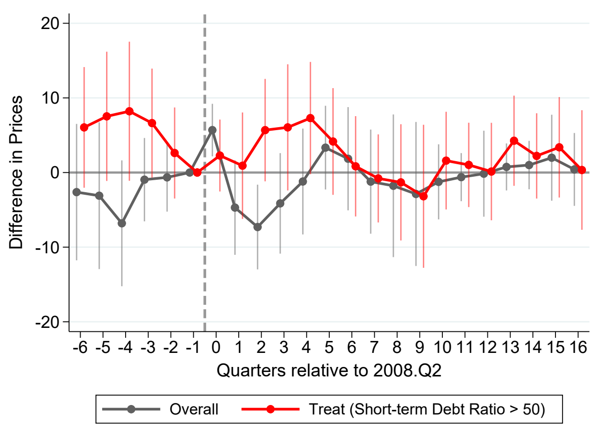


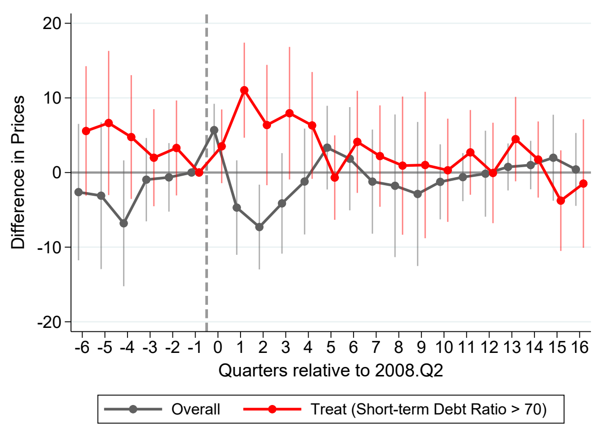
Table A2: Types of Observations in the Capital IQ Data

Outstanding Debt	Maximum Limit of Debt
Accrued Interest	N/A
Bank Loans	N/A
Bank Overdraft	Bank Overdraft
Bills Payable	Bills Payable
Bonds and Notes	N/A
Commercial Paper	Commercial Paper
Commercial Paper in RC Facility	N/A
Debentures	N/A
Debt Adjustments	N/A
Federal Funds Purchased	Federal Funds Purchased
Federal Home Loan Bank Borrowings	Federal Home Loan Bank Borrowings
Federal Reserve Bank Credit	Federal Reserve Bank Credit
General Borrowings	N/A
Lease Liabilities	N/A
Letters of Credit	Letters of Credit
Mortgage Bonds	N/A
Mortgage Loans	N/A
Mortgage Notes	N/A
Notes Payable	Notes Payable
Other Borrowings	N/A
Preferred Securities	N/A
Revolving Credit	Revolving Credit
Securities Loaned	N/A
Securities Sold Under Agreement to Repurchase	N/A
Securitization Facility	Securitization Facility
Term Loans	Term Loans
Unamortized Discount: Mortgage Notes	N/A

Notes: This table records all of the debt types in the Capital IQ data. Some debts have both of the outstanding amount and its maximum limit of credit lines. N/A refers to the maximum limit of credit line is not applicable in that case.

Figure A7: Heterogeneous Effect of Credit Supply Shock





B Solution Algorithm

Period T

We solve the model using backward induction. In the last period T, the firm makes decision on default base on the value

$$\begin{aligned} V_T(\mathcal{S}) &= V_T(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z}) \\ &= \max_{\vec{\mathcal{D}}_T} \left[\vec{\mathcal{O}},\ \max_{\vec{P}_T} (\vec{P}_T - \frac{W}{A})[(\vec{P}_T)^{-\eta} X_T + \theta \vec{m}_T] - (c+1)\vec{B}^L - \sigma \vec{m}_T \vec{z}_T \right] \end{aligned}$$

Then for each state (row element) in $\mathcal{S}$ we can calculate the default threshold by

$$\overrightarrow{z}^*_T = \frac{(\vec{P}^*_T - \frac{W}{A})[(\vec{P}^*_T)^{-\eta} X_T + \theta \vec{m}_T] - (c+1)\vec{B}^L}{\sigma \vec{m}_T}$$
$$\text{where } \vec{P}^*_T \text{ solves } \max_{\vec{P}_T} (\vec{P}_T - \frac{W}{A})[(\vec{P}_T)^{-\eta} X_T + \theta \vec{m}_T]$$

This shows that the default threshold $\overrightarrow{z}^*_T$ at period T is dependent on $(\vec{m}_T, \vec{B}^L)$ which are determined through the choices on $(\vec{P}_{T-1}, \vec{m}_T, \vec{B}^L)$ at period $T-1$.

In each given state, if $z_T < z^*_T$ the firm chooses not to default, otherwise, it chooses to default. Through this decision rules, we can compute the value function $V_T(\mathcal{S}) = V_T(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z})$

Period T-1

(1) We first look at the pricing function $\overrightarrow{Q}^L_{T-1}(\mathcal{S}) = \overrightarrow{Q}^L_{T-1}(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z})$. Since we have calculated the default threshold for each state at period T, we are able to calculate the price of long-term debt it issues at period T-1 through the pricing function

$$\overrightarrow{Q}^L_{T-1}(\mathcal{S}) = \Phi(\mathcal{S})\overrightarrow{C}^L = \mathbb{1}(\vec{z} < \overrightarrow{z}^*_T)(1+c)$$

We can update $\overrightarrow{C}^L_{Ini}$ for $\overrightarrow{C}^L_{T-1}$ from the above equation.

(2) Now given $\overrightarrow{C}^L_{T-1}$ and $\overrightarrow{C}^e_{Ini}$, we can solve for the maximization problem in period T-1

$$
\begin{aligned}
V^C_{T-1} &= V^C_{T-1}(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z}) \\
&= \Phi(\mathcal{S})\vec{C}_{T-1} \\
&= \max_{\vec{P}_{T-1}, \vec{m}_T, \vec{B}^L_T} (\vec{P}_{T-1} - \frac{W}{A})[(\vec{P}_{T-1})^{-\eta} X_T + \theta \vec{m}_{T-1}] - (c+1)\vec{B}^S_{T-1} - (c+\gamma)\vec{B}^L_{T-1} - \sigma \vec{m}_T \vec{z}_T \\
&\quad + \overrightarrow{Q}^L_{T-1}[\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}] - \zeta[max\{\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}, 0\}]^2 + \Lambda\Phi([\vec{m}_T, \vec{B}^S_T, \vec{B}^L_T, z_{T-1}])\overrightarrow{C}^e_{Ini}
\end{aligned}
$$

where function $\overrightarrow{Q}^L_{T-1}$ is as defined in (1)

(3) From the equation in (2), we can solve for $\vec{C}_{T-1}$ and update $\vec{C}_{Ini}$ for $\vec{C}_{T-1}$. Then using the updated $\vec{C}_{T-1}$ we can find

$$
V_{T-1}(\mathcal{S}) = \max_{\vec{\mathcal{D}}_{T-1}}[\vec{\mathcal{O}}, V^C_{T-1}(\mathcal{S})] = \max_{\vec{\mathcal{D}}_{T-1}}[\vec{\mathcal{O}}, \Phi(\mathcal{S})\vec{C}_{T-1}]
$$

From the decision rule on default, we can also find the threshold for default $\overrightarrow{z}^*_{T-1}$

(4) Now, we need to update $\overrightarrow{C}^e_{Ini}$. In order to do this, we utilize the expectation equation as below

$$
\begin{aligned}
V^e_{T-1}(\mathcal{S}) &= \Phi(\mathcal{S})\overrightarrow{C}^e_{T-1} \\
&= (\mathbb{1}_{N_z} \otimes f') \otimes I_{N_m \times N_S \times N_L}[\vec{\mathcal{D}}_{T-1} \odot \vec{\mathcal{O}} + (\mathbb{1}_N - \vec{\mathcal{D}}_{T-1}) \odot \Phi(\mathcal{S})\vec{C}_{T-1}]
\end{aligned}
$$

From the equation above, we can finally update $\overrightarrow{C}^e_{Ini}$ for $\overrightarrow{C}^e_{T-1}$.

(5) We store all of the updated ($\overrightarrow{C}_{T-1}$, $\overrightarrow{C}^e_{T-1}$, $\overrightarrow{C}^L_{T-1}$) from the maximization process in period T-1, and the threshold for default $\overrightarrow{z}^*_{T-1}$.

Period T-2

(1) We examine both of the short-term bond and long-term bond pricing function $\overrightarrow{Q}^L_{T-2}(\mathcal{S}) = \overrightarrow{Q}^L_{T-2}(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z})$ and $\overrightarrow{Q}^S_{T-2}(\mathcal{S}) = \overrightarrow{Q}^S_{T-2}(\vec{m}, \vec{B}^S, \vec{B}^S, \vec{z})$. In the previous step, since we have calculated the default threshold for each state at period T-1, we derive the equation of the pricing functions according to the rules

$$
\begin{aligned}
\overrightarrow{Q}^S_{T-2}(\mathcal{S}) &= \Phi(\mathcal{S})\overrightarrow{C}^S = \mathbb{1}(\vec{z} < \overrightarrow{z}^*_{T-1})(1+c) \\
\overrightarrow{Q}^L_{T-2}(\mathcal{S}) &= \Phi(\mathcal{S})\overrightarrow{C}^L = \mathbb{1}(\vec{z} < \overrightarrow{z}^*_{T-1})(\gamma + c + (1-\gamma)\overrightarrow{Q}^L_{T-1}(\mathcal{S})) \\
&= \mathbb{1}(\vec{z} < \overrightarrow{z}^*_{T-1})(\gamma + c + (1-\gamma)\Phi(\mathcal{S})\overrightarrow{C}^L_{T-1})
\end{aligned}
$$

Now we can update $(\overrightarrow{C}^S_{T-1}, \overrightarrow{C}^L_{T-1})$ for $(\overrightarrow{C}^S_{T-2}, \overrightarrow{C}^L_{T-2})$ from the above equation.

(3) Now given $\overrightarrow{C}^L_{T-1}$, $\overrightarrow{C}^S_{T-1}$ and $\overrightarrow{C}^e_{T-1}$, we can solve for the maximization problem in period T-2

$$\begin{aligned}
V^C_{T-2} &= V^C_{T-2}(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z}) \\
&= \Phi(\mathcal{S})\vec{C}_{T-2} \\
&= \max_{\vec{P}_{T-2}, \vec{m}_{T-1}, \vec{B}^S_{T-1}, \vec{B}^L_{T-1}} (\vec{P}_{T-2} - \frac{W}{A})[(\vec{P}_{T-2})^{-\eta} X_{T-2} + \theta \vec{m}_{T-2}] - (c+1)\vec{B}^S_{T-2} - (c+\gamma)\vec{B}^L_{T-2} \\
&\quad - \sigma \vec{m}_{T-2}\vec{z}_{T-2} + \overrightarrow{Q}^S_{T-2}\vec{B}^S_{T-1} + \overrightarrow{Q}^L_{T-2}[\vec{B}^L_{T-1} - (1-\gamma)\vec{B}^L_{T-2}] \\
&\quad - \zeta[max\{\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}, 0\} + \vec{B}^S_{T-2}]^2 + \Lambda\Phi([\vec{m}_{T-1}, \vec{B}^S_{T-1}, \vec{B}^L_{T-1}, z_{T-2}])\overrightarrow{C}^e_{T-1} \\
&\text{where function } \overrightarrow{Q}^S_{T-2} = \Phi([\vec{m}_{T-1}, \vec{B}^S_{T-1}, \vec{B}^L_{T-1}, z_{T-2}])\overrightarrow{C}^S_{T-2} \\
&\qquad\qquad\qquad \overrightarrow{Q}^L_{T-2} = \Phi([\vec{m}_{T-1}, \vec{B}^S_{T-1}, \vec{B}^L_{T-1}, z_{T-2}])\overrightarrow{C}^L_{T-2}
\end{aligned}$$

(3) Again, from the equation in (2), we can solve for $\vec{C}_{T-2}$ and update $\vec{C}_{T-1}$ for $\vec{C}_{T-2}$. With the updated $\vec{C}_{T-2}$ we can find

$$V_{T-2}(\mathcal{S}) = \max_{\vec{\mathcal{D}}_{T-2}}[\vec{\mathcal{O}}, V^C_{T-2}(\mathcal{S})] = \max_{\vec{\mathcal{D}}_{T-2}}[\vec{\mathcal{O}}, \Phi(\mathcal{S})\vec{C}_{T-2}]$$

By comparing the continuation value and default value, we can find the threshold for default $\overrightarrow{z}^*_{T-2}$

(4) Net, we need to update $\overrightarrow{C}^e_{T-1}$. In order to do this, we utilize the expectation equation as below

$$\begin{aligned}
V^e_{T-2}(\mathcal{S}) &= \Phi(\mathcal{S})\overrightarrow{C}^e_{T-2} \\
&= (\mathbb{1}_{N_z} \otimes f') \otimes I_{N_m \times N_S \times N_L}[\vec{\mathcal{D}}_{T-2} \odot \vec{\mathcal{O}} + (\mathbb{1}_N - \vec{\mathcal{D}}_{T-2}) \odot \Phi(\mathcal{S})\vec{C}_{T-2}]
\end{aligned}$$

From the equation above, we can finally update $\overrightarrow{C}^e_{T-1}$ for $\overrightarrow{C}^e_{T-2}$.

(5) After all of the steps before, We store all of the updated $(\overrightarrow{C}_{T-2}, \overrightarrow{C}^e_{T-2}, \overrightarrow{C}^L_{T-2})$ from the maximization process in period T-2, and the threshold for default $\overrightarrow{z}^*_{T-2}$.

Iterative Procedures

After the optimization procedures in period T-2, we can now proceeds iteratively until all of the value function and pricing functions converge. This procedure allows us to iterate value functions and pricing kernels simultaneously to speed up the iteration process.