Corporate Debt Maturity and Output Price Dynamics*

Minseog Kim[†] Geunyong Park[‡]

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Abstract

This paper investigates the effect of firms' debt maturity composition on their product pricing behaviors. To empirically examine this, we construct a novel micro-level dataset that links product prices with data on manufacturers' debt maturity schedules. By leveraging both a quasi-exogenous credit supply shock and a monetary policy shock, we show that firms with higher short-term debt ratios increase product prices more substantially when refinancing of maturing debt becomes more costly and refinancing options are limited. Our findings suggest that firms respond to refinancing challenges by strategically raising prices to mitigate rollover risk. To rationalize these results, we develop a dynamic firm model where firms issue both short- and long-term debt to finance operations in the face of negative cash-flow shocks. In our model, firms set prices strategically, which in turn affects the accumulation of customer capital. The results indicate that under increased debt repayment pressure and unfavorable refinancing conditions, firms raise product prices to mitigate rollover risk, even at the cost of losing future customers. Overall, our findings underscore the critical role of debt maturity profiles in shaping firms' product pricing decisions.

JEL classification: D11, D12, D21, D22, E31, G32
Keywords: Credit Supply, Customer Capital, Debt Maturity, Product Pricing, Rollover Risk

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[†]Department of Economics, University of Texas at Austin. Email: minseog.kim@utexas.edu.
[‡]Department of Strategy and Policy, National University of Singapore. Email: gpark17@nus.edu.sg.

"About a year ago, the FOMC introduced a variation on its earlier purchase programs, known as the maturity extension program (MEP), under which the Federal Reserve would purchase $400 billion of long-term Treasury securities and sell an equivalent amount of shorter-term Treasury securities over the period ending in June 2012. The FOMC subsequently extended the MEP through the end of this year. By reducing the average maturity of the securities held by the public, the MEP puts additional downward pressure on longer-term interest rates and further eases overall financial conditions."

— Ben S. Bernanke (2012):

Monetary Policy since the Onset of the Crisis, At the Federal Reserve Bank of Kansas City Economic Symposium, Jackson Hole, Wyoming

1 Introduction

There has long been an interest among economists and policymakers in the effects of financial frictions on firms' pricing decisions. Previous studies exploring this question have primarily focused on financial frictions such as liquidity, leverage, credit access, and firm characteristics like size or age (Gilchrist et al., 2017; Kim, 2020; Lenzu et al., 2022; Renkin and Züllig, 2024; Balduzzi et al., 2024). However, there is a lack of evidence on how a firm's debt maturity structure affects its pricing strategies. Our study aims to fill this gap by examining the effect of a firm's maturity structure on its output pricing, providing important insights into the broader economic implications of financial conditions.

A firm's debt maturity structure is a particularly important aspect of financial frictions, as it can impose substantial financial pressures in two key ways. First, as firms approach their debt repayment dates, they face considerable pressure to either repay or refinance their obligations, which increases rollover risk. When financial conditions worsen, credit suppliers may become reluctant to offer new loans or refinance existing debt, raising the firm's default risk due to limited access to funding. Second, the cost of refinancing or issuing new debt can become burdensome. If unfavorable market conditions force firms to rollover maturing debt at significantly higher interest rates or issuance costs, this creates additional financial burdens. These two dimensions of debt management highlight the substantial pressures debt maturity structures can introduce, which may ultimately shape firms' pricing decisions.

During periods of severe financial distress, increased concerns about firms' default risk lead financial intermediaries to become increasingly reluctant to extend medium- to long-term loans, as such lending is perceived as highly risky. In our data, we observe a nearly 30% decline in firms' remaining debt maturities following the 2008 financial crisis. As a result, firms face significant refinancing challenges during financial turmoil, particularly those with substantial short-term debt or obligations maturing in the near term. Firms with a high concentration of short-term debt experience acute distress, as refinancing becomes difficult, and even when achievable, it comes at a significantly higher cost. This is further exacerbated by rising borrowing costs, as evidenced by a steep increase in corporate bond spot rates during periods of financial crisis.[1]

In our empirical analysis, we find that firms' pricing responses to credit supply shocks vary greatly based on their debt maturity profiles. Using a difference-in-differences event study model, we show that firms with substantial debt obligations maturing within one year tend to raise their product prices in reaction to negative credit supply shocks, relative to firms with a lower share of short-term repayment obligations. This divergence in pricing strategies underscores the important role of short-term debt repayment pressures in shaping firms' pricing strategies under negative financial conditions.

Our findings help reconcile the varied results in recent literature examining the relationship between financial frictions and firms' product pricing strategies. Recent papers find that firms facing financial constraints tend to raise product prices as a strategy to increase revenue and mitigate financial distress (Gilchrist et al., 2017; Renkin and Züllig, 2024; Balduzzi et al., 2024). In contrast, Kim (2020) and Lenzu et al. (2022) find that firms facing credit constraints tend to lower product prices to boost internal cash flows, thus increasing liquidity during credit crunch periods. Our findings indicate that firms facing imminent debt repayment obligations adopt a more short-term outlook by raising prices to quickly increase cash flow. In contrast, firms without immediate debt repayment pressures avoid raising their product prices, aiming to retain future customers and protect their market share. Through the lens of debt maturity structures, our analysis explains how immediate debt repayment pressures may shape firms' pricing responses to

[1]For instance, during the 2008-2009 financial crisis, the high-quality market (HQM) corporate bond spot rates surged substantially across all maturities.

financial constraints, bridging the gap between disparate findings in earlier research.

We develop a dynamic heterogeneous firm model incorporating endogenous default, debt maturity, and customer capital to rationalize the empirical relationship between corporate debt maturity schedules and pricing decisions. The results from this model indicate that firms facing greater short-term debt repayment pressure raise their product prices, even at the risk of losing future customers. Moreover, when two firms have the same amount of total outstanding debt, the firm with a higher proportion of short-term debt increases its product prices more. In addition, the model shows that firms with greater exposure to cash-flow shocks raise product prices more, as the severity of these shocks increases the firm's default risk if the firm cannot collect a sufficient amount of revenues.

Moreover, we perform a counterfactual analysis by comparing two economies with differing required repayment ratios on outstanding debt principals. We find that in economies with a higher required debt repayment ratio, the stationary equilibrium becomes more dependent on short-term debt, resulting in a reduced average debt maturity in the economy. This, in turn, resulted in a higher economy-wide price level associated with the shortened average debt maturity observed in our counterfactual analysis.

These findings have significant implications regarding the Federal Reserve's Maturity Extension Program (MEP). Following the Fed's implementation of MEP, our data indicate that firms substantially extended their average debt maturities, with overall inflation remaining notably low after the crisis. Our counterfactual analysis aligns with this observation, suggesting that the Fed's intervention facilitated debt maturity extensions across firms, thereby alleviating pressures related to imminent repayment schedules and reducing inflationary pressures economy-wide.

Several challenges arise in examining how a firm's debt maturity schedule affects its product pricing decisions. A first challenge in our research is the need for extensive data to effectively examine this issue. This requires detailed information on both firms' debt maturity structures and their product pricing behavior in product markets. The scarcity of such granular data presents a significant hurdle to empirical analysis.

To address this challenge, we construct a novel dataset that links firms' debt maturity schedules, their banking relationships, and product pricing across various outlets. In particular, our dataset integrates the following sources. First, firm-level debt maturity data from Capital IQ, which provides comprehensive coverage of the debt capital structure of all U.S. public firms. Importantly, the dataset specifies exact maturity dates, enabling us to construct detailed maturity schedules at any point in time. Second, we combine this with Dealscan data to capture firm-level credit supply shocks, following the methodology in Chodorow-Reich (2014) and Kim (2020). Dealscan tracks firms' borrowings from the syndicated loan market, allowing us to analyze each firm's banking relationships and exposure to credit market disruptions. Third, for product pricing, we utilize Nielsen Retail Scanner data, which records point-of-sale information from various retail outlets.[2] Finally, we merge this dataset with Compustat data to obtain firm-level balance sheet and income statement information.

The second challenge in our analysis lies in the fact that debt maturity is an endogenous variable that firms actively manage. Since a firm's debt structure influences its cost of financing, it is critical for firms to optimize their debt structure to maximize profits while minimizing financing costs. Colla et al. (2020) provide a comprehensive survey on firms' capital structure decisions. This endogeneity complicates identification, making it difficult to establish a causal link between a firm's debt maturity profile and its impact on product pricing.

To address the endogeneity issue in firms' debt maturity schedules, we construct firm-level credit supply shocks, following the approach of Chodorow-Reich (2014) and Kim (2020). Using Dealscan data, which provides detailed loan-level information from the syndicated loan market, we identify the banks involved in each firm's financing arrangements. In the credit market, switching banks is costly due to inefficiencies and information asymmetries—a phenomenon widely documented in the literature on bank switching costs (Kim et al., 2003; Vesala, 2007; Liaudinskas, 2023; Gopalan et al., 2011). As a result, firms find it difficult to switch financial intermediaries when their primary banks face distress. We exploit this to construct an exogenous measure of firm-level credit supply shocks by tracking the health of banks and firms' exposure to these banks based on prior lending relationships. This approach allows us to identify the causal impacts of a firm's debt maturity structure on its product pricing behavior during the financial crisis.

[2] Since Nielsen data lacks manufacturer identifiers, we use GS1 US Data Hub to link each UPC to its corresponding manufacturer.

We find that corporate debt maturity profiles significantly influence firms' product pricing behavior. Using firm-level credit supply shocks during the 2008-2009 financial crisis as an exogenous shock to financial conditions, We document that firms with a larger share of debt maturing in the near term make different pricing decisions compared to firms with a smaller share of debt maturing soon. Specifically, firms facing tighter repayment constraints tend to raise product prices more than those with extended repayment horizons. To estimate this, we construct a firm-by-store-by-product-group price difference index, comparing the pre-Lehman period (2007.Q4 to 2008.Q2) with the post-Lehman period (2008.Q4 to 2009.Q2). Our results strongly indicate that firms with imminent debt repayment deadlines adjust prices more aggressively than firms with longer-term repayment obligations, highlighting the significant impact of debt maturity structure on pricing decisions.

We also conduct an event study analysis comparing price changes between two groups of firms to investigate the dynamic impact of debt maturity schedules on firms' product pricing behaviors. We classify firms with a short-term debt ratio above 60% as the treatment group and those with a ratio below 60% as the control group. Our findings reveal that firms with a higher ratio of short-term debt tend to increase their product prices relative to those with a lower ratio. These results underscore the important role of debt maturity schedules in shaping product pricing strategies. Notably, our findings reconcile with the mixed evidence in the literature regarding the effect of financial constraints on pricing behavior.

To further isolate the role of debt maturity profiles in firms' product pricing decisions and examine their pricing responses to rising refinancing costs, we leverage monetary policy shocks for our analysis. Firms with different maturity schedules are likely to respond differently to interest rate changes depending on the term structure of their debt. Short-term interest rate fluctuations are expected to have a greater impact on firms with significant short-term borrowing, whereas medium- to long-term interest rates more strongly affect firms with long-term debt. To address this, we employ the monetary policy shock decomposition from Swanson (2021), which separates monetary policy shocks into a federal funds rate factor (target) and a forward guidance factor (path). Firms with predominantly short-term debt are likely to be more sensitive to the target factor, while those with more long-term debt should respond more to the path factor. This approach allows us to identify how monetary policy transmission varies across firms with different debt structures.

Using local projection estimation as in Jordà (2005), we find that the target factor of a monetary policy shock primarily influences firms' pricing behavior through the short-term debt channel. In contrast, the path factor of monetary policy impacts pricing decisions via medium- to long-term debt. Our results demonstrate that firms with concentrated debt maturities are more sensitive to monetary policy shocks, as these shocks exert differential effects across interest rate maturities. Consequently, firms with shorter-term debt schedules exhibit the most pronounced adjustments in their product pricing.

Lastly, a key challenge in developing a dynamic heterogeneous model lies in the model's requirement for firms to set strategic pricing dynamically while simultaneously selecting optimal capital structures, which introduces heterogeneity into firms' debt maturity schedules.

To analyze the role of a firm's debt maturity structure in its product pricing behavior, we develop a dynamic firm model that incorporates corporate debt maturity profiles into pricing decisions. Our model incorporates the deep habit framework from Ravn et al. (2006) and Gilchrist et al. (2017), which allow firms to build customer capital based on their pricing strategies. Since future customer capital depends on current pricing decisions, firms face a dynamic trade-off: they can either exploit their existing customer base to maximize current profits or sacrifice short-term profits to accumulate more customer capital for future periods. This dynamic framework enables firms to strategically set prices while accounting for the long-term effects on customer capital.

To integrate pricing decisions with debt maturity management, we introduce two types of financing: short-term debt, which must be repaid in the subsequent period, and long-term debt, which requires only partial repayment in each period. To maintain tractability while incorporating both short-term and long-term debt into the model, we follow a capital structure framework similar to that in Leland (1994). Firms are also subject to cash-flow shocks, and upon observing the realized cash-flow shock and their current debt obligations, they make strategic pricing decisions. Specifically, firms may choose to leverage their existing customer base to mitigate rollover risk or reduce prices to build future customer capital at the expense of current profits. This model allows us to analyze firms' pricing strategies under different conditions, including financial market shocks, varying debt obligations, the optimal accumulation of customer capital, and the risk of default.

Our paper is closely related to several strands of the literature. First, we build on existing research examining the relationship between financial frictions and firms' product pricing behaviors (see, e.g., Gilchrist et al. (2017); Kim (2020); Lenzu et al. (2022); Renkin and Züllig (2024); Balduzzi et al. (2024)). Prior studies have largely explored how financial constraints influence pricing through factors such as liquidity, leverage, credit access, and firm characteristics like size or age. Our study extends this literature by investigating the role of a firm's debt maturity structure in shaping its pricing strategies. To our knowledge, this is the first study to examine product pricing through the lens of debt maturity structures, providing a novel perspective on how the timing of debt repayment pressures influences firms' pricing decisions. As Farre-Mensa and Ljungqvist (2016) notes, traditional measures of financial constraints, such as those developed in Kaplan and Zingales (1997) and Whited and Wu (2006), may not fully capture the complexities of financial pressure. Our study highlights how debt repayment schedules and the structure of a firm's debt maturities introduce a critical dimension to understanding financial constraints, influencing firms' product pricing decisions.

Our paper also helps reconcile differing findings in the existing literature on how financial constraints impact firms' pricing decisions. Some studies (e.g., Gilchrist et al. (2017); Renkin and Züllig (2024); Balduzzi et al. (2024)) suggest that financial constraints lead firms to raise prices, while others (e.g., Kim (2020); Lenzu et al. (2022)) report the opposite effect. We bridge these findings by showing that firms without imminent debt repayment obligations tend to lower their prices to boost revenue—consistent with the "inventory firesale" channel discussed in Kim (2020). In contrast, firms facing substantial debt repayment pressure within the coming year increase their prices to generate immediate revenue, even if this strategy risks eroding future customer capital and market share.

Furthermore, existing studies that use dynamic firm models to explore how financial constraints impact pricing decisions frequently rely on simplified assumptions, such as limiting firms to equity issuance as their sole source of financing (e.g., Gilchrist et al. (2017); Dou and Ji (2021)), largely for the sake of model tractability. Such assumptions, however, may mask the influence of diverse debt maturity structures on firms' pricing strategies and, consequently, on aggregate inflation dynamics. Our model addresses this gap by incorporating both short-term and long-term debt as distinct financing options, thereby capturing the implications of diverse debt maturity structures on firm-level pricing behaviors and economy-wide price dynamics.

Our paper also connects to the literature on the “missing deflation puzzle” during the financial crisis and the “missing inflation puzzle” after the crisis. Studies like Coibion and Gorodnichenko (2015) and Bianchi and Melosi (2017) examine the missing deflation by focusing on inflation expectations, while Christiano et al. (2015) and Del Negro et al. (2015) attribute the missing deflation to financial frictions. Additionally, Mineyama (2023) and Iwasaki et al. (2021) analyze downward wage rigidities as explanations for these inflation puzzles.

This paper offers a unified framework to explain these inflation puzzles through shifts in firms’ average debt maturity during and after the financial crisis, linking debt maturity structures to firms’ pricing decisions. A shorter debt maturity horizon can increase debt repayment pressures, potentially driving firms to raise prices and thereby muting the expected deflationary effects during the crisis. Conversely, the lengthened average debt maturities—supported by the Fed’s unconventional monetary policies, such as quantitative easing and the Maturity Extension Program—eased repayment pressures after the crisis, contributing to lower-than-expected inflation for an extended period. Additionally, our study sheds light on how Fed policies, specifically the Maturity Extension Program, shaped inflation dynamics after the financial crisis.

Lastly, our paper is related to the literature examining the impact of firms’ debt maturity profiles on the transmission channels of monetary policy. For instance, Poeschl (2023) and Jungherr and Schott (2021) study optimal debt maturity and its implications over the business cycle. Jungherr et al. (2022) shows that firms with more maturing debt are more responsive to monetary policy shocks, while Deng and Fang (2022) finds that firms holding more long-term debt exhibit lower sensitivity to monetary policy shocks. While most of the existing literature focuses on how debt maturity structures influence firms’ investment decisions, our paper examines a new perspective by highlighting the role of debt maturity structures in shaping firms’ product pricing behavior.

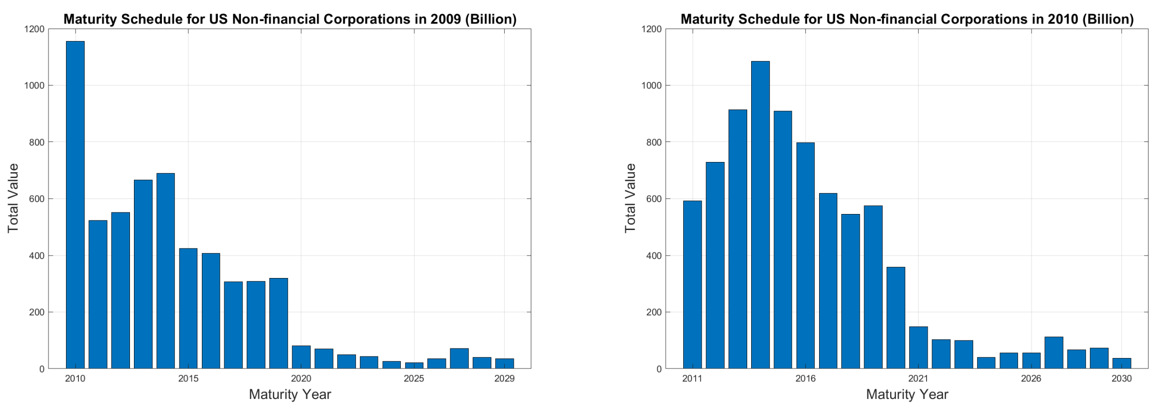
2 Stylized Facts

This section provides stylized facts on how the financial crisis impacted firms' debt maturity structure. The facts and background discussed here are important as they outline a plausible mechanism through which a firm's debt maturity structure can influence its strategic product pricing behavior.

First, we present evidence that when financial market conditions become unfavorable, firms face increasing difficulty in maintaining their optimal debt maturity profiles. As balancing repayment schedules becomes more challenging, firms experience increased pressure to meet their debt obligations. Second, even when firms manage to secure financing, the cost of borrowing rises substantially during financial turmoil. The increase in refinancing costs as existing debt matures imposes additional burdens on firms.

Figure 1: Cumulative Corporate Debt Maturity Schedule

(a) Year 2009 (b) Year 2010



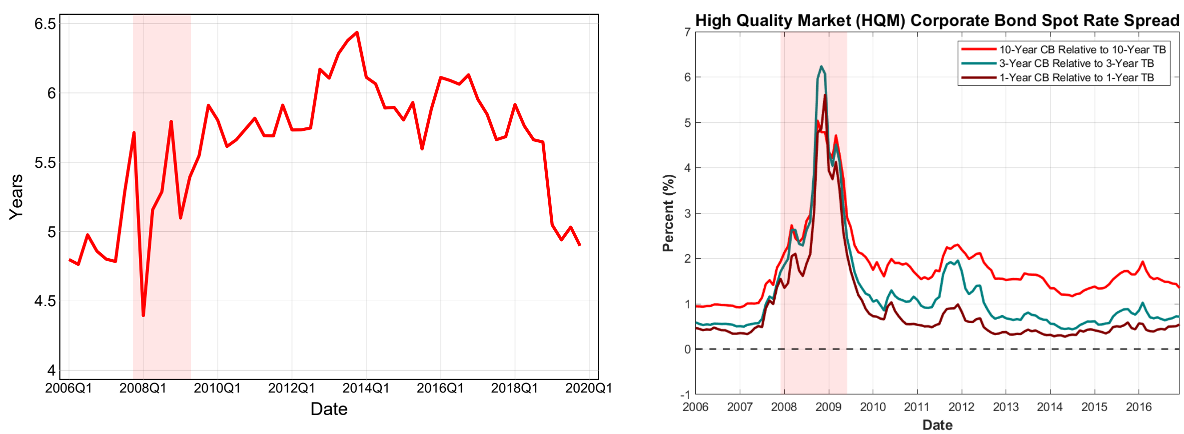
Notes: This figure shows the cumulative amount of corporate debt maturing each year. Panels (a) and (b) display the debt maturity schedules based on snapshots from the end of 2009 and 2010, respectively. Each bar represents the total amount of debt (in billions) maturing in a given year. The data is sourced from the Capital IQ database, with observations lacking maturity date information excluded from the analysis. Only non-financial corporations are included in the analysis.

Panels (a) and (b) in Figure 1 present snapshots of the maturity schedules of U.S. non-financial firms. Each bar in the graphs represents the total remaining outstanding debt in each year, measured in USD billions. Panel (a) displays the maturity profile as of the end of 2009, revealing a significant concentration of debt maturing in 2010. The large volume of debt set to mature within one year underscores the potential stress on firms, raising concerns about their ability to refinance or roll over their upcoming debt obligations.

In contrast, Panel (b) shows the maturity profile at the end of 2010, following a period of gradual financial recovery. Here, the skewness observed in Panel (a) is reduced, with a lower concentration of debt maturing in 2011. The distribution is more balanced, with a substantial portion of debt maturing between 2013 and 2015. This shift suggests that firms have been able to extend their debt maturities, alleviating immediate rollover risks and providing them with greater financial flexibility. The more evenly distributed maturity schedule in Panel (b) indicates a reduction in short-term debt pressures, allowing firms more room to manage their obligations and mitigate the risk of default.

Figure 2: Debt Maturity Trend and Corporate Bond Spreads

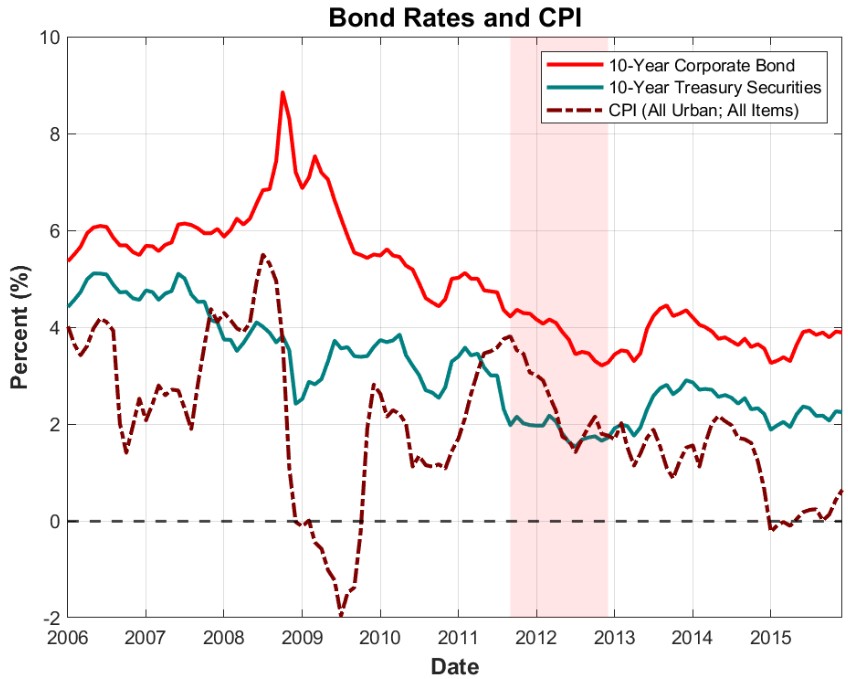
(a) Maturity Due Remaining (Years) (b) Trends of Corporate Bond Spread



Notes: Panel (a) in this figure displays the time trend of the weighted average remaining maturity, measured in years, where weights are based on debt amounts. Data is sourced from the Capital IQ database, excluding observations without maturity date information, and includes only non-financial corporations. Panel (b) shows the trend in corporate bond spreads, calculated as the difference between the high-quality market (HQM) corporate bond spot rate and the treasury bond rate, with data obtained from FRED. The shaded areas in both panels indicate recession periods as identified by the NBER.

The heightened rollover risk during the financial crisis is further evidenced in Panels (a) and (b) of Figure 2. Panel (a) illustrates the time trends in firms' weighted average remaining debt maturities, measured in years. The shaded area indicates the recession period as defined by the NBER. A notable observation is the significant shortening of the average remaining maturity during periods of financial distress. Particularly in the first quarter of 2008, there was a sharp decline in the average debt maturity, likely driven by increased caution from banks in extending long-term loans and refinancing for firms needing to roll over their debt.

Figure 3: Corporate Bond Spot Rates and CPI



Notes: This figure shows the time trends of the 10-year corporate bond spot rate in the high-quality market (HQM), the 10-year Treasury bond rate (both sourced from FRED), and the Consumer Price Index (CPI) for all urban consumers and items, obtained from the Bureau of Labor Statistics (BLS). The shaded area indicates the periods when the Federal Reserve's Maturity Extension Program (MEP) was in effect. In September 2011, the Federal Open Market Committee (FOMC) announced a $400 billion MEP, scheduled for completion by the end of June 2012. In June 2012, the FOMC extended the program through the end of 2012, involving an additional $267 billion in treasury securities purchases, sales, and redemptions.

As the financial distress subsided, the remaining years to debt maturity gradually increased, with a marked extension from the first quarter of 2012 onward. This extension in debt maturities suggests that firms faced less rollover risk compared to the crisis period, benefiting from a more favorable financial environment with reduced pressures to meet short-term obligations.

Moreover, in addition to the difficulties firms face in finding lenders willing to roll over their debt and extend their maturity profiles, the situation is exacerbated by the rising rollover costs during periods of financial distress. This is illustrated in Panel (b) of Figure 2, which displays the spread between spot rates of corporate bonds in the high-quality market (HQM) and treasury bond across various maturities. The figure shows a significant increase in spreads for corporate bonds across all maturities during adverse economic conditions. This surge in borrowing costs indicates that firms not only struggle to secure financing from intermediaries but also face significantly higher costs even when they succeed in obtaining the necessary financial resources.

Furthermore, the increase in spreads is more pronounced for medium-term (3-year) and long-term (10-year) corporate bonds compared to short-term (1-year) bonds. This disparity suggests that it is particularly costly for firms to smooth their debt repayment schedules to avoid a concentration of obligations maturing within a short time frame. Such conditions impose additional challenges on firms trying to maintain their desired debt maturity structures during times of economic uncertainty.

Lastly, we present suggestive evidence suggesting that firms' debt maturity structures are closely tied to their pricing behavior, offering insights into the "missing deflation puzzle" during the financial crisis and the "missing inflation puzzle" in the post-crisis period. Figure 3 shows a sharp decline in the CPI rate during the financial crisis, followed by a swift rebound, stabilizing around 2% in the subsequent years. From the perspective of firms' debt maturity management, this pattern can be partly attributed to the challenges firms face in sustaining prolonged periods of low pricing. The financial market conditions during the crisis made it difficult for firms to maintain balanced debt maturity structures at low financing costs.

In the post-crisis period, as depicted in Figure 3, the environment is characterized by persistently low corporate bond spot rates, accompanied by firm's longer average debt maturities as shown in Panels (a) of Figure 1. This change can be linked to the Federal Reserve's accommodative monetary policies, including quantitative easing and the Maturity Extension Program (MEP), which put downward pressure on long-term interest rates. These policies created a more favorable financial environment, enabling firms to manage their debt maturities more effectively and access longer-term financing at lower costs.

The shaded region in Figure 3 marks the period of the MEP, during which the Federal Reserve aimed to support economic recovery by easing financial conditions for firms. This program allowed firms to more easily balance their debt maturities and reduce refinancing costs, providing a "golden period" where firms could issue long-term debt with minimal financial strain. A notable feature of the post-crisis CPI trend in this figure is the persistent containment of inflation below 2%, coinciding with the accommodative financial conditions during the quantitative easing and MEP period. This suggests that the more favorable financing environment reduced firms' incentives to raise prices, as they were better able to maintain optimal maturity structures and access low-cost funding when refinancing or rolling over maturing debt.

3 Data

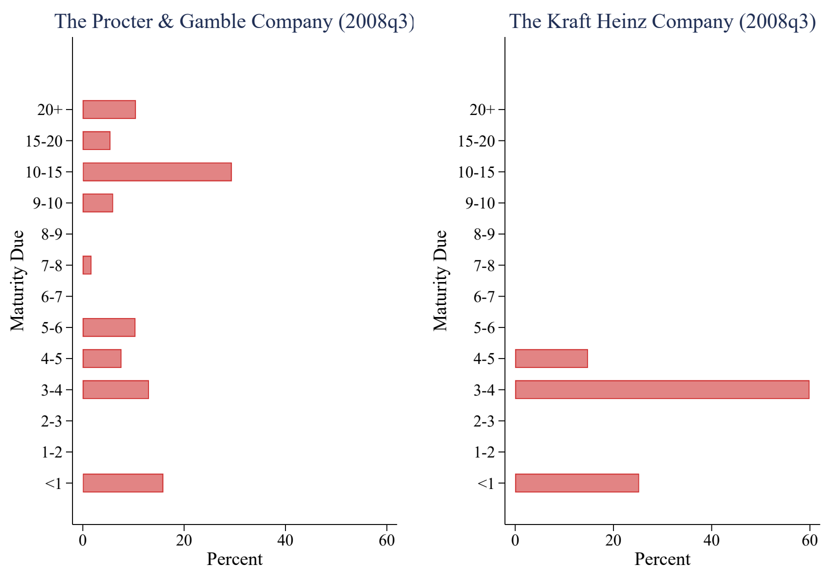
In this section, we describe in detail the sources of data to investigate the relationship between debt maturity profile and product pricing empirically. We construct a novel dataset that links detailed firm-level borrowing data, including maturity information, with the firm's product pricing data.

3.1 Capital IQ Data

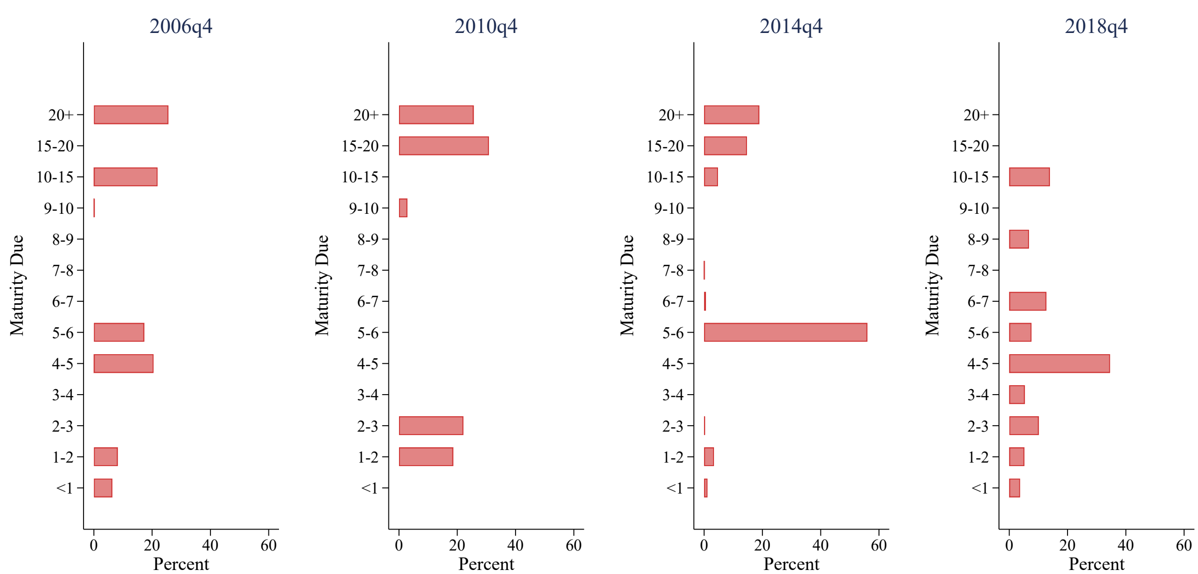
We utilize the S&P Capital IQ database to provide a detailed, quarterly snapshot of each firm's debt maturity schedule. S&P Capital IQ database records extensive information on companies' debt capital structure. The data provides item-level information, which includes a description of the debt, the start 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. We implement several steps to enhance the accuracy and reliability of the data. The S&P Capital IQ data contains many duplicate entries, making it crucial to filter out duplicates and retain a single unique observation per loan, company, and quarter. The specific steps taken to eliminate numerous duplicate entries using the available information are detailed in the Appendix. 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. The details of the data cleaning steps are provided in Appendix A. After cleaning the Capital IQ data, we constructed a quarter-by-firm maturity profile dataset. For each firm in a given quarter, we can track the detailed maturing schedule of its total debt. Figure 4 illustrates that each firm has a unique maturity schedule over time, showing substantial variation not only between firms within the same quarter but also across quarters within the same firm.

Figure 4: Maturity Structure

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



(b) Maturity Structure of The Kraft Heinz Company



Notes: This figure presents the maturity structures of Kimberly-Clark and P&G across different quarters. The maturity data in each graph reflects the snapshot at the specified quarter. Each bar represents the ratio of debt maturing within a specified year range to the total debt held by the firm at the time of the snapshot. The data is calculated from Capital IQ.

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

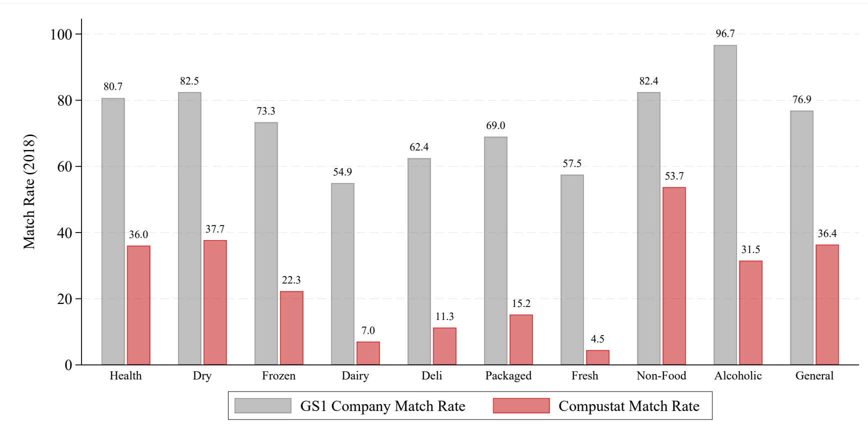
UPC code consists of 13 digits of the number, and each UPC code can identify a unique product registered by the producer through the GS1 US system. Among the 13 digits of the number, the first 6 to 11 digits are company prefix that corresponds to the producer who registered UPC codes to their products 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. We also manually checked the validity of the matching in the final step of the matching. The matching rate is shown in Figure 5.

Figure 5: Match Rate Between Nielsen & GS1 & Compustat

(a) Match Rate of Year 2006

(b) Match Rate of Year 2018



Notes: This figure presents the matching rates between Nielsen, GS1 US Data Hub, and Compustat. The gray bar represents the percentage of UPCs matched between Nielsen Retail Scanner Data and GS1, while the red bar represents the percentage of UPCs matched between Nielsen and Compustat. Panels (a) and (b) show the matching percentages for the years 2006 and 2018, respectively.

The consistency of the matching rate over time (comparing the matching rates from 2006 to 2018) shown in Figure 5 confirms the robustness of our matching algorithm. The figure demonstrates that a substantial number of UPC barcodes in the Nielsen data can be linked to their manufacturers. However, as not all manufacturers are public companies, only a portion of them can be matched with Compustat, which provides balance sheet data for U.S. public companies. Categories such as Dairy, Deli, and Fresh generally have lower match rates, likely due to the difficulty in identifying manufacturers for products like bread and fresh vegetables.

Since only a portion of the Nielsen barcode-level data is matched to the public firms analyzed in this paper, questions may arise regarding the representativeness of our dataset. Does our data reflect the overall economy? To address this, we construct a firm-level price index and compare it with the official CPI rate released by the Bureau of Labor Statistics (BLS) to assess the representativeness of our data.

We follow an approach similar to Leung (2021) to construct store-by-firm-by-product-group and firm-by-product-group price indices using the matched sample. However, unlike Leung (2021), which does not match the Nielsen Retail Scanner data with Compustat, our analysis takes an additional step by constructing firm-level price indices based on the matched data. In our dataset, we exclude UPCs that do not appear consistently throughout the entire sample period to ensure that results are not biased by store entry and exit. We also retain only those UPCs that are observed continuously across each year. Given that Nielsen Retail Scanner data is recorded weekly, we aggregate the prices of each UPC to a quarterly level by calculating the quarterly price as the total sales in each quarter divided by the total quantity sold. The store-by-product-group price index $P^L_{j,t,y}$ 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 $P^L_{f,j,t,y}$ is constructed as:

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

Following Leung (2021), the quantity weights $q_{i,y}$, and $q_{f,i,y}$ are updated annually to prevent chain drift. We additionally use one-year lagged quantity weights to ensure that price changes are not driven by shifts in product demand or consumption patterns in response to price fluctuations and local shocks. The store-evel price index is computed in both of chain method and the Tornqvist method:

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

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

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

To check the validity of the constructed price data, we compare the CPI index that we construct from Nielsen Retail Scanner data to the official CPI index from Bureau of Labor Statistics (BLS). Figure 6 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.

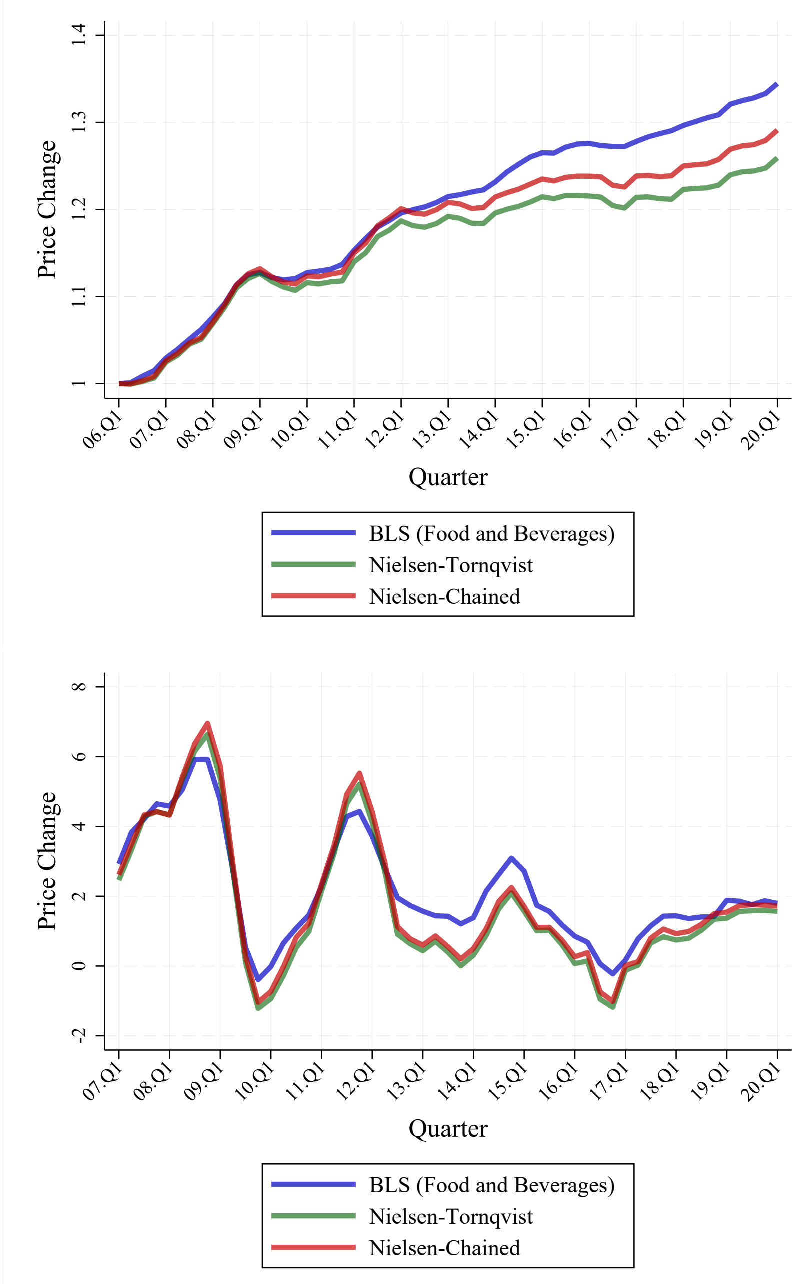
3.3 Dealscan Data

To construct a firm-level idiosyncratic credit supply shock, we incorporate Dealscan data into our analysis. Dealscan provides detailed information on firms' borrowings from the syndicated loan market, offering valuable insights into firms' existing lender relationships and how they might be impacted by the financial health deterioration of these lenders. We retain only observations for loans where the primary borrowing purpose is 1) General Purpose, 2) Equipment Upgrade/Construction, 3) Purchase of Software/Services, or 4) Working Capital. Additionally, we include only original deals, excluding observations that record amendments to the original loans. Following Chodorow-Reich (2014), we identify the lead agent and participants for each deal and use lender role information to estimate each lender's loan share within the tranche when specific tranche share data is unavailable.

3.4 Compustat Data

Firms' financial information is sourced from Compustat data, which comprises comprehensive records of public firms' balance sheets 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,

Figure 6: Price Index Comparisons



Notes: This figure illustrates the price index constructed from Nielsen Retail Scanner data using both the chained and Tornqvist methods. The index is based on store-firm level data, weighted by store sales. For comparison, the BLS price index is included, using the "Food and Beverages" series for U.S. city averages across all urban consumers, obtained from the Bureau of Labor Statistics.

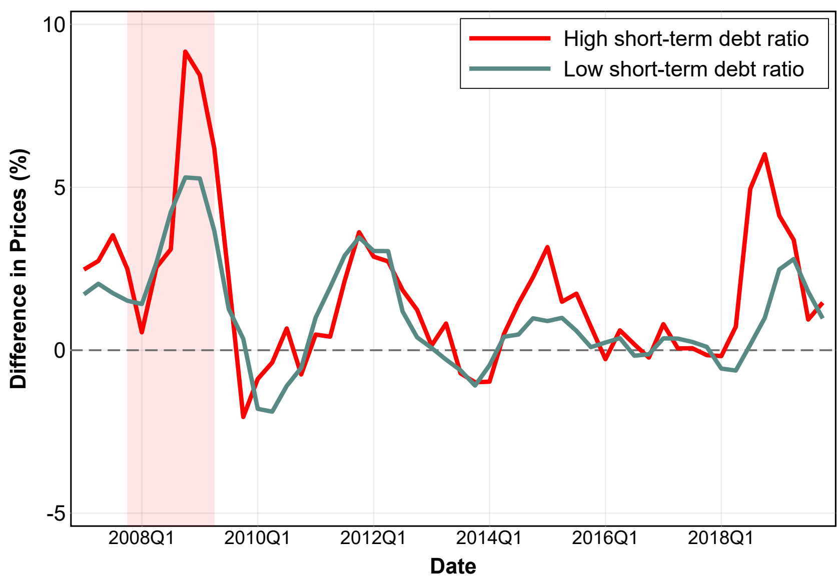
we keep observations that correspond to the current fiscal year to maintain consistency in the analysis.

4 Empirical Analysis

4.1 Descriptive Analysis

In this section, we present suggestive evidence that firms facing more imminent debt repayments attempt to mitigate rollover risk by raising product prices. Figure 7 shows the price change dynamics for two groups of firms. Firms are divided into two groups based on the ratio of debt maturing within one year to their total debt, with a 90% threshold for classification. Trends using alternative thresholds are provided in Appendix Figure A3.

Figure 7: Heterogeneity in the Dynamics in Output Prices Based on Short-term Debt Ratio



Notes: This figure shows year-over-year price changes for two different firm groups, based on matched data from the Nielsen and Capital IQ databases. Firms are categorized into "high short-term debt ratio" and "low short-term debt ratio" groups. The "high short-term debt ratio" group consists of firms with more than 90% of their total debt maturing within one year, while the "low short-term debt ratio" group includes firms with less than 90% of their debt maturing within one year.

Figure 7 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. Several potential channels may explain the divergent patterns of price changes between the two groups of firms. In subsequent analysis, we demonstrate that differences in the composition of debt maturities play a significant role in driving these varying price change patterns.

This suggestive 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.

We first use the specification below to investigate the importance of debt maturity in a firm's price-setting behavior during the financial crisis:

$$\Delta P_{fgs} = \alpha_f + \gamma_g + \lambda_s + \beta \mathbf{D_f} + \theta \mathbf{X_f} + \varepsilon_{fgs}, \tag{5}$$

where the dependent variable ΔP_{fgs} is the change in prices between the pre-crisis period (2007.Q4–2008.Q2) and the post-crisis period (2008.Q4–2009.Q2) for product group g produced by firm f at store s. The specification includes fixed effects for firms, product groups, and stores. The main coefficient of interest, β, captures the effect of debt maturity structure on changes in output prices. The vector D_f indicates firm f's debt maturity composition, specifying the proportions due within each of the next five years: within 1 year, between 1 and 2 years, between 2 and 3 years, between 3 and 4 years, and between 4 and 5 years. In line with previous research, we also control for a variety of firm characteristics, including firm size, book leverage, Tobin's Q, cash holding, and the total debt-to-asset ratio of a firm. We also include additional controls following Gilchrist et al. (2017), such as liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The analysis in Gilchrist et al. (2017) emphasizes the liquidity channel's influence on the firm's price-setting behavior. By incorporating the controls used in Gilchrist et al. (2017), we examine whether debt maturity has an effect on output prices even after accounting for the liquidity channel. 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 A3.

The main results are presented in Table 1. As shown in columns (1)–(5), the effect of the ratio of short-term debt on output price changes is statistically significant at the 1% or 5% significance level across all columns, even after controlling for various firm

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

	(1)	(2)	(3)	(4)	(5)
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)
Firm Controls	Y	Y	Y	Y	Y
Store Fixed Effects	Y	Y	Y	Y	Y
Product Group Fixed Effects	Y	Y	Y	Y	Y
Observations	3,781,504	3,781,504	3,781,504	3,781,504	3,781,504
R^2	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). Firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, 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. The definition of each variable can be found in Appendix Table A3.

controls. Specifically, in column (1), the result indicates that a 1 percent point increase in short-term debt ratio, due within one year, is associated with an approximate 0.06 percent point increase in product price changes. This finding aligns with our previous results in Figure 7, 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.[3] For the robustness check, Appendix Table A4 presents the results when employing an accumulated measure of debt ratio instead of using debt maturity bins. The results are consistent with

[3]Although not reported in Table 1, the signs of the of estimated results of the maturity related variables 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.

our previous observations, indicating that short-term debt has positive effects on a firm's price change. In particular, the results of the Appendix Table A4 demonstrates that this positive relationship becomes less significant when we include relatively long-term debt.

4.2 Credit Supply Shock

Given that a firm's debt maturity is an endogenous decision, the results presented in section 4.1 may still leave questions about causality. To address this, in this section, we construct a firm-level credit supply shock and perform a difference-in-differences event study analysis to investigate how firms' price-setting behavior varies with debt maturity structure during the financial crisis.

Before presenting the main specification used in this section, we first explain the construction of the firm-level credit supply shock. We construct the credit supply shock at the firm level following the approach of Chodorow-Reich (2014) and Kim (2020). 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. The pre-Lehman period is selected from 2007.Q4 to 2008.Q2.

We use Dealscan data to construct a firm-level credit supply shock. An example deal from Dealscan is illustrated in Appendix Figure A1, 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, we 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 with which a specific firm had established relationships prior to the Lehman failure, we calculate the deterioration in the health of these banks during the financial crisis. The change in the health of the banks with which a firm has established relationships is defined as follows:

$$\Delta(\text{ Bank Health })_{-f,b} = \frac{\sum_{j\neq f} \alpha_{jb,\text{ post}} \times \mathbb{1}(b \text{ lent to } j \text{ post-Lehman })}{\frac{1}{2}\sum_{j\neq f} \alpha_{jb,\text{ pre}} \times \mathbb{1}(b \text{ lent to } j \text{ pre-Lehman })}. \tag{6}$$

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.

Since we have calculated the deterioration in bank health for each bank with which the firm has established a relationship, we can now proceed to calculate the firm-level credit supply shock as follows:

$$\Delta L_f = \sum_{b\in S_f} \alpha_{fb,\text{ last}}\, \Delta(\text{ Bank Health })_{-f,b}. \tag{7}$$

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.

We now extend Equation 5 from subsection 4.1 by introducing a credit supply shock measure, where the idiosyncratic firm-level credit supply shock is interacted with the debt ratio across various maturities. The specification incorporating the credit supply shock is as follows:

$$\Delta P_{fgs} = \alpha_f + \gamma_g + \lambda_s + \beta(-\Delta L_f)\mathbf{D_f} + \theta\mathbf{X_f} + \varepsilon_{fgs}. \tag{8}$$

All terms are the same as in Equation 5, with the only difference being the inclusion of the firm-level credit supply shock measure, ΔL_f. We place a minus sign, $-\Delta L_f$, so that a positive value of $-\Delta L_f$ represents a negative credit supply shock. The main coefficient of interest, β, captures the effect of debt maturity structure on changes in output prices.

Table 2 presents the estimation results of Equation 8, incorporating the credit supply shock constructed as described above. Comparing these results with those in Table 1, we find notable differences. Columns (1)–(5) 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 less statistically significant in column (1), it becomes much more statistically significant when other debt maturities are included. In columns (2) to (5), 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 1.1 to 1.3 percentage points. These results indicate a meaningful impact of the credit supply shock and short-term debt ratio on the firm's price dynamics.

In Appendix Table A5, we explore an alternative measure of accumulated debt ratio due in two years, three years, four years, and five years for the robustness check. 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

Table 2: Effects of Debts with Various Maturities on Price Change (Credit Supply Shock)

	(1)	(2)	(3)	(4)	(5)
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)
Firm Controls	Y	Y	Y	Y	Y
Store Fixed Effects	Y	Y	Y	Y	Y
Product Group Fixed Effects	Y	Y	Y	Y	Y
Observations	3,708,820	3,708,820	3,708,820	3,708,820	3,708,820
R^2	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). Firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, 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. The definition of each variable can be found in Appendix Table A3. The shock variable is defined as in Equation 5 and Equation 8.

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.

Event study analysis. 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 it 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 event study model that takes the following form:

$$100 * \left(\frac{P_{fgt} - P_{fgt-4}}{P_{fgt-4}}\right) = \sum_{t \neq 2008.Q2} \left\{ \underbrace{\alpha_t}_{\text{Overall}} + \underbrace{\gamma_t}_{\text{Heterogeneous}} \times 1\{\text{ShortTerm\_Debt}^{Pre} > \text{Cutoff}\}_f \right\} \times \underbrace{(-L_f)}_{\text{Credit Shock}} \times \mathbf{1_t}$$
$$+ \kappa' \underbrace{X_{ft-1}}_{\text{Firm Controls}} + \sigma_f + \lambda_g + \delta_t + \varepsilon_{fgt}. \tag{9}$$

Each observation in Equation 9 is the year-over-year price change of individual firm f for product group g 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), product group fixed effects (λ_g), and time fixed effects (δ_t). We also control for the lagged firm-level time-varying covariates, which include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. In the estimation, standard errors are clustered at the firm and product group levels and the regression is weighted by total sales.

Figure 8 clearly shows the difference in price response to credit supply shock depending on the ratio of the firm's short-term debt ratio. The gray line shows how the shock affects price changes over time, while the red line shows the effect of the shock on price changes among the treatment group relative to the control group. The observed pattern suggests

Figure 8: Heterogeneous Effect of Credit Supply Shock

Notes: This figure shows the estimated results from Equation 9. The red line represents the heterogeneous effects of a negative credit supply shock on price changes for the group of firms with more than 60% of their debt maturing within one year, while the grey line represents the overall effects of negative credit supply shock on price changes. Lagged firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The definitions of all variables are provided in Appendix Table A3. The definition of the credit supply shock $(-\Delta L_f)$ is based on Equations 6 and 7. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. The confidence intervals are calculated at the 5% significance level.

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 thresholds of short-term debt ratio for the treated group. Appendix Figure A4 shows that the channel is still valid with different thresholds of short-term debt ratio.

4.3 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. This result also illustrates how variations in debt burden during normal times, influenced by differing debt maturity structures, can impact a firm's product pricing behavior.

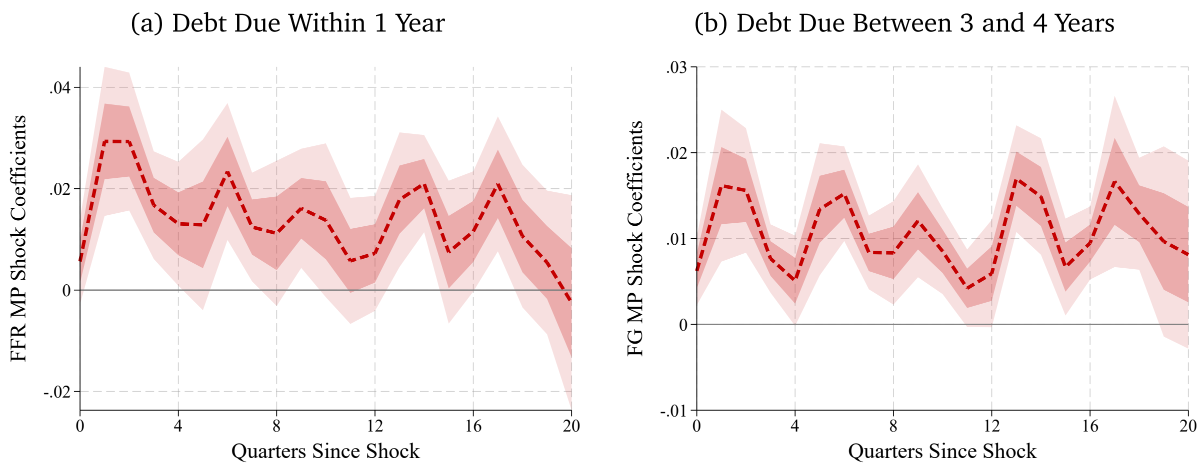
First, we use the monetary policy shock proposed by Swanson (2021) which extends the approach of Gürkaynak et al. (2005). Both of the papers use factor model to extract the unexpected component of change in federal funds rate, forward guidance, large scale asset purchase (LSAP). This approach offers 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.

$$\log \frac{P_{fgt+h}}{P_{fgt-1}} = \beta_1^h \,\mathrm{Debt}_{ft}\, \varepsilon_t^{\mathrm{MP}} + \alpha_g^h + \alpha_t^h + \alpha_f^h + \varepsilon_t^{\mathrm{MP}} + \Gamma_1^h X_{ft-1} + \varepsilon_{it}. \tag{10}$$

The dependent variable is log price change of product group g produced by firm f between time $t+h$ and $t-1$. $\varepsilon_t^{\mathrm{MP}}$ denotes the monetary policy shock. We 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. We estimate each specification using different definitions of Debt_{ft}. We define Debt_{ft} as the proportion of firm f's debt maturing within 1 year, between 1 and 2 years, between 2 and 3 years, between 3 and 4 years, and between 4 and 5 years, and then estimate Equation 10 for each definition, respectively. The lagged firm controls include firm size, book leverage, Tobin's Q, cash holdings, total debt-to-asset ratio, as well as additional variables from Gilchrist et al. (2017), such as liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. Standard errors are two-way clustered at the firm and product group levels. In the regression, the product group FEs (α_g^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. In the left panel of 9, the contractionary monetary

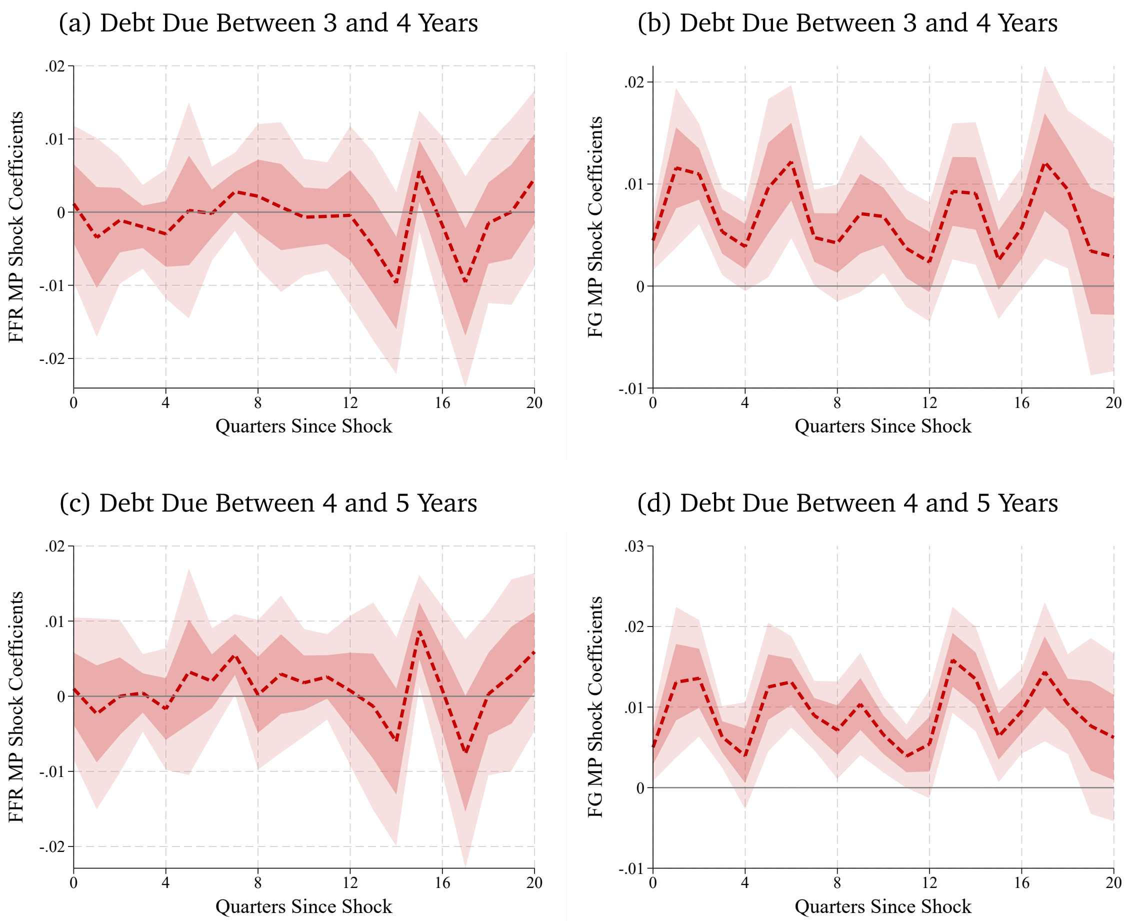
Figure 9: Response of Price to Target and Path of Monetary Policy Shock



Notes: This figure presents the estimated results from Equation 10. Panel (a) illustrates the response of price changes to the FFR (target) monetary policy shock (as in Swanson (2021)), interacted with the ratio of debt maturing within one year to total debt. Panel (b) shows the response of price changes to the FG (path) monetary policy shock (as in Swanson (2021)), interacted with the ratio of debt maturing between three to four years to total debt. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. Lagged firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The definition of each variable can be found in Appendix Table A3. The shaded area illustrates the pointwise confidence bands at the 5% and 10% significance levels.

policy shock in target component has immediate effect on price changes 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 impact on price changes for firms with more debt burden maturing in the medium-term. Figure 10 also shows a similar story. The first row of the figure shows that target component of monetary policy attributes 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 10 shows that the path component of monetary policy attributes 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

Figure 10: Response of Price to Target and Path of Monetary Policy Shock



Notes: This figure presents the estimated results from Equation 10. Panel (a) and (b) illustrates the response of price changes to the FFR (target) and FG (path) monetary policy shock (as in Swanson (2021)), interacted with the ratio of debt maturing between three to four years to total debt. Panel (c) and (d) illustrates the response of price changes to the FFR (target) and FG (path) monetary policy shock (as in Swanson (2021)), interacted with the ratio of debt maturing between four to five years to total debt. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. Lagged firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The definition of each variable can be found in Appendix Table A3. The shaded area illustrates the pointwise confidence bands at the 5% and 10% significance levels.

of the firm's price change depending on their debt burdens of different maturities.

For the robustness check, we estimate a specification similar to Equation 10. However, in this specification, we simultaneously control for various debt maturity variables within a single model. The model specification is as follows:

$$\log\frac{P_{fgt+h}}{P_{fgt-1}} = \beta_1^h \text{ Debt } 1_{ft}\varepsilon_t^{\text{MP}} + \beta_2^h \text{ Debt } 2_{ft}\varepsilon_t^{\text{MP}} + \beta_3^h \text{ Debt } 3_{ft}\varepsilon_t^{\text{MP}}$$
$$+ \beta_4^h \text{ Debt } 4_{ft}\varepsilon_t^{\text{MP}} + \beta_5^h \text{ Debt } 5_{ft}\varepsilon_t^{\text{MP}} + \alpha_g^h + \alpha_t^h + \alpha_{\text{f}}^h + \varepsilon_t^{\text{MP}} + \Gamma_1^h X_{ft-1} + \varepsilon_{it}, \tag{11}$$

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_{ft} represents the ratio of debt due within one year, while Debt2_{ft} represents the ratio of debt due between one and two years. Similarly, the variables Debt3_{ft}, Debt4_{ft}, and Debt5_{ft} are defined accordingly. We control for lagged variables X_{ft-1}, which include the same firm controls as specified in Equation 10, along with 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

In this section, we introduce the model used to rationalize our paper's findings. This model provides a theoretical framework explaining how a negative shock to a firm's earnings, combined with an imminent debt repayment obligation, can pressure the firm to increase product prices to mitigate rollover risk. To explore this, we allow firms to issue both short-term and long-term debt, enabling them to select their optimal capital structures. We further utilize this model as a framework to assess the impacts of the Fed's monetary policies, such as the Maturity Extension Program (MEP), on the distribution of capital structures within the economy and on overall price levels.

5.1 Households

Household's Maximization Objective. We assume there exists 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 utility

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

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

$$X_t \equiv \left[\int_0^1 \left(\frac{c_{it}}{m_{i,t}^{\theta}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}} ; \quad \theta < 0 \text{ and } \eta > 0, \tag{13}$$

where $c_{i,t}$ is differentiated consumption goods, $m_{i,t}$ 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. Given the CES aggregation, we can solve the consumer's consumption expenditure minimizing problem of $\int_0^1 P_{i,t} c_{i,t} di$ subject to constraint $X_t \equiv \left[\int_0^1 \left(\frac{c_{it}}{m_{i,t}^{\theta}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}$. From which we can derive the consumer's demand for product i which can be expressed as

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

in which $P_t \equiv \left[\int_0^1 P_{it}^{1-\eta} di\right]^{\frac{1}{1-\eta}}$ is aggregate price index. The main difference between our model and the standard habit formation framework is that, unlike the traditional model where habits are formed based on aggregate consumption, our model assumes that consumers form habits for each differentiated good.

Household's Budget Constraint. 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

$$\mathcal{X}_t + \mathcal{B}_{t+1}^S + \mathcal{B}_{t+1}^L + \mathcal{Q}_t = \mathcal{W}_t \mathcal{L}_t + \mathcal{R}_t^S \mathcal{B}_t^S + \mathcal{R}_t^L \mathcal{B}_t^L + \mathcal{R}^{stock} \mathcal{Q}_{t-1} \tag{15}$$

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. $\mathcal{W}_t \mathcal{L}_t = W_t \int_i L_{i,t} di$ is the household's total labor income, $\mathcal{B}_{t+1}^S = \int_i Q_{i,t}^S B_{i,t+1}^S di$ is the total investment in short-term debt, $\mathcal{B}_{t+1}^L = \int_i Q_{i,t}^L B_{i,t+1}^L di$ is the total investment in long-term debt, and $\mathcal{Q}_t = \int_i Q_{i,t} di$ is total stock holdings. From the household's optimization problem, the stochastic discount factor is given as $\Lambda_{t,t+1} = \beta \frac{U'(X_{t+1})}{U'(X_t)}$.

Evolution of Customer Capital. Given the demand function for individual product i, firms can attract additional consumers by undercutting product prices. The mechanism we aim to develop is that consumption inertia enables firms to increase future customer demand by lowering prices. This idea is captured in the influential paper Phelps and Winter (1970) and Ravn et al. (2006). In order to incorporate this channel in our model, we assume the following law of motion of evolution of customer base

$$m_{i,t+1} = \rho m_{i,t} + (1-\rho) c_{i,t} \tag{16}$$

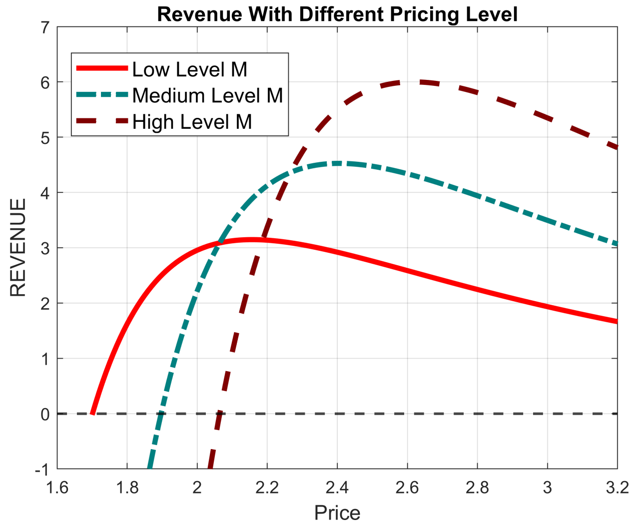
The evolution of customer base indicates that the household's current consumption is weighted sum of all of its past consumption. The parameter ρ captures the speed of customer base depreciation. Firms' revenues are influenced by their accumulated customer capital and the strategic pricing decisions they implement, both of which stem from the dynamic nature of customer capital as modeled in household utility functions. Figure 11 illustrates the evolution of these dynamics.

Panel (a) of Figure 11 demonstrates that firms with greater accumulated customer capital can charge higher prices and achieve higher maximized revenues. The dotted dark red line in panel (a) illustrates the relationship between a firm's pricing strategy and its corresponding revenues, with the firm possessing higher customer capital compared to those represented by the dark green and red lines. Firms with higher customer capital can set higher prices and achieve greater revenue. However, several factors deter firms from charging the maximum possible price or extracting the maximum current-period revenues. These considerations arise from the dynamic evolution of customer capital, as shown in Equation 16. A firm that fully exercises its market power by charging the maximum price today risks eroding its future customer capital and consequently reducing its ability to exert market power in subsequent periods. Therefore, firms may choose to restrain their current market power by setting lower prices to preserve or enhance customer capital for future periods. This restraint may arise from a precautionary approach to mitigate potential future adverse conditions or a strategic aim to increase market share and enhance future market power in the customer market.

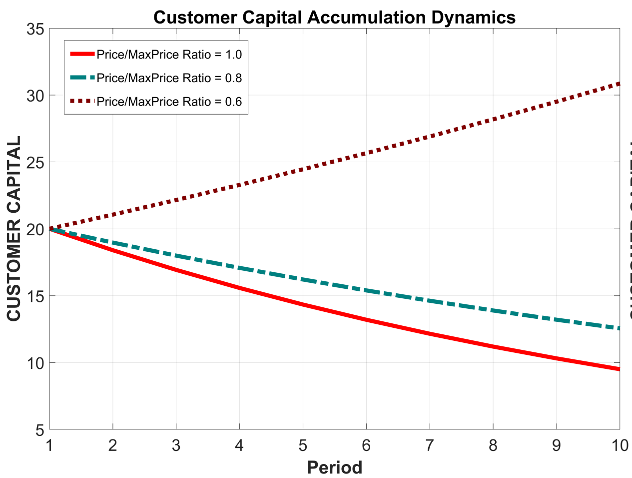
The strategic nature of firms' pricing behavior is further illustrated in panel (b) of Figure 11. At period 1, all firms are assumed to have the same initial level of accumulated customer capital. However, the firm represented by the red line is assumed to fully exercise its market power each period by charging the maximum possible price, while the firms represented by the dark green and dark red lines only exercise partial market power, charging 80% and 60% of the maximum possible prices, respectively. Over time, the figure reveals that firms fully exercising their market power (red line) experience a decline in customer capital in subsequent periods. In contrast, the firm in the dark green line, which charges a lower price, also experiences a decline in customer capital, but at a slower rate than the red line. However, the firm adopting the most conservative pricing strategy, represented by the dark red line, manages to increase its customer capital over time, enhancing its market power further. These different patterns in the evolution of customer capital, driven by the firms' strategic pricing decisions, underscore the dynamic motivations underlying firms' price-setting behavior.

Figure 11: Dynamics of Customer Capital

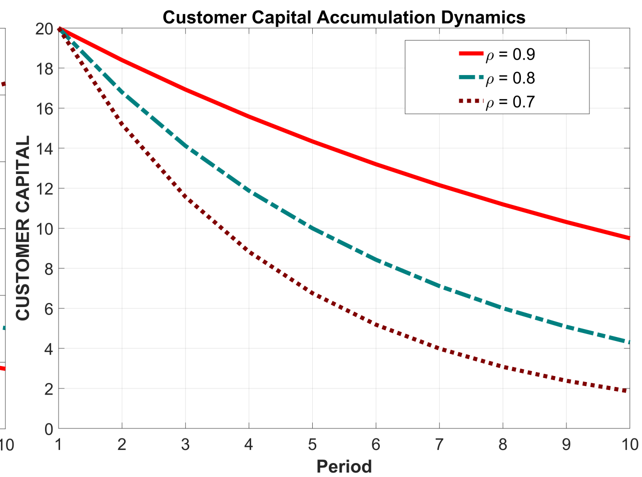
(a) Customer Capital and Firm Revenues



(b) Dynamics with Different Pricing Strategies



(c) Stickiness of Customer Capital



Notes: This figure illustrates the dynamics of customer capital accumulation. Panel (a) shows the relationship between pricing levels and corresponding firm revenue, highlighting how the relationship between price and revenue varies for firms with different levels of customer capital. Panel (b) depicts the relationship between pricing strategy and the evolution dynamics of customer capital, assuming all firms begin with the same level of customer capital. The red line represents the trajectory of customer capital when firms consistently charge the maximum possible price. In contrast, the dotted green line and dark red line illustrate the evolution of customer capital when firms charge only 80% and 60% of the maximum price, respectively. Panel (c) illustrates the evolution of customer capital, assuming all firms start with the same initial level of customer capital and charge the maximum possible price, but experience different rates of customer capital depreciation.

Panel (c) of Figure 11 highlights the significance of the parameter ρ in shaping the evolution of customer capital in response to firms' strategic pricing behavior. In this panel, all firms are assumed to charge the maximum possible price, and the figure illustrates how the dynamics of customer capital vary depending on the value of ρ. The parameter $(1-\rho)$ reflects the speed at which customer capital accumulates, with a higher value of ρ indicating that the evolution of customer capital is less sensitive to the current level of demand, $c_{i,t}$. As shown in panel (c), when ρ is larger, firms experience a smaller reduction in future customer capital even when fully exercising their market power.

5.2 Heterogeneous Producers

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

$$Y_{it} = A(L_{it})^{\alpha}; \quad 0 < \alpha < 1, \tag{17}$$

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

$$\Pi_{it} = P_{it}Y_{it} - W_t L_{it}, \tag{18}$$

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

$$\Pi_{it} = P_{it}Y_{it} - W_t L_{it} = P_{it}\left[(\frac{P_{it}}{P_t})^{-\eta} m_{it}^{\theta(1-\eta)} X_t\right] - W_t(\frac{Y_{it}}{A})^{\frac{1}{\alpha}}. \tag{19}$$

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

In our model firms are assumed to have access to financial markets, enabling them to raise capital through debt issuance. To capture the impact of varying debt maturity structures on product pricing, we allow firms to issue two different types of debt: short-term bonds and long-term bonds. Firms determine the optimal balance of short-term and long-term debt, thereby choosing their optimal capital structure. To maintain tractability in the model, we adopt the approach used in Leland (1994) for modeling long-term debt.

Short-term Debt. Short-term debt represents a commitment to repay one unit of the composite good, along with a coupon payment c, after one period. At the start of each period t, the outstanding stock of short-term debt is denoted by $B^S_{i,t}$. The firm is required to repay the total amount, $(1+c)B^S_{i,t}$, at the beginning of the subsequent period $t+1$.

Long-term Debt. Long-term debt entails a commitment to repay a fraction $\gamma \in (0,1)$ of the principal, along with a coupon payment c, after one period. At the start of each period t, the outstanding balance of long-term debt is denoted by $B^L_{i,t}$. In the subsequent period $t+1$, a fraction $(1-\gamma)$ of the bond remains unpaid. The portion of long-term debt rolled over at the beginning of period t is denoted by $(1-\gamma)B^L_{i,t}$.

Debt Issuance Cost. Debt issuance incurs a cost. We assume a quadratic issuance cost ζ per unit for both short-term and long-term debt. Additionally, we assume that repurchasing outstanding long-term debt is costless. The functional form of the debt issuance cost is expressed as follows:

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

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

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

where $\Pi_{it} = P_{it}\left[(\frac{P_{it}}{P_t})^{-\eta}m_{it}^{\theta(1-\eta)}X_t\right] - W_t(\frac{Y_{it}}{A})^{\frac{1}{\alpha}}$ and $z_{i,t}$ is an idiosyncratic firm specific cash-flow shock which follows i.i.d log-normal distribution.

The objective of the firm's managers is to maximize the value of the firm for its shareholders. Managers compare the continuation value of the firm with the exit value, which is zero. If the continuation value falls below zero, the managers opt to default, leading the firm to exit the market. Following optimal decisions on pricing and the optimal mix of short-term and long-term debt issuance, the firm's manager will choose to remain in the market and continue operations if the continuation value exceeds the default value. The value firms to its shareholder can be expressed as

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

where $m_{i,t+1} = \rho m_{i,t} + (1-\rho)C_{i,t} = \rho m_{i,t-1} + (1-\rho)\left[(\frac{P_{it}}{P_t})^{-\eta}m_{it}^{\theta(1-\eta)}X_t\right]$.

Additionally, firms face financial frictions that require them to maintain a positive cash flow at all times, and they are subject to an upper limit on borrowing.[4] The financial friction is expressed as below:

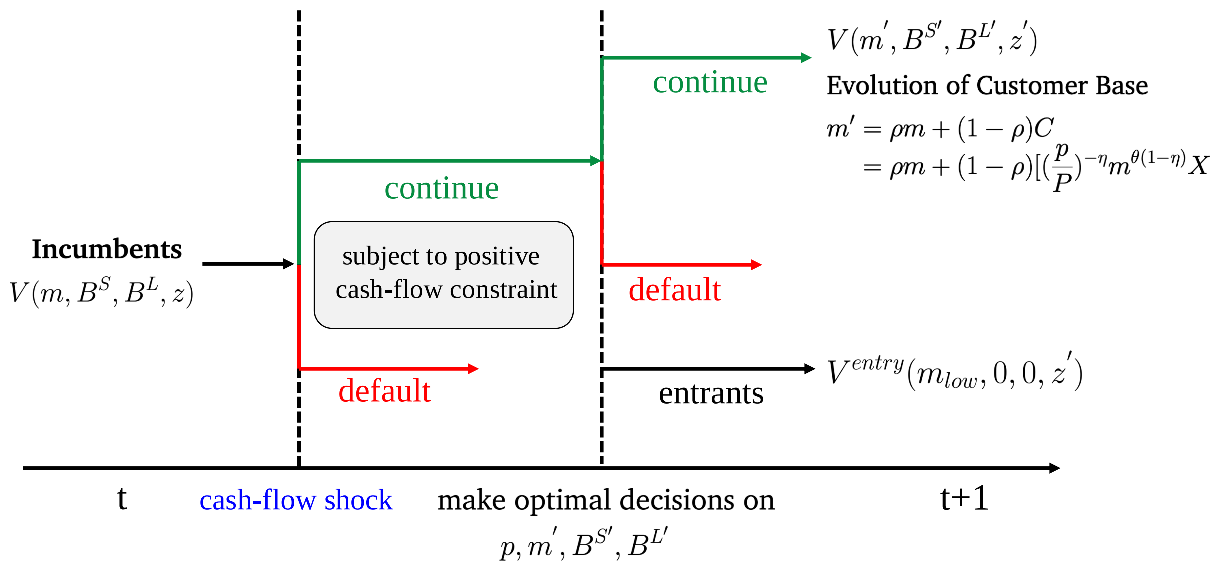
$$\underbrace{P_{it}\left[(\frac{P_{it}}{P_t})^{-\eta}m_{it}^{\theta(1-\eta)}X_t\right] - W_t(\frac{Y_{it}}{A})^{\frac{1}{\alpha}}}_{\text{operating profit}} - \underbrace{(1+c)B^S_{i,t} - (c+\gamma)B^L_{it}}_{\text{repayment of debt}} - \underbrace{\sigma z_{it}m_{it}}_{\text{cash-flow shock}}$$
$$+ \underbrace{Q^S_{it}B^S_{it+1} + Q^L_{it}(B^L_{it+1} - (1-\gamma)B^L_{it})}_{\text{new debt issuance}} \geq 0. \quad (22)$$

[4]This condition resembles the upper limit constraint on dividend payouts, where equity issuance is permitted in the model. In the presence of equity issuance, firms are restricted from depleting their existing capital by distributing excessive dividends.

5.5 Model Timing

Each period, the firm's profits are subject to a cash-flow shock, which is observed at the beginning of the period. Firms are required to repay the entire outstanding stock of short-term debt $B^S_{i,t}$ plus coupon, along with a fraction $\gamma B^L_{i,t}$ of their long-term debt plus coupon. These debt obligations, combined with the realized cash-flow shock, make firms to strategically determine their product pricing and optimize their financial resource acquisition by issuing both short-term and long-term debt. After making decisions regarding optimal pricing and financing, firms must also decide whether to default.

Figure 12: Timing of the Model



Notes: This figure illustrates the timing of the model. At the start of period t, incumbent firms have four state variables: customer capital, outstanding short-term and long-term debt, and the realized cash-flow shock. Firms will choose to default if they cannot satisfy the positive cash-flow constraint or if the continuation value falls below the default value. If the firm does not default, it proceeds to make optimal decisions regarding pricing and the optimal mix of short-term and long-term debt. We assume that new entrants begin with the minimum possible customer capital and no outstanding debt.

There are two potential triggers for default: (1) Financial frictions necessitate that the firm maintains a positive cash-flow and operates under a borrowing limit. The firm exits the market if this constraint is violated, i.e., it defaults if it cannot satisfy Equation 22. (2) Even if the firm satisfies the positive cash-flow constraint, it will choose to default and exit the market if the optimized continuation value falls below zero. The timing of the model proceeds as follows:

(i) **Default Decision.** Each firm begins period t with a cash-flow shock, customer capital, outstanding short-term debt, and long-term debt $(m_{i,t}, B^S_{i,t}, B^L_{i,t}, z_{i,t})$. At the start of the period, the firm assesses whether it can satisfy the positive cash-flow constraint; if this condition cannot be met, the firm defaults.

(ii) **Price Setting and Financing Decision.** If the firm is able to satisfy the positive cash-flow constraint, it then sets strategic pricing and determines the optimal levels of short-term and long-term debt issuance. Following this optimization, if the firm's continuation value falls below zero, the firm defaults and exits the market. However, if the continuation value remains positive, the firm proceeds to the next period.

5.6 Financial Markets

Firms can finance their productions through the financial markets. Creditors in the financial market are assumed to be 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 get zero profits. The lenders' zero-profit conditions give the debt pricing kernel as below:

$$\begin{aligned}
&Q^S_{it}(z_{it}, m_{it}, B^S_{it+1}, B^L_{it+1}) \\
&= E_t\Lambda_{t,t+1}\int_{z_{it+1}}\left\{(1-\mathbb{D}_{it+1})(1+c)+\mathbb{D}_{it+1}\times 0\right\}d(z_{it+1}), \\
&Q^L_{i,t}(z_{i,t}, m_{i,t}, B^S_{i,t+1}, B^L_{i,t+1}) \\
&= E_t\Lambda_{t,t+1}\int_{z_{i,t+1}}\left\{(1-\mathbb{D}_{i,t+1})(\gamma+c+(1-\gamma)Q^L_{i,t+1})+\mathbb{D}_{i,t+1}\times 0\right\}d(z_{i,t+1}).
\end{aligned} \tag{23}$$

By assessing the default risk, investors determine the value of purchasing one unit of either short-term or long-term debt. If the firm avoids default, short-term debt holders receive a coupon payment c plus the principal of the debt they purchased. For long-term debt holders, if there is no default, they receive the coupon c along with a fraction of their principal, while the remaining principal is evaluated based on the firm's decisions and state variables in the next period. This remaining fraction of the long-term debt after repayment links its pricing to future values of long-term debt, which are, in turn, influenced by the firm's future actions.

5.7 General Equilibrium

We now turn to the equilibrium of the economy. A firm maximizes its shareholder value by maximizing the objective function in Equation 21 subject to the positive cash-flow constraint 22. In the equilibrium we restrict our interest to Markov perfect equilibrium in which firms take their future best responses as given and choose its best response today. The value function of continuation $V^C(z_{i,t}, m_{i,t}, B^S_{i,t}, B^L_{i,t})$ is a function of the firm's state at the beginning of each period. At the beginning of each period, the firms observes the cash-flow shock $z_{i,t}$ which will has impacts on the revenues that the firm can collect after a production cost. Also, in order for firms to continue operation, firms need to repay all of its existing debt. This includes all of the outstanding amount of short-term debt $B^S_{i,t}$ and a fraction of its outstanding amount of long-term debt $\gamma B^L_{i,t}$. Given these considerations, firms choose a set of optimal policy $\phi(m_{i,t}, B^S_{i,t}, B^L_{i,t}, z_{i,t}) = \{P_{i,t}, m_{i,t+1}, B^S_{i,t+1}, B^L_{i,t+1}, \mathbb{D}_{i,t}\}$ to maximize its shareholder profits. The recursive formulation of the firm's problem is defined as follows:

Firm Equity Value $$V(m, B^S, B^L, z) = \max_{\mathbb{D}} \left[\underbrace{V_D(m, B^S, B^L, z)}_{=0},\ V_C(m, B^S, B^L, z) \right]$$

Continuation Value

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

Evolution of Customer Base $$m' = \rho m + (1-\rho)C = \rho m + (1-\rho)[(\frac{p}{P})^{-\eta} m^{\theta(1-\eta)} X]$$

Debt Pricings $$Q^S(m, B^S, B^L, z) = E\Lambda \int_z \left\{ (1-\mathbb{D}')(1+c) + \mathbb{D}' \times 0 \right\} d(z)$$

$$Q^L(m, B^S, B^L, z) = E\Lambda \int_z \left\{ (1-\mathbb{D}')(\gamma + c + (1-\gamma)Q^{L'}) + \mathbb{D}' \times 0 \right\} d(z)$$

Positive Cash-flow Constraint

$$p\left[(\frac{p}{P})^{-\eta}m^{\theta(1-\eta)}X\right] - W(\frac{Y}{A})^{\frac{1}{\alpha}} - (c+1)B^S - (c+\gamma)B^L - \sigma z m$$
$$+ Q^S(B^{S'}) + Q^L(B^{L'} - (1-\gamma)B^L) \geq 0. \tag{24}$$

Given the firm's policy function from the recursive problem, we can define the stationary distribution of the economy.

$$\mu\left(m', B^{S'}, B^{L'}, z'\right) = \int_m \int_{B^S} \int_{B^L} \int_z \mathscr{I}\left(m', B^{S'}, B^{L'}; m, B^S, B^L, z\right)[1 - \mathbb{D}(m, B^S, B^L, z)]$$
$$\times \pi[z'|z]\mu(m, B^S, B^L, z)\, dm\, dB^S\, dB^L\, dz + \mathscr{M}\left(m', B^{S'}, B^{L'}, z'\right), \tag{25}$$

in which the indicator function $\mathscr{I}\left(m', B^{S'}, B^{L'}; m, B^S, B^L, z\right) = 1$ when $m', B^{S'}, B^{L'}$ corresponds to the firm's optimal choice strategy $\phi(m, B^S, B^L, z) = \{m', B^{S'}, B^{L'}\}$. Also, there is endogenous default of firms when $\mathbb{D}(m, B^S, B^L, z) = 1$. The function $\mathscr{M}\left(m', B^{S'}, B^{L'}, z'\right)$ is entry of firms and we assume that the mass of entry of firms is equal to M at $m = m_{lowest}, B^S = 0, B^L = 0, z = z_{lowest}$. This means that the entry of firms have the lowest possible level of custoemr capital and cash-flow shock and they start from the zero amount of outstanding debts. In the stationary equilibrium the total mass of firms of the economy is fixed and the mass of entry M is constant.

Definition (Stationary Equilibrium) The stationary equilibrium of the economy is composed of (i) the values functions $V(m, B^S, B^L, z)$, $V_C(m, B^S, B^L, z)$, (ii) a policy vector $\phi(m, B^S, B^L, z) = \{p, m, B^S, B^L, \mathbb{D}\}$, (iii) pricing kernels for short-term debt and long-term debt $Q^S(m, B^S, B^L, z)$, $Q^L(m, B^S, B^L, z)$, (iv) household's aggregate consumption X, and labor supply L, (v) aggregate price levels P and W, (vi) the stationary distribution μ^* and equilibrium mass of entrants $\mathscr{M}^*$, such that:

1. The value functions $V(m, B^S, B^L, z)$, $V_C(m, B^S, B^L, z)$ and policy functions $\phi(m, B^S, B^L, z) = \{p, m, B^S, B^L, \mathbb{D}\}$ solves the firm's maximization problem (24).

2. The equilibrium price of short-term debt and long-term debt are determined in the financial markets as in (23).

3. The representative household chooses the optimal level of aggregate consumption X and labor supply L to maximize household's utility in (12) given the equilibrium wage W.

4. The labor market and final goods market clears. The market clearing condition and aggregate price is given by

$$L = \int_m \int_{B^S} \int_{B^L} \int_z l(m, B^S, B^L, z) dz \, dB^L dB^S dz, X = \left[\int_0^1 \left(\frac{Y_{it}}{m_{i,t}^{\theta}} \right)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}. \tag{26}$$

6 Quantitative Analysis

6.1 Computation Methods

We employ global solution methods, where the objective functions are estimated using value function iteration techniques. Several challenges arise in computing the equilibrium of our model.

First, the associated objective function involves four state variables (m, B^S, B^L, z), and the computational burden increases significantly as the dimensionality of the state space expands. To address this, we implement collocation methods, where the objective functions are fully vectorized, and integrals are pre-computed to enhance computational efficiency.

Second, the model incorporates numerous nonlinearities and asymmetries, including firm default decisions and the issuance of defaultable short-term and long-term bonds, making the problem particularly challenging. Many studies addressing defaultable corporate bonds, such as Jungherr et al. (2022), Jungherr and Schott (2022), Jungherr and Schott (2021) tackle this issue by estimating the default threshold of shocks within the model. Rather than estimating the threshold at each period, we leverage the firm's policy function to directly determine the default probability for each state.

Third, the pricing kernel for long-term bonds exhibits forward-looking behavior. As indicated by Equation (23), the pricing kernel for long-term bonds is a function of future bond prices, which are in turn influenced by the firm's future decisions. To address this, we employ a time-iteration procedure, solving the model backwards by first tackling the firm's terminal problem in a finite horizon. We then iterate backwards over time until the value functions and pricing kernels converge. Such time-iteration techniques are widely used in the macro-finance and sovereign debt default literature (as in Hatchondo et al. (2010), Hatchondo et al. (2016)). An additional advantage of this approach is that it significantly reduces computation time by using a one-loop algorithm that iterates simultaneously on the value and bond price functions, rather than a two-loop algorithm, where the outer loop iterates on bond prices and the inner loop on value functions. The details of the solution algorithm is outlined in the Appendix B.

6.2 Calibration

In this section, we describe the calibrated parameters in our dynamic firm model. We follow the standard literature in our calibration. For now we concentrate on the equilibrium in which the wage rate is internally calibrated not from the labor market. We assume in each period the firm is exposed to log-normal idiosyncratic cash-flow shock. Following Dou and Ji (2021), we assume that the exposure to negative cash-flow shock is proportional to the firm size (customer capital).

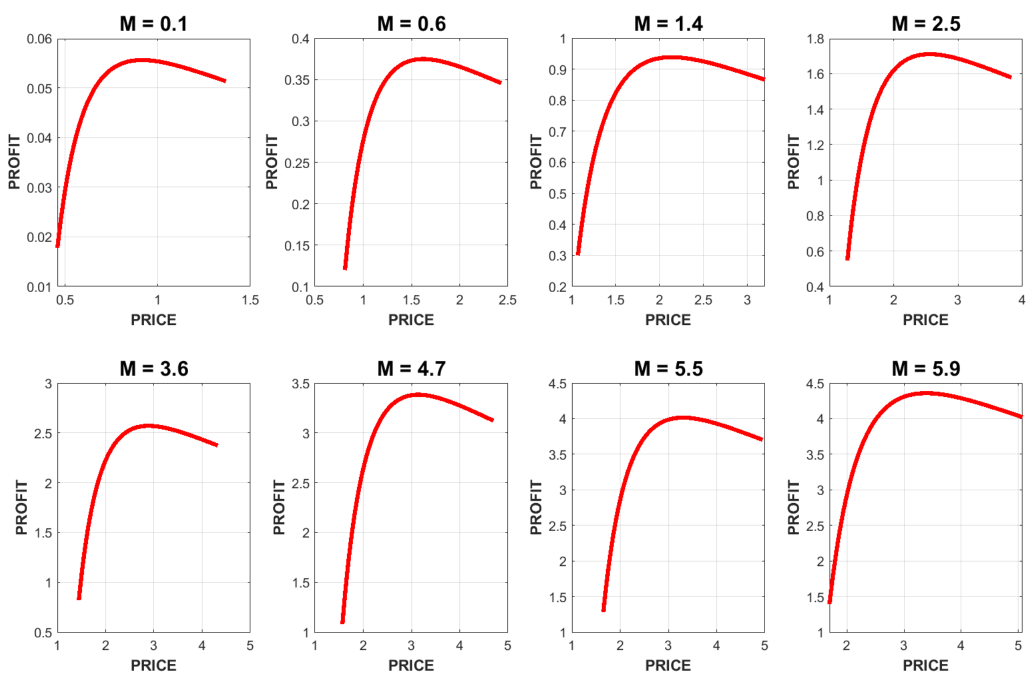
Table 3: Parameterization

Parameter	Description	Value	Reference
c	debt coupon	0.05	Jungherr et al. (2022)
β	discount factor	0.98	Standard
μ	idiosyncratic cash-flow shock	-0.2	Dou and Ji (2021)
σ	idiosyncratic cash-flow shock	0.09	Dou and Ji (2021)
ρ	persistence of habit stock	0.8	Ravn et al. (2006)
θ	deep habit parameter	-2.1	Gilchrist et al. (2017)
η	elasticity of substitution	1.6	Gilchrist et al. (2017)
γ	repayment rate of long-term debt	0.05	Jungherr et al. (2022)
α	returns-to-scale parameter	0.8	Gilchrist et al. (2017)
A	productivity	1.0	Internal
W	wage rate	0.7	Internal

The parameter σ and μ determines the size of the shock dependent on the firm's customer capital. The setting of deep habit parameter θ and elasticity of substitution η follows Gilchrist et al. (2017) and this determines the elasticity of demand of the customer and hence the firm's demand function. We adjust these parameters to ensure there is realistic default rate for the firm. Another important parameter is ρ which determines the persistence of the customer habit and affects the depreciation rate of customer capital. The parameter c determines debt coupon rate and hence the pricing of the short-term and long-term debt. The parameter γ determines the proportion of long-term debt principal that should be repaid after one-period and this also affect the pricing kernel of the long-term debt. We follow Jungherr and Schott (2021) to set the paramter of c and γ.

Figure 13 illustrates the relationship between the firm's pricing strategy and its resulting profits. The parameters θ and η shape the profit function concerning price by influencing the elasticity of customer demand. Additionally, an increase in customer capital enhances the firm's pricing power, leading to higher profit levels. We set these parameters to ensure that while customer capital growth elevates maximum profit levels, it does not cause profits to increase exponentially with rising customer capital.

Figure 13: The Relationship between Pricing and Profit



Notes: This figure illustrates the relationship between the firm's price and its profit, with each panel title indicating the respective level of customer capital. When customer capital increases, firms can charge higher prices and generate greater revenue.

6.3 Model Results with Short-term Debt

In this section, we present the results of our model. To explore the mechanism through which short-term debt and cash-flow shocks influence the firm's strategic product pricing behavior, we first simplify the model to highlight the role of short-term debt in shaping the firm's pricing decisions.

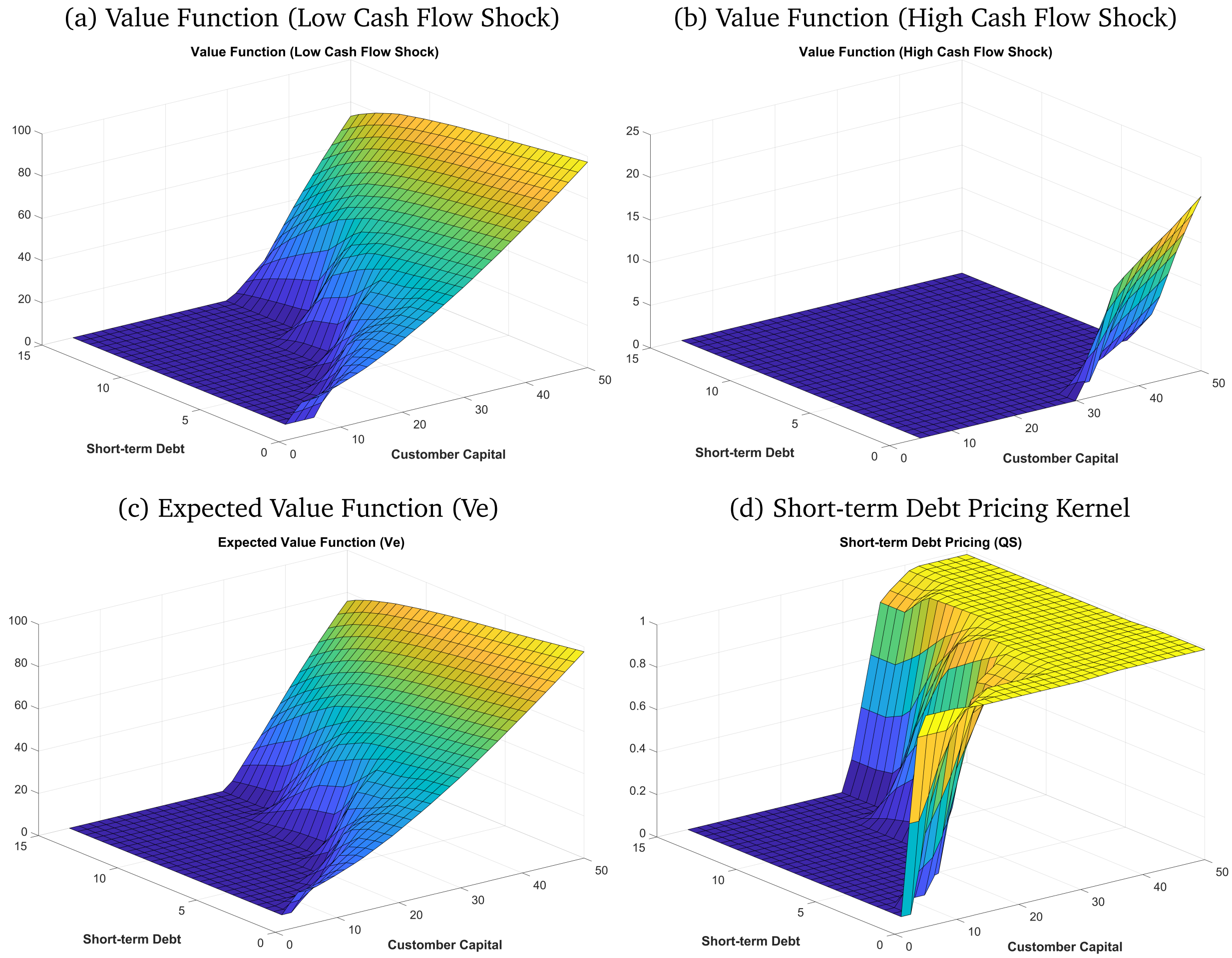
Figure (14) presents the estimated value functions from our model. Panels (a) and (b) compare the value functions under different cash-flow shocks. The value function drops to zero when the firm is unable to maintain positive shareholder value and opts for default. Firms tend to default, regardless of their accumulated customer capital or outstanding short-term debt, when exposed to sufficiently high cash-flow shocks. Moreover, as illustrated in panel (c), the firm's default probability is influenced by both the level of customer capital it has accumulated and the outstanding short-term debt that must be repaid in the upcoming period.

The firm's default probability decreases with higher levels of customer capital but increases as the firm issues more short-term debt. The pricing kernel, determined by the break-even condition in financial markets, is illustrated in panel (d). In this panel, we observe that investors anticipate higher default risk when a firm issues large amounts of debt, leading to greater discounting of the debt price. However, if the firm has accumulated significant customer capital, the debt price is discounted less. Firms with more customer capital are better positioned to survive even with higher debt levels, resulting in a smaller discount on debt issuance prices for firms with greater customer capital.

Next, Figure (15) illustrates the firm's policy rules for product pricing, markups, the price-to-maximum-price ratio, and decisions regarding customer capital. The lines in the graph, represented by different colors, correspond to firms exposed to varying levels of cash-flow shocks. We compare firms with the same amount of customer capital, so the variation in policy responses stems from differences in cash-flow shocks and the amount of outstanding debt that must be repaid immediately. The black line reflects the decisions of firms facing the highest level of cash-flow shock, while the green line represents firms exposed to a high level of cash-flow shock. The blue and red lines represent firms facing medium and low levels of cash-flow shock, respectively.

Panel (a) illustrates the product pricing decisions of firms. Notably, when the level of

Figure 14: Estimated Value Functions and Pricing Kernel



(a) Value Function (Low Cash Flow Shock)

(b) Value Function (High Cash Flow Shock)

(c) Expected Value Function (Ve)

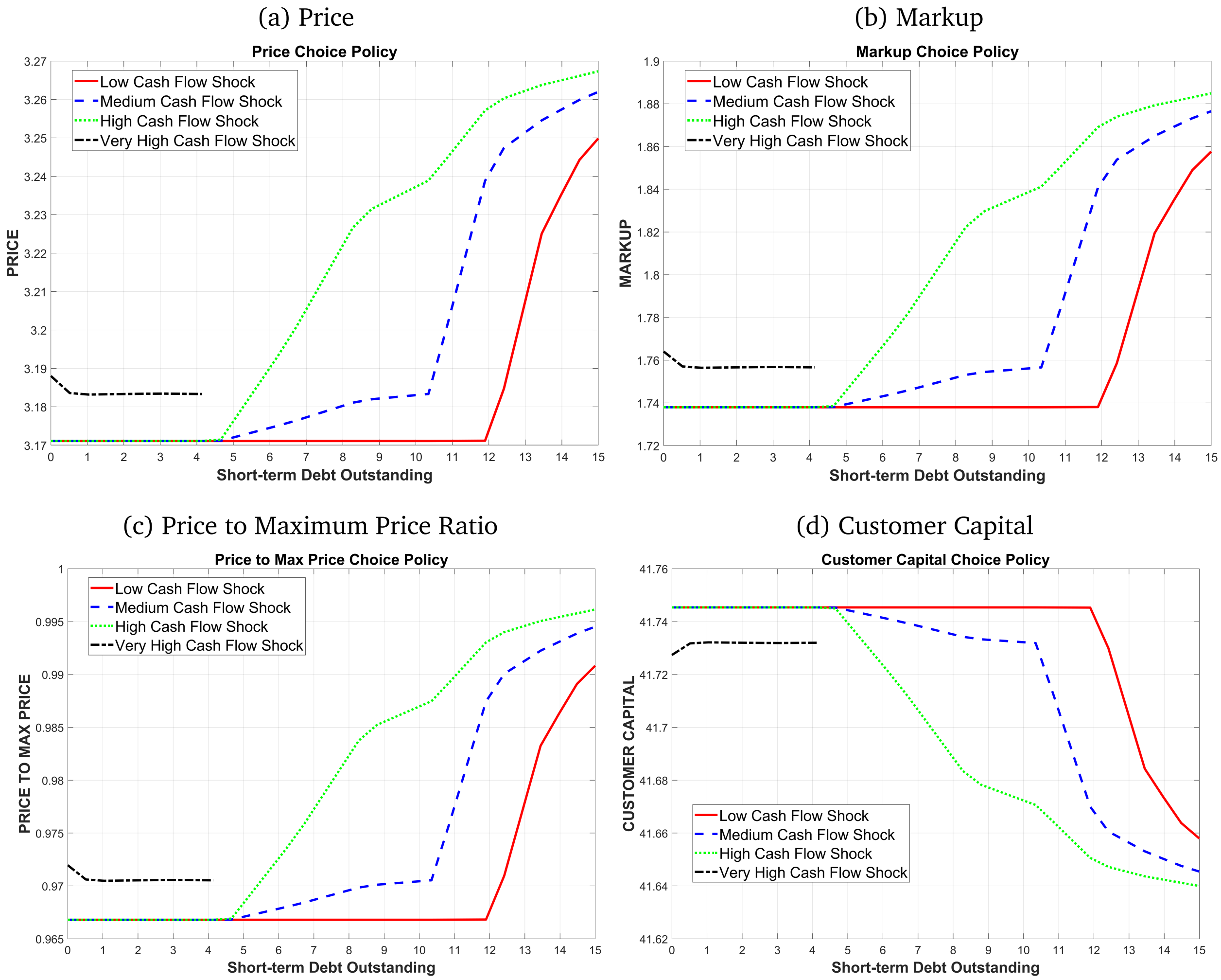
(d) Short-term Debt Pricing Kernel

Notes: This figure displays the estimated variables in the model when firms are allowed to issue only short-term debt. The x-axis represents the level of outstanding short-term debt, while the y-axis represents the level of customer capital.

short-term debt is low, all firms charge similar prices, with the exception of those exposed to the highest level of cash-flow shock. Firms facing the most severe shock (black line) set higher prices compared to others. As the outstanding short-term debt gradually increases, we observe that the black line truncates at a certain threshold. This occurs because firms default, and no pricing decisions are made once a firm enters default.

This indicates that the firm represented by the black line raises prices in an effort to survive. However, the firm is unable to sustain operations once its debt obligations exceed a certain threshold. After this threshold, around 4.5, firms represented by the

Figure 15: Firm's Decision Rules



Notes: This figure illustrates the policy functions of firms when they are restricted to issuing only short-term debt. All firms share the same amount of customer capital but face varying levels of negative cash-flow shocks. The figure highlights the differing policy responses based on the level of outstanding short-term debt and the degree of exposure to negative cash-flow shocks.

green and blue lines begin to gradually increase their prices. This reflects their willingness to sacrifice customer capital to survive, as they face a higher level of short-term debt that must be repaid immediately. The increase in product pricing allows these firms to generate more revenue in the current period to meet their debt obligations and continue operations. Additionally, the firm represented by the green line raises prices more sharply than the blue line, as it faces a more severe cash-flow shock and requires greater revenue to survive. In contrast, the firm in red does not raise prices despite the increased level of short-term debt, as it is exposed to the lowest level of cash-flow shock and can still operate without raising prices. However, as debt obligations continue to rise, surpassing a threshold around 12, the firm in red eventually increases its prices. This indicates that the firm also faces mounting debt pressure and must raise revenues through higher prices to meet its obligations.

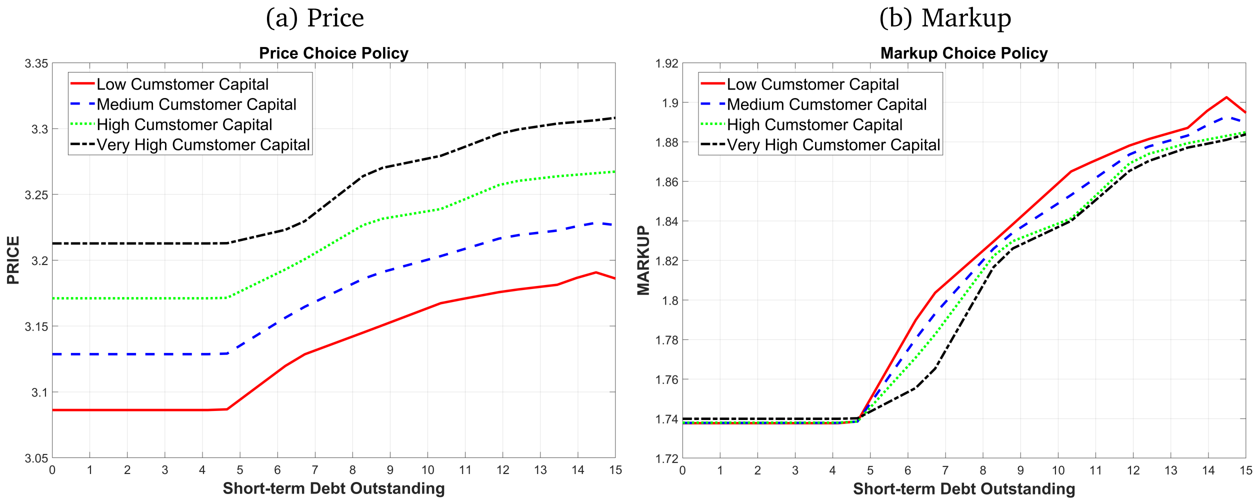
The pricing mechanism discussed in panel (a) is further evidenced in panel (b), which illustrates the relationship between firms' markup decisions and the outstanding short-term debt across varying levels of exposure to cash-flow shocks. Firms are generally reluctant to raise their markups as long as they can meet their debt obligations through current revenues, net of the cash-flow shock. However, as their debt burden increases, firms raise markups to generate higher revenues at the expense of future customer capital. Additionally, firms facing more severe cash-flow shocks exhibit less patience in restraining price increases, despite the negative impact on their customer capital, as the need to meet immediate debt obligations becomes more pressing.

In panel (c), the "maximum price" refers to the price at which firms can achieve their highest possible revenue. Charging this price implies that firms are fully leveraging their market power based on their accumulated customer capital. A price-to-maximum-price ratio below 1 indicates that firms are not fully utilizing their market power. As shown in panel (c), firms tend to reserve this ability when they face lower debt repayment obligations (i.e., lower levels of outstanding short-term debt) and less severe cash-flow shocks. However, as debt repayment obligations increase and cash-flow shocks worsen, firms become less patient and more inclined to fully exploit their market power in order to navigate the financial distress and mitigate default risk.

The graph in Panel (d) represents the counterpart to the dynamics observed in Panel (a). When firms choose to raise prices and markups to navigate the immediate challenges of repaying debt and surviving negative cash-flow shocks, this decision comes at the cost of eroding future customer capital. This trade-off is clearly illustrated in Panel (a), where short-term survival strategies reduce the firm's ability to sustain customer capital in the long run.

Figure (16) illustrates the policy rules of firms, holding their exposure to cash-flow shocks constant. The different colored lines represent firms with varying levels of existing customer capital. The firm represented by the black line possesses the largest amount of customer capital, followed by the firm in green, which has the second-largest amount. The

Figure 16: Firm's Decision Rules



Notes: This figure illustrates the policy functions of firms limited to issuing only short-term debt, all of which are subject to the same level of negative cash-flow shock. The figure highlights varying policy responses based on the level of outstanding short-term debt and the accumulated level of customer capital.

firm in blue has a medium level of customer capital, while the firm in red has the lowest level.

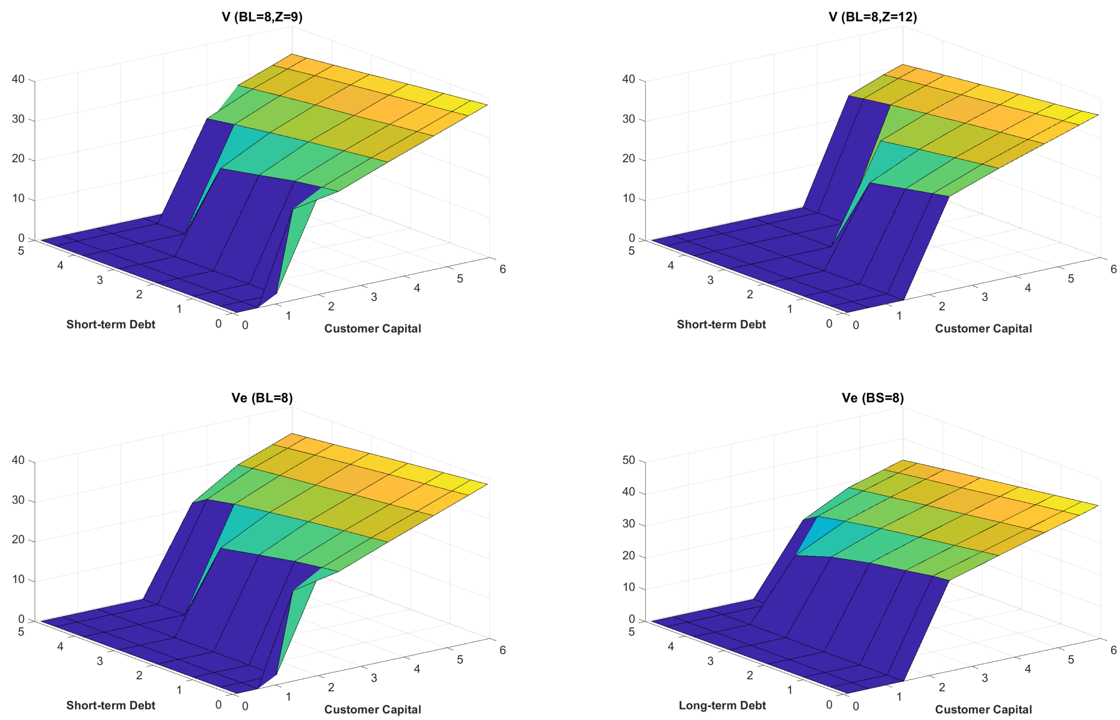
6.4 Model Results with Short- and Long-term Debt

In this section, we present the complete model that incorporates both short-term and long-term debt. Firms in this model face a recurring need to issue debt, driven by negative cash-flow shocks that occur in every period. These shocks create liquidity challenges for firms, as they must simultaneously manage debt repayments, labor costs, and other financial obligations while ensuring a positive cash flow. The primary revenue source is product sales, but when revenue falls short, firms turn to debt issuance to avoid default.

A key consideration in firms' financial strategy is the balance between maintaining liquidity and minimizing future losses in customer capital due to excessive price increases. Raising prices may provide immediate revenue but risks losing future customers. Hence, firms have incentives to issue debt as a means of smoothing cash flow and preserving their customer capital.

Firms also aim to optimize their capital structure by deciding how much short-term

Figure 17: Firm's Value Functions (V & V^e)

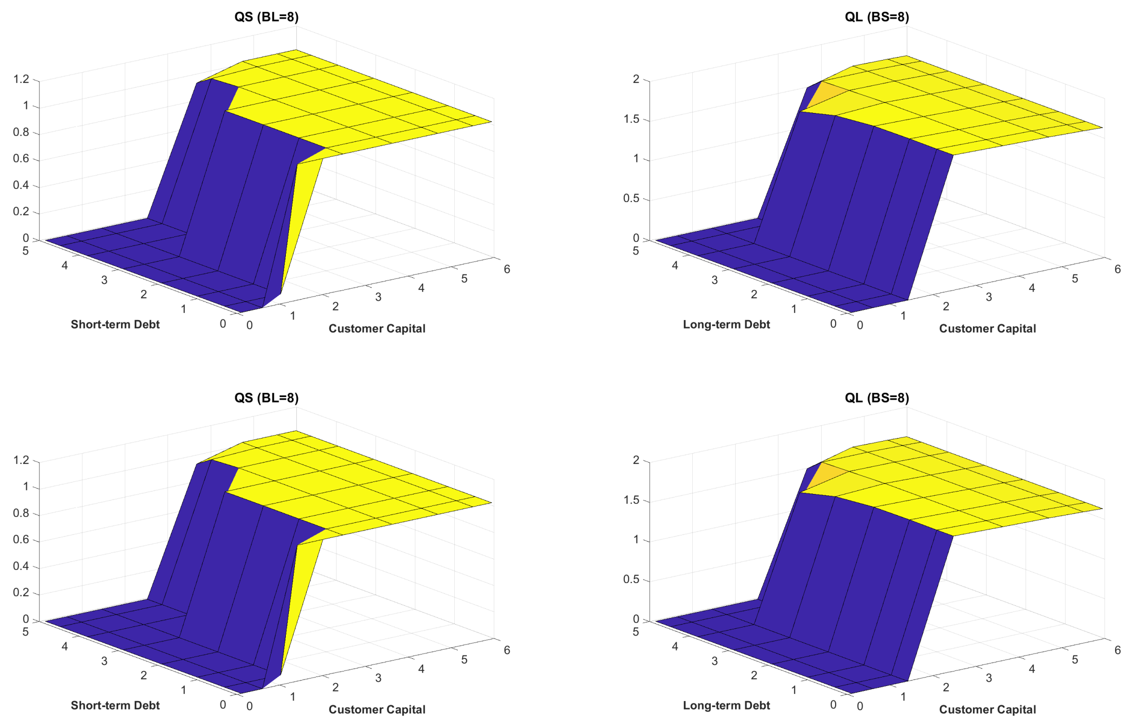


Notes: This figure presents the estimated value function and continuation value function for firms in the full model, which allows issuance of both short-term and long-term debt. It illustrates how the firm's value varies with different levels of outstanding short-term debt and accumulated customer capital, while holding outstanding long-term debt (or short-term debt) and exposure to cash-flow shocks constant.

and long-term debt to issue. The advantage of long-term debt is that only a portion γ of the principal must be repaid each period, allowing firms to maintain a certain level of outstanding debt stock to reduce debt issuance costs. However, an excessive reliance on long-term debt can result in debt overhang, increasing the risk of default. Investors, anticipating this risk, will heavily discount the price of long-term debt, making it more expensive to issue. Thus, firms face the challenge of finding the optimal mix of short-term and long-term debt. While long-term debt reduces the need for frequent refinancing, over-reliance can increase the cost of new debt. By carefully balancing the two types of debt, firms can efficiently manage their financing needs.

Figure 17 and Figure 18 shows our estimated results of four main objects: 1) the value function $V(m, B^S, B^L, z)$, (2) continuation value function $V(m, B^S, B^L)$, (3) short-term debt pricing kernel $Q^S(m, B^S, B^L)$, and (4) long-term debt pricing kernel $Q^L(m, B^S, B^L)$.

Figure 18: Firm's pricing Kernels (Q^S & Q^L)

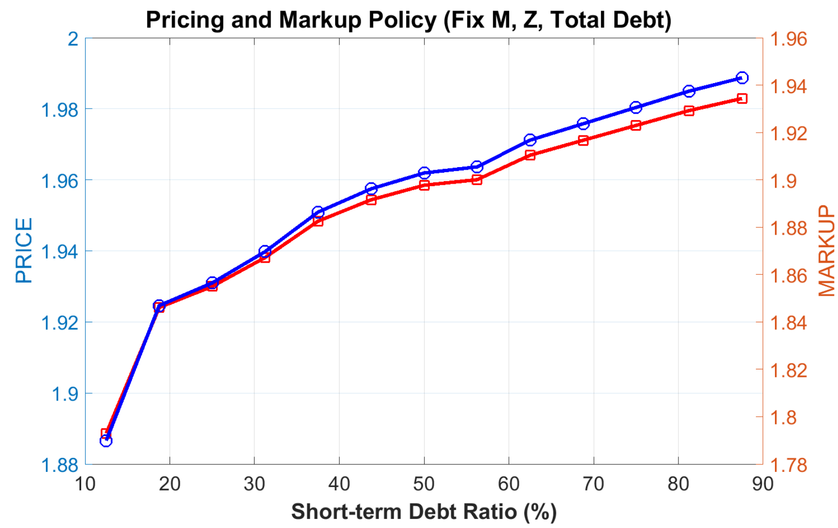


Notes: This figure presents the estimated short-term debt and long-term debt pricing kernels in the full model, which allows issuance of both short-term and long-term debt. It illustrates how the pricing kernel varies with different levels of outstanding short-term debt and accumulated customer capital, while holding outstanding long-term debt (or short-term debt) and exposure to cash-flow shocks constant.

The value functions illustrate that firms derive greater value from accumulating customer capital, which enhances their capacity to generate future cash flows. However, an increase in both short-term and long-term debt obligations diminishes the firm's value due to the heightened default risk associated with these liabilities. Furthermore, the firm's value is adversely affected by more severe cash-flow shocks, highlighting the negative consequences of financial constraints on the firm's long-term viability.

The pricing kernels for short-term and long-term debt reveal that customer capital and the volume of debt issuance are key determinants of debt pricing. Firms with greater customer capital face a lower likelihood of default, which reduces their cost of financing. However, when a firm issues excessive amounts of either short-term or long-term debt, investors anticipate a higher probability of future default. This increased risk is reflected in the discounted debt prices, raising the firm's overall cost of issuing additional debt.

Figure 19: Firm’s Pricng & Markup Decisions

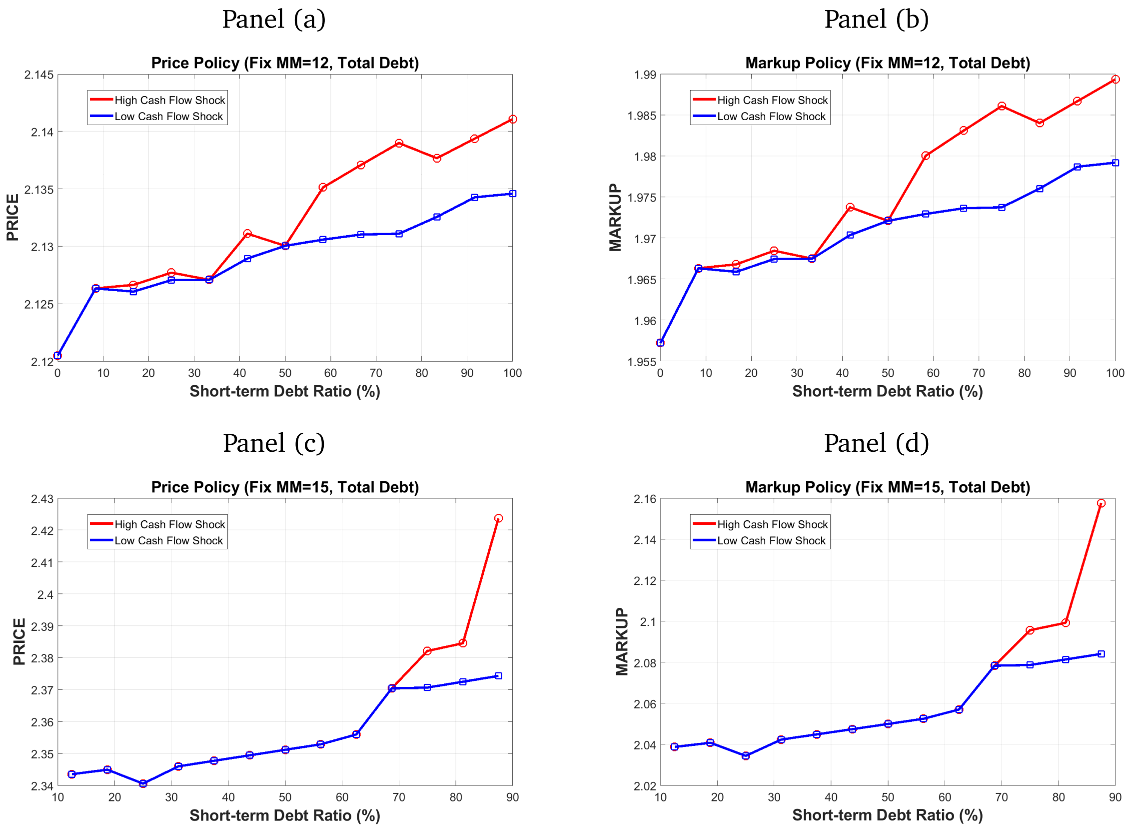


Notes: This figure presents the firm’s optimal policies for price and markup in the full model, which allows issuance of both short-term and long-term debt. The left axis represents the price level, and the right axis represents the markup level. This figure illustrates the firm’s pricing strategy as the ratio of short-term debt to total debt varies, while holding total debt, customer capital, and cash-flow shock exposure constant.

After solving the model, we examine how firms adjust their product pricing and markup decisions in response to their debt repayment schedules. Figure 19 presents the product pricing strategies relative to the proportion of short-term debt in the firms’ debt portfolios. To explore how debt composition influences pricing behavior, we compare firms that have the same level of accumulated customer capital and exposure to negative cash flow shocks. Importantly, we control for the total level of debt by holding it constant across firms, allowing us to isolate the impact of the short-term debt ratio. This approach enables us to assess whether, even when the total debt level is fixed, firms facing a higher proportion of short-term debt - hence greater pressure from imminent debt repayments - adjust their pricing differently. The blue line in Figure 19 represents the firm’s pricing decision, while the red line illustrates its markup strategy. Both pricing and markup decisions indicate that, despite a constant total debt level, firms with a higher proportion of short-term debt raise prices and markups more aggressively compared to firms with lower proportions of short-term debt, suggesting that the pressure of imminent repayments drives these decisions.

Figure 20 presents another set of results demonstrating that, although the total amount of outstanding debt remains the same, firms with higher short-term debt

Figure 20: Firm's Pricng & Markup Decisions



Notes: This figure presents the firm's optimal policies for price and markup in the full model, which allows issuance of both short-term and long-term debt. It illustrates how the pricing and markup strategies change as the ratio of short-term debt to total debt increases, with total debt and accumulated customer capital held constant. Additionally, it compares the impact of different cash-flow shock exposure levels on the firm's optimal pricing and markup decisions.

repayment obligations tend to raise their prices and markups more significantly than firms with fewer imminent repayment commitments. Additionally, when firms face a greater negative cash-flow shock, they become more impatient and more in need of immediate cash to avoid default. To illustrate this mechanism, each panel of Figure 20 compares firms exposed to a more severe cash-flow shock (red line) with those facing less exposure (blue line).

In Panels (a) and (b), firms have the same levels of customer capital and total debt outstanding. In Panels (c) and (d), firms also share the same level of customer capital and total debt outstanding, but they hold more customer capital than those in Panels (a) and (b), resulting in higher markups and prices. The findings in Figure 20 reveal that, even with identical amounts of total debt, firms with larger short-term repayment obligations feel greater pressure, prompting them to increase prices and markups more than firms with less repayment pressure. Furthermore, the differing pricing behaviors between the red and blue lines indicate that firms more severely impacted by cash-flow shocks tend to raise prices more aggressively compared to those facing milder shocks. This suggests that, even when both the total debt and short-term debt ratios are fixed, firms with greater exposure to negative cash-flow shocks feel more pressure on default, leading them to raise prices and markups to secure higher revenues and cash flows to mitigate the default risk.

6.5 Counterfactual Analysis

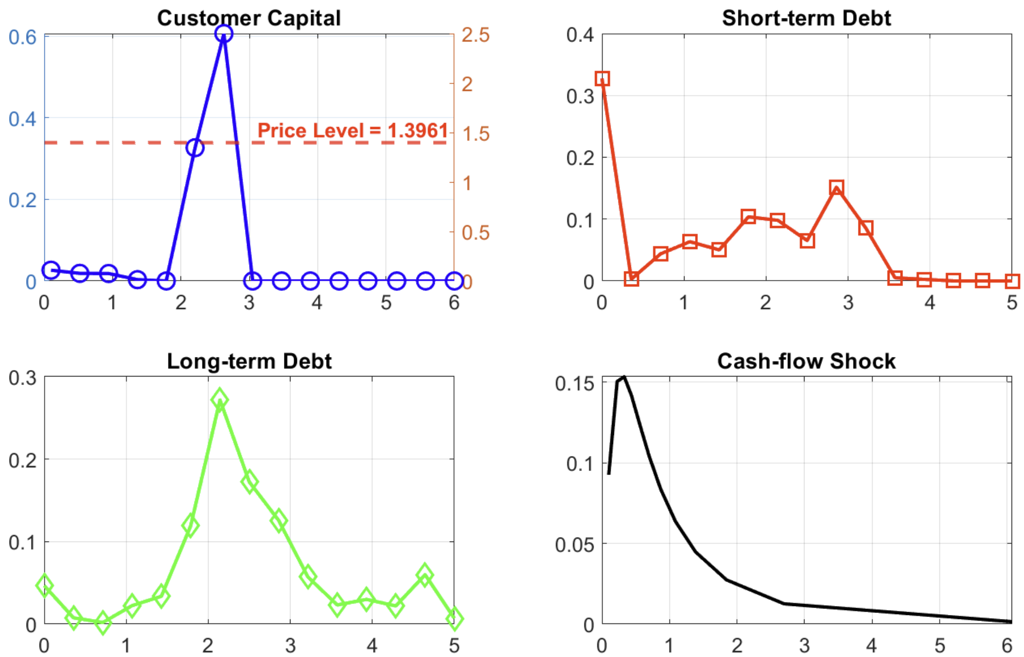
In this section, we perform a counterfactual analysis to explore how unconventional monetary policies by the Federal Reserve, such as the Maturity Extension Program (MEP), may have contributed to a reduction in the overall price level of the economy after 2008 global financial crisis. Under the MEP, the Federal Reserve purchased a significant amount of long-term Treasury securities while selling short-term securities. This program aimed to lower long-term bond rates by raising long-term bond prices. Consequently, firms could issue long-term corporate bonds more affordably, as demand from reach-for-yield market participants shifted from long-term Treasury securities to long-term corporate bonds.

In our model, the key parameter determining the ease and cost of a firm's long-term debt issuance is γ. An increase in γ makes long-term debt issuance more expensive for firms, as it raises the cost associated with issuing long-term bonds. Additionally, a higher γ intensifies the firm's debt repayment obligations, placing greater pressure on meeting debt payments each period.

We solve for the model's stationary equilibrium for each value of γ, ranging from the benchmark value of 0.05 to 0.09 and 0.13. Figure 21 displays the stationary distribution of the economy for the benchmark value of $\gamma = 0.05$. Appendix Figures A8 and A9 show the stationary distributions for γ values of 0.09 and 0.13, respectively.

$$\begin{aligned}\text{Weighted Average Maturity} &= 1 \times \left[\frac{b^S + \gamma b^L}{b^S + b^L}\right] + 2 \times \left[\frac{\gamma(1-\gamma)b^L}{b^S + b^L}\right] + 3 \times \left[\frac{\gamma(1-\gamma)^2 b^L}{b^S + b^L}\right] + \cdots \\ &= \frac{b^S + \gamma b^L(1 + 2(1-\gamma) + 3(1-\gamma)^2 + \cdots)}{b^S + b^L} = \frac{\gamma b^S + b^L}{\gamma b^S + \gamma b^L}. \qquad (27)\end{aligned}$$

Figure 21: Stationary Distribution of Firms ($\gamma = 0.05$)

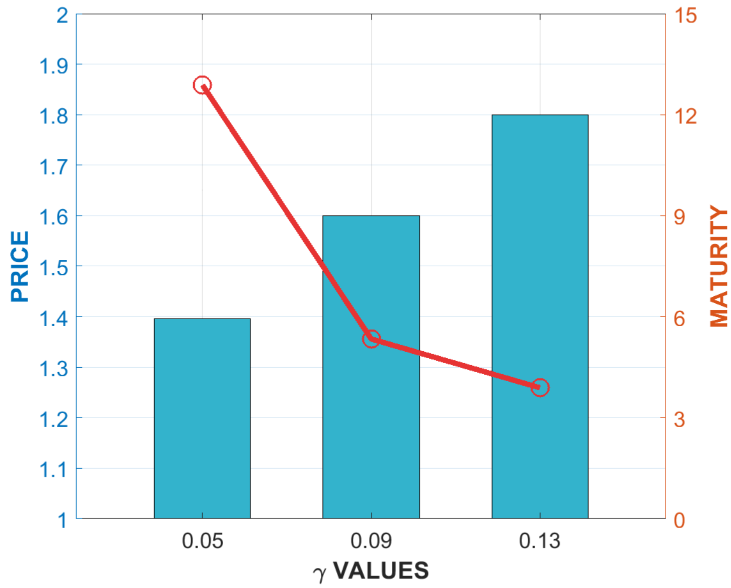


Notes: This figure displays the stationary distribution of firms when the debt repayment ratio, γ, is set to 0.05. Beginning with the upper-left panel and moving clockwise, each panel displays the stationary distribution of customer capital, outstanding short-term debt, outstanding long-term debt, and cash-flow shock, respectively. The upper-left panel also includes the aggregate price level.

After obtaining the stationary equilibrium, we calculate the overall economy's price level and weighted average debt maturity using Equation 27. By comparing the stationary distributions across three scenarios with varying values of γ, an interesting pattern emerges. When policy increases the cost of long-term debt issuance by raising the long-term debt repayment parameter γ, the economy shifts towards a greater reliance on short-term debt and a reduced reliance on long-term debt, making it more short-term debt-intensive. Notably, as the economy becomes more reliant on short-term debt, the aggregate price level rises. This pattern is shown in Figure 21, Appendix Figure A8, and Appendix Figure A9, with Figure 22 providing a clearer illustration. As γ values increase, we observe that the economy relies more heavily on short-term debt, leading to a significant reduction in average maturity. Concurrently, the economy experiences a higher aggregate price level.

This counterfactual analysis provides important insights into the impact of the Fed's unconventional monetary policy, particularly the MEP, on firms' financing behaviors and

Figure 22: Stationary Equilibrium of Price Level and Maturity



Notes: This graph displays the aggregate price level and the economy's weighted average debt maturity across different values of the parameter γ. The price level is represented by a bar chart, with its values displayed on the left y-axis, while the weighted average maturity is shown as a line plot with values on the right y-axis.

price-setting incentives. By enabling firms to issue long-term debt with greater ease, the MEP helped reduce the pressures associated with short-term debt repayment. With lower immediate repayment demands, firms experienced reduced need to raise prices as a means of meeting these obligations. This shift not only allowed firms to manage their capital structure optimally, but also contributed to a lower aggregate price level in the economy.

7 Conclusion

In this paper, we study the importance of debt maturity structure in firms' price setting behaviors. We find that firms adjust their product pricing strategies differently based on their varying debt maturity structures. Our empirical findings show that firms with a significant share of debt coming due within one to two years are inclined to raise their product prices to enhance revenue. This suggests that firms strategically adjust their pricing to meet debt obligations and reduce rollover risk.

Our model's results also reveal that firms with a higher proportion of short-term debt in their portfolios, combined with a significant negative cash-flow shock, tend to raise product prices to generate immediate cash flow and alleviate debt repayment pressure. However, this decision comes at the cost of future customer capital and market share. This mechanism highlights a critical channel through which heterogeneity in firms' debt maturity structures can influence their pricing decisions.

This study is the first to explore the connection between a firm's pricing strategies and its debt maturity profile. The findings are especially important as they offer valuable insights into the inflation dynamics within the economy. During financial crises, the average debt maturity shortens significantly, whereas firms manage to sustain longer average debt maturities after the crisis. Our framework helps explain the "missing inflation puzzle" observed during the 2008 global financial crisis and "missing deflation puzzle" after the crisis.

This finding also has meaningful policy implications regarding the impact of the Fed's unconventional monetary policies, such as the Maturity Extension Program, on inflation dynamics. Counterfactual analysis in our model suggests that if policy interventions facilitate the issuance of long-term debt, the economy will hold a greater amount of long-term debt, thereby extending the average debt maturity profile. With a lengthened maturity structure, firms experience reduced pressure from immediate debt repayments, allowing them to set lower prices. Our study highlights a potential channel through which the Fed's unconventional monetary policy can influence aggregate inflation dynamics.

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Kim and Park (2024)

A Steps in Cleaning S&P Capital IQ Data

(1) 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.

(2) 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.

(3) 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.

(4) Given the presence of numerous duplicate entries in the Capital IQ dataset, we refine the data by leveraging details such as loan amounts, loan types, and maturity dates to address redundancy. For each firm, multiple records of the same loan may exist, differing only by the reporting date. To resolve these, we classify loans as identical if they have the same loan amount and type. In such instances, we retain only the record with the latest reporting date, ensuring that our dataset captures the most recent and accurate information while removing redundant entries.

(5) Despite the data refinement in step (4), a significant number of duplicate entries remain. To address this, we leverage the unique identifier (ID) information provided by S&P Capital IQ, which tags each company's specific debt obligation. For each unique identifier corresponding to a particular debt obligation, we retain only the record with the most recent reporting date. This approach ensures that our dataset is streamlined, capturing the most up-to-date information while eliminating redundant records.

(6) Even after completing the procedure in step (5), some redundant loan records remain for each company. This occurs because certain debt obligations are recorded as duplicates even with the same reporting date. To enhance the accuracy of our dataset, we cross-verify this information using the total debt outstanding data retrieved from Compustat. Ideally, a firm's total outstanding

debt from Compustat should align with the aggregate outstanding debt computed from the Capital IQ data. We leverage the linked Capital IQ and Compustat datasets to compare these values and validate the debt information from Capital IQ. Specifically, we sum the total outstanding loan amounts derived from Capital IQ after applying steps (1) through (5) and compare this sum with the total debt obligations reported in Compustat. If we observe that the discrepancy between the Capital IQ and Compustat figures corresponds to the amount of debt duplicated due to identical reporting dates, we attribute this error to these duplicate loan entries. In such cases, we retain only one unique record per loan for each firm, ensuring consistency and accuracy in the data.

After completing the procedures from steps (1) through (6), we achieve a cleaned dataset in which the total debt obligations constructed from Capital IQ closely align with those reported in Compustat. This cross-verification with Compustat serves as a validation of the accuracy of our data cleaning process. The remaining discrepancy between the Capital IQ and Compustat totals is minimal, indicating that any residual differences are likely due to minor data reporting variations rather than substantive data quality issues. This alignment enhances the credibility and reliability of the debt data used in our analysis.

B Solution Algorithm

We use the global solution methods with time iteration procedures to solve the model. We utilize this technique since the long-term bond price is a forward looking object which depends on the firm's future optimal behaviors on default. To speed up the solution algorithm, we also make use of one-loop algorithm in which both of the pricing kernel and the firm's value functions are estimated simultaneously instead of two-loop algorithm. 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

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

The firm's value functions can be expressed 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

$$\begin{aligned}
\Phi(\mathbb{S})\vec{c} = \max_{\vec{p}, \vec{B}^{S'}, \vec{B}^{L'}} & (\vec{p} - \frac{w}{A}) \left[(\frac{\vec{p}}{P})^{-\eta} X + \theta \vec{m} \right] - (1+c)\vec{B}^S - (c+\gamma)\vec{B}^L - \sigma \vec{m} \odot \vec{z} \\
& + \vec{Q}^S \odot \vec{B}^{S'} + \vec{Q}^L \odot (\vec{B}^{L'} - (1-\gamma)\vec{B}^L) - \zeta \left(\vec{B}^{S'} + \ max\{\vec{B}^{L'} - (1-\gamma)\vec{B}^L, 0\} \right)^2 \\
& + \Lambda \Phi([\vec{m}', \vec{B}^{S'}, \vec{B}^{L'}], \vec{z}) \vec{c^e} \\
\Phi(\mathbb{S})\vec{c^e} = & (\mathbf{1}_{N_z} \otimes f') \otimes \mathbf{I}_{N_m \times N_s \times N_L} \max \{\vec{\mathbb{O}}, \ \Phi(s)\vec{c}\} \\
= & (\mathbf{1}_{N_z} \otimes f') \otimes \mathbf{I}_{N_m \times N_s \times N_L} \left[\mathbf{I}(s) \odot \mathbb{O} + (\mathbf{1}_N - \mathbf{I}(s)) \odot \Phi(s)\vec{c} \right].
\end{aligned}$$

We solve for the steady-state equilibrium using value function iteration by discretizing 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.

Solutions in Period T

In the last period T, the firm needs to repay all of the existing debts including both of the short-term debt and long-term debt. A firm is subject to a cash-flow shock and it makes decision on whether to default based on the firm's value after debt repayment. The continuation value of a firm is dependent on the existing customer capital (m), outstanding stock of short-term debt (B^S), long-term debt (B^L), and exposure to cash-flow shock (z). We denote the endogenous states $(\vec{m}, \vec{B}^S, \vec{B}^L)$ as S and the combination of endogenous state and exogenous state $(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z})$ as

$\mathcal{S}$. The value functions of a firms is given by:

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

where $\vec{Y}_T = (\vec{P}_T)^{-\eta}(\vec{m}_T)^{\theta(1-\eta)}X_T$

In the notation of collocation methods, we are able to find $\overrightarrow{c_T^c}$ from

$$V_T^c(\mathcal{S}) = V_T^c(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z}) = \Phi(\mathcal{S})\overrightarrow{c_T^c}$$
$$= \max_{\vec{P}_T}\ \vec{P}_T[(\vec{P}_T)^{-\eta}(\vec{m}_T)^{\theta(1-\eta)}X_T] - W(\frac{\vec{Y}_T}{A})^{\frac{1}{\alpha}} - (c+1)\vec{B}_T^L - (c+1)\vec{B}_T^S - \sigma\vec{z}_T$$

Solutions in Period T-1

(1) Before we solve the firm's maximization problem, we first need to characterize the pricing kernels for short-term debt and long-term debt. The pricing kernel for short-term debt in period T-1 can be expressed according to

$$\overrightarrow{Q}_{T-1}^S(\vec{m}, \vec{B}^S, \vec{B}^L) = \mathbb{E}_{z'}\left\{(c+1) \times \mathbb{I}\left[V_T^c(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z'}) \geq 0\right]\right\}$$
$$= \sum_{z_i} f(z_i)(c+1) \times \mathbb{I}\left[V_T^c(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z'}) \geq 0\right]$$

From the collocation notation, we can find the parameter vector $\overrightarrow{c_{T-1}^S}$ from

$$\Phi([\vec{m}, \vec{B}^S, \vec{B}^L])\overrightarrow{c_{T-1}^S} = \left[w' \otimes I_{N_m \times N_{Bs} \times N_{Bl}}\right](c+1) \times \mathbb{I}\left[\Phi([\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z}])\overrightarrow{c_T^c} \geq 0\right]$$

(2) Since in the last period T, all of the outstanding amount of long-term debts should be repaid, the pricing kernel for long-term debt is similar to the short-term debt in period T-1. The pricing kernel of long-term debt can be expressed as

$$\overrightarrow{Q}_{T-1}^L(\vec{m}, \vec{B}^S, \vec{B}^L) = \mathbb{E}_{z'}\left\{(c+1) \times \mathbb{I}\left[V_T^c(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z'}) \geq 0\right]\right\}$$
$$= \sum_{z_i} f(z_i)(c+1) \times \mathbb{I}\left[V_T^c(\vec{m}, \vec{B}^S, \vec{B}^L, \vec{z'}) \geq 0\right]$$

From the collocation notation, we can find the parameter vector $\overrightarrow{c_{T-1}^L}$ from

$$\Phi([\vec{m},\vec{B}^S,\vec{B}^L])\overrightarrow{c^L_{T-1}} = \left[w^{'} \otimes I_{N_m\times N_{Bs}\times N_{Bl}}\right](c+1)\times \mathbb{I}\left[\Phi([\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}])\overrightarrow{c^c_T} \geq 0\right]$$

(3) Since we have found the parameters for both of the pricing kernels $\overrightarrow{c^S_{T-1}}$ and $\overrightarrow{c^L_{T-1}}$, we can solve the firm's maximization problem

$$\begin{aligned}
V_{T-1}(\mathcal{S}) &= V_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}) = \max_{\vec{\mathcal{D}}_{T-1}}\left[\vec{\mathcal{O}}, V^c_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,\vec{z})\right] \\
&= \max_{\vec{\mathcal{D}}_{T-1}}\Bigg\{\vec{\mathcal{O}}, \max_{\vec{P}_{T-1},\vec{B}^S_T,\vec{B}^L_T} \vec{P}_{T-1}[(\vec{P}_{T-1})^{-\eta}(\vec{m}_{T-1})^{\theta(1-\eta)}X_{T-1}] - W(\frac{\vec{Y}_{T-1}}{A})^{\frac{1}{\alpha}} - (c+\gamma)\vec{B}^L_{T-1} \\
&- (c+1)\vec{B}^S_{T-1} - \sigma\vec{z}_{T-1} + \vec{B}^S_T \odot Q^S(\vec{m}_T,\vec{B}^S_T,\vec{B}^L_T) + (\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}) \odot Q^L(\vec{m}_T,\vec{B}^S_T,\vec{B}^L_T) \\
&- \zeta\left[\vec{B}^S_T + \max\{\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}, 0\}\right]^2 + \mathbb{E}_{z^{'}}\left[\Lambda V_T(\vec{m}_T,\vec{B}^S_T,\vec{B}^L_T,z^{'})\right]\Bigg\}
\end{aligned}$$

subject to (i) **[Positive Cash Flow Constraint]**

$$\vec{P}_{T-1}[(\vec{P}_{T-1})^{-\eta}(\vec{m}_{T-1})^{\theta(1-\eta)}X_{T-1}] - W(\frac{\vec{Y}_{T-1}}{A})^{\frac{1}{\alpha}} - (c+\gamma)\vec{B}^L_{T-1} - (c+1)\vec{B}^S_{T-1} - \sigma\vec{z}_{T-1}$$
$$+ \vec{B}^S_T \odot Q^S(\vec{m}_T,\vec{B}^S_T,\vec{B}^L_T) + (\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}) \odot Q^L(\vec{m}_T,\vec{B}^S_T,\vec{B}^L_T) \geq 0$$

(ii) **[Evolution of Customer Base]**

$$\vec{m}_T = \rho\vec{m}_{T-1} + (1-\rho)\mathbb{C}(\vec{P}_{T-1},\vec{m}_{T-1})$$

(iii) **[Cosumer Demand]**

$$\mathbb{C}(\vec{P}_{T-1},\vec{m}_{T-1}) = (\vec{P}_T)^{-\eta}(\vec{m}_T)^{\theta(1-\eta)}X_T$$

(iv) **[Production Technology]**

$$\vec{Y}_T = (\vec{P}_T)^{-\eta}(\vec{m}_T)^{\theta(1-\eta)}X_T \ \ \& \ \ \vec{Y}_T \leq \mathbb{C}(\vec{P}_{T-1},\vec{m}_{T-1})$$

In the notation of collocation methods, our objective is to find $\overrightarrow{c^c_{T-1}}$ from the equation below given $\overrightarrow{c^c_T}$, subject to the three constraints listed above.

$$\begin{aligned}
&\Phi([\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}])\overrightarrow{c^c_{T-1}} \\
&= \max_{\vec{P}_{T-1},\vec{B}^S_T,\vec{B}^L_T} \vec{P}_{T-1}[(\vec{P}_{T-1})^{-\eta}(\vec{m}_{T-1})^{\theta(1-\eta)}X_{T-1}] - W(\frac{\vec{Y}_{T-1}}{A})^{\frac{1}{\alpha}} - (c+\gamma)\vec{B}^L_{T-1} \\
&- (c+1)\vec{B}^S_{T-1} - \sigma\vec{z}_{T-1} + \vec{B}^S_T \odot \Phi([\vec{m},\vec{B}^S,\vec{B}^L])\overrightarrow{c^s_{T-1}} + (\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}) \odot \Phi([\vec{m},\vec{B}^S,\vec{B}^L])\overrightarrow{c^L_{T-1}} \\
&- \zeta\left[\vec{B}^S_T + \max\{\vec{B}^L_T - (1-\gamma)\vec{B}^L_{T-1}, 0\}\right]^2 + \Lambda\Phi([\vec{m},\vec{B}^S,\vec{B}^L])\overrightarrow{c^c_T}
\end{aligned}$$

(4) Once we have solved for $\overrightarrow{c^c_{T-1}}$, we can finally find $\overrightarrow{c^e_{T-1}}$ through the equation for the expectation.

$$\begin{aligned} V^e_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L) &= \mathbb{E}_{z'}\left\{V_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z')\right\} \\ &= \sum_{z_i} f(z_i) V^c_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z_i) \times \mathbb{I}\left[V^c_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z_i) \geq 0\right] \end{aligned}$$

We now can find the $\overrightarrow{c^e_{T-1}}$ through the collocation notation using $\overrightarrow{c^c_{T-1}}$ as we find in (3) through the equation

$$\Phi([\vec{m},\vec{B}^S,\vec{B}^L])\overrightarrow{c^e_{T-1}} = \left[w' \otimes I_{N_m \times N_{Bs} \times N_{Bl}}\right] \times \Phi([\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}])\overrightarrow{c^c_{T-1}} \odot \mathbb{I}\left[\Phi([\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}])\overrightarrow{c^c_{T-1}} \geq 0\right]$$

Solutions in Period T-2

From periods T-2 we can proceed the iterative procedures as we discussed in period T-1 except the price kernels for long-term debt.

$$\begin{aligned} \vec{Q}^L_{T-2}(\vec{m},\vec{B}^S,\vec{B}^L) = \mathbb{E}_{z'}\Big\{&(c+\gamma+\vec{Q}^L_{T-1}(\vec{m}_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z'),\vec{B}^S_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z'),\vec{B}^L_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z'))) \\ &\times \mathbb{I}\left[V^c_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z') \geq 0\right]\Big\} \\ = &\sum_{z_i} f(z_i)(c+\gamma+\vec{Q}^L_{T-1}(\vec{m}_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z_i),\vec{B}^S_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,_i),\vec{B}^L_{T-1}(\vec{m},\vec{B}^S,\vec{B}^L,z_i))) \\ &\times \mathbb{I}\left[V^c_T(\vec{m},\vec{B}^S,\vec{B}^L,z_i) \geq 0\right] \end{aligned}$$

From the collocation notation, we can find the parameter vector $\overrightarrow{c^S_{T-1}}$ from

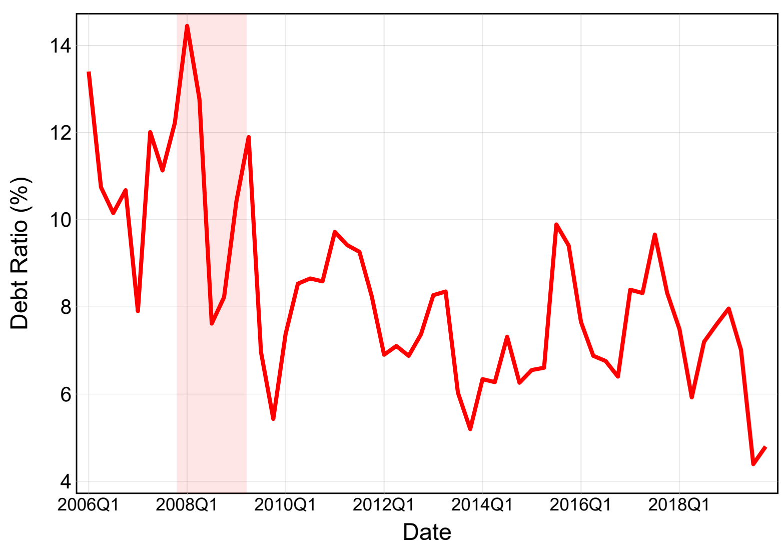
$$\begin{aligned} \Phi([\vec{m},\vec{B}^S,\vec{B}^L])\overrightarrow{c^L_{T-2}} = \left[w' \otimes I_{N_m \times N_{Bs} \times N_{Bl}}\right]&\left(c+\gamma+\Phi\Big([\vec{m}(\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}),\vec{B}^S(\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}),\vec{B}^L(\vec{m},\vec{B}^S,\vec{B}^L,\vec{z})]\Big)\overrightarrow{c^L_{T-1}}\right) \\ &\times \mathbb{I}\left[\Phi([\vec{m},\vec{B}^S,\vec{B}^L,\vec{z}])\overrightarrow{c^c_{T-1}} \geq 0\right] \end{aligned}$$

C Additional Figures and Tables

Figure A1: Example of Barcode Level Data

Notes: This figure provides an example of barcode-level data. Each unique product in the participating Nielsen store is assigned a distinct UPC code. Each product's barcode serves as a unique identifier, and we use the barcode prefix to determine the manufacturer through GS1 Data Hub as the Nielsen data lacks manufacturer information.

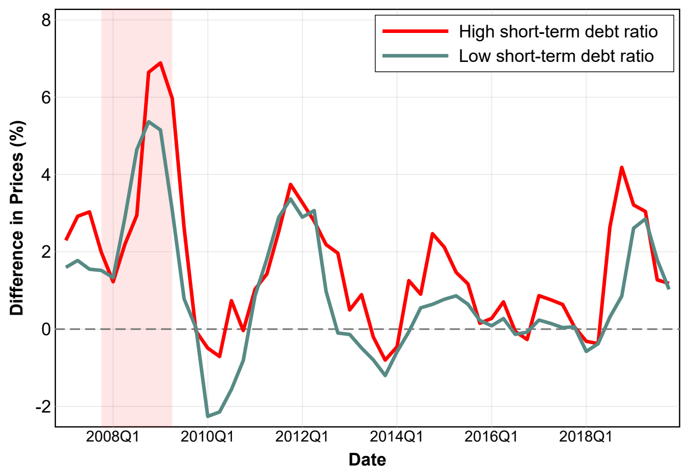
Figure A2: Trend in Firms' Share of Short- and Medium-Term Debt Ratio



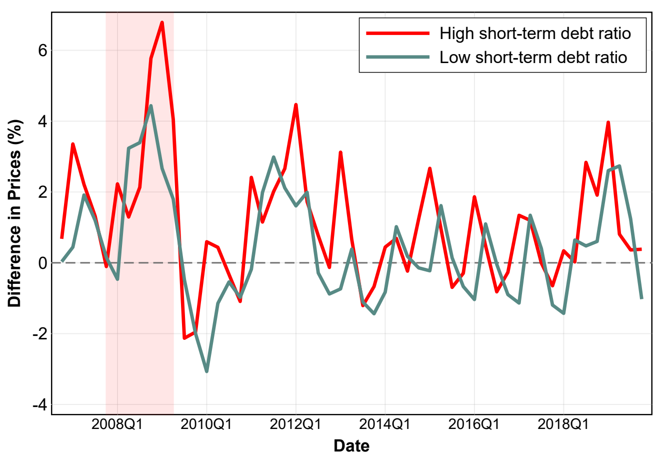
Notes: This figure shows the quarterly trends in the weighted average ratio of short-term debt (debt maturing within one year) to total debt. For each firm, we calculate the ratio of short-term debt to total debt and then compute the weighted average, using the firm's total debt as the weighting factor. The data is derived from Capital IQ. The shaded area represents the period of recessions defined by NBER.

Figure A3: Price Change Difference With Different Maturity Group

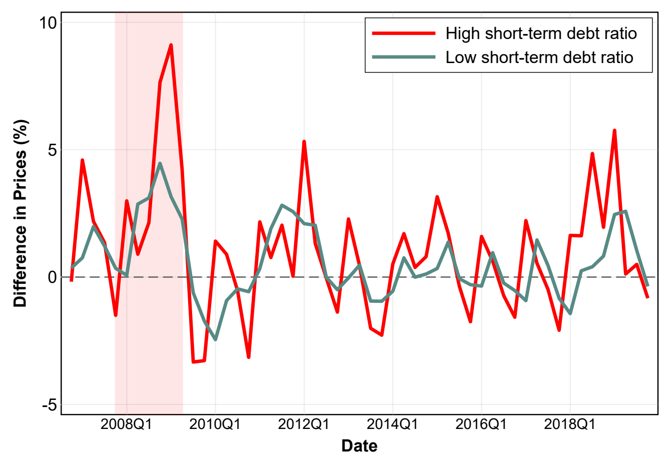
(a) Price Change $(t-4)$, Threshold Between Two Groups: 50



(b) Price Change $(t-3)$, Threshold: 75

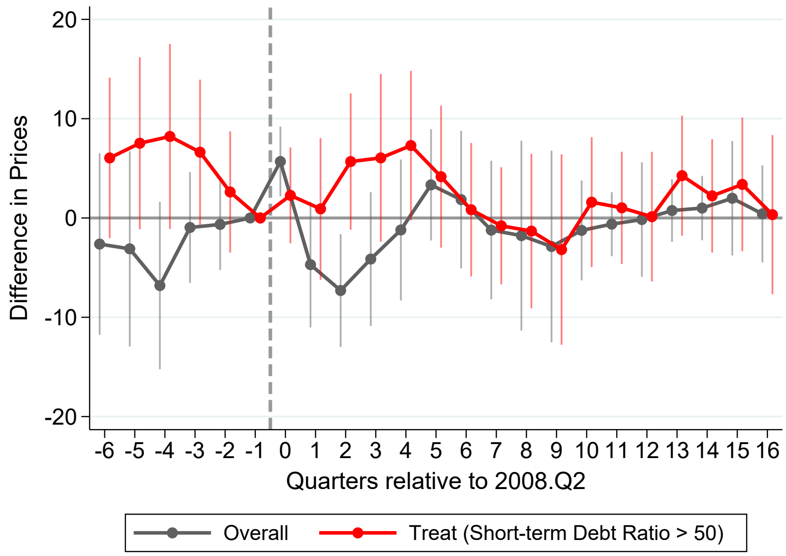


(c) Price Change $(t-3)$, Threshold: 90



Notes: This figure shows the evolution of pricing dynamics among firms with different debt maturities. Price data is sourced from the Nielsen Retail Scanner, while maturity data comes from Capital IQ. The final sample consists of matched data between these sources. The red line represents firms with a high ratio of short-term debt to total debt, while the green line represents firms with a low short-term debt ratio. A specified threshold in the short-term debt ratio is used to categorize firms into two groups. Within each group, price changes are averaged. Panel (a) presents year-over-year price changes, while panels (b) and (c) show price changes compared to three quarters before. Panels (a), (b), and (c) use thresholds of 50%, 75%, and 90% to classify firms as high or low short-term debt ratio, respectively.

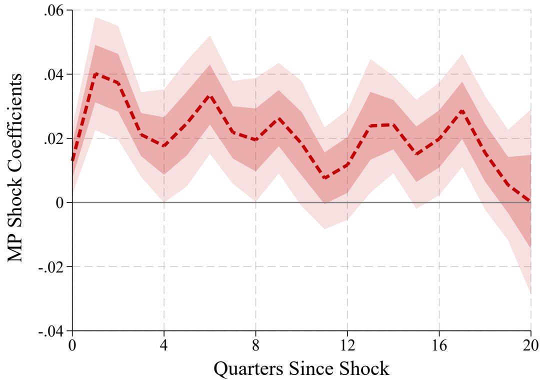
Figure A4: Heterogeneous Effect of Credit Supply Shock



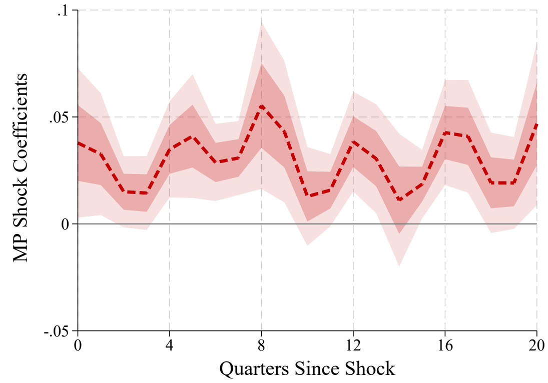
Notes: This figure shows the estimated results from Equation 9. The red line represents the heterogeneous effects of a negative credit supply shock on price changes for the group of firms with more than a specified threshold ratio of their debt maturing within one year, while the grey line represents the overall effects of negative credit supply shock on price changes. The upper panel shows the results using a 50% threshold, while the lower panel displays the results with a 70% threshold. Lagged firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The definitions of all variables are provided in Appendix Table A3. The definition of the credit supply shock $(-\Delta L_f)$ is based on Equations 6 and 7. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. The confidence intervals are calculated at the 5% significance level.

Figure A5: Price Change Impulse Response to Monetary Policy Shock

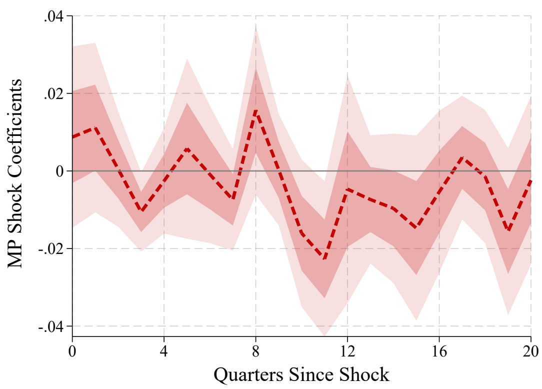
(a) Debt Due within 1 Year



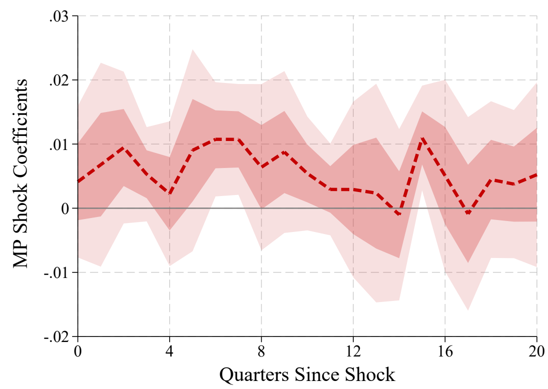
(b) Debt Due within 2 Years



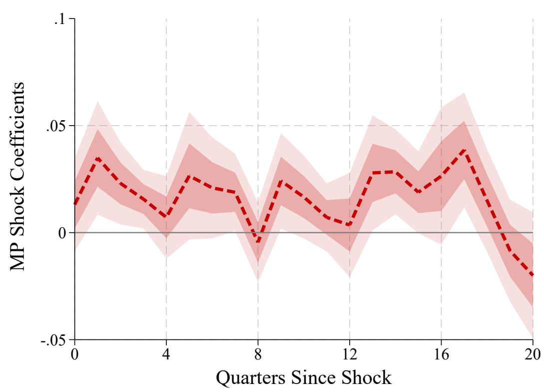
(c) Debt Due within 3 Years



(d) Debt Due within 4 Years



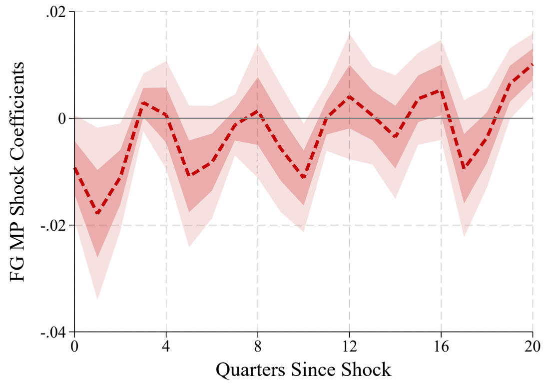
(e) Debt Due within 5 Years



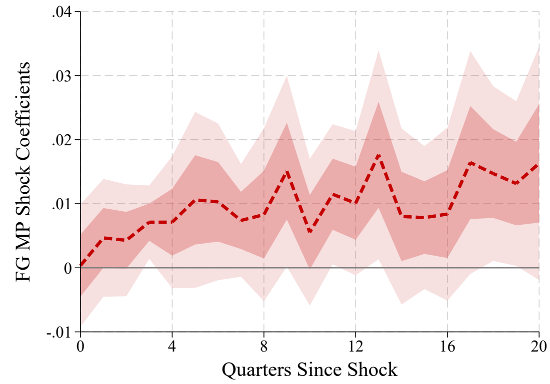
Notes: This figure displays the estimated results of Equation 11 using the target shock defined by Swanson (2021). From top to bottom and left to right, each panel presents the estimated coefficients for β_1^h, β_2^h, β_3^h, β_4^h, and β_5^h, respectively. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. Lagged firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The definition of each variable can be found in Appendix Table A3. The shaded area illustrates the pointwise confidence bands at the 5% and 10% significance levels.

Figure A6: Price Change Impulse Response to Monetary Policy Shock

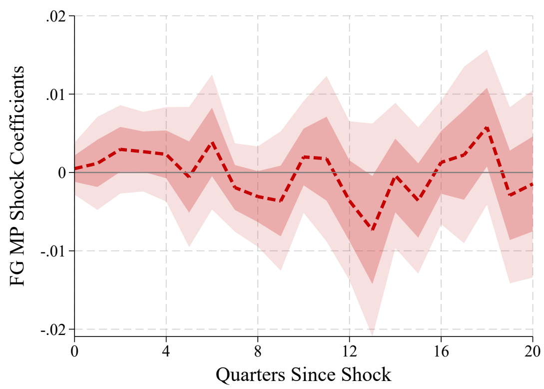
(a) Debt Due within 1 Year



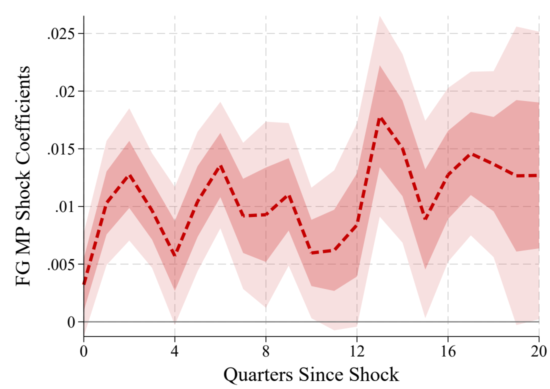
(b) Debt Due within 2 Years



(c) Debt Due within 3 Years



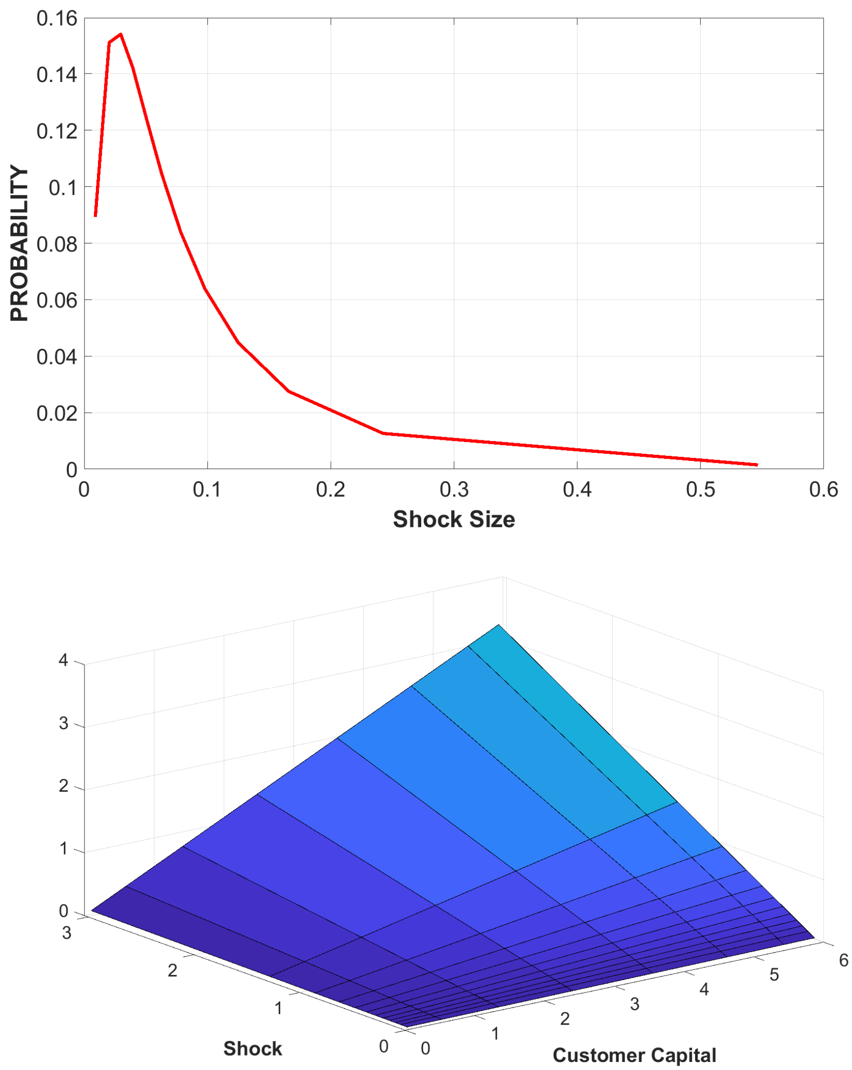
(d) Debt Due within 4 Years



(e) Debt Due within 5 Years

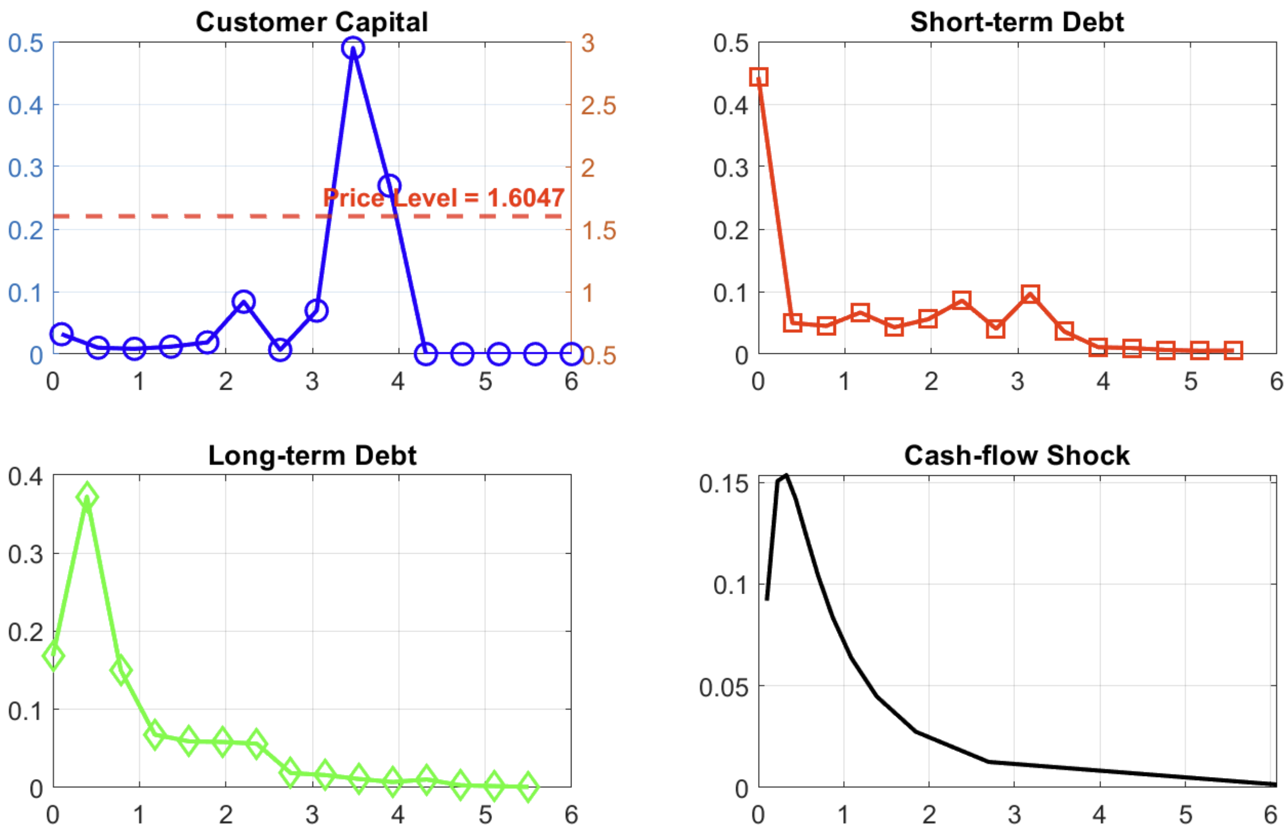
Notes: This figure displays the estimated results of Equation 11 using the forward guidance shock defined by Swanson (2021). From top to bottom and left to right, each panel presents the estimated coefficients for β_1^h, β_2^h, β_3^h, β_4^h, and β_5^h, respectively. This specification includes only floating-rate debts as defined in Capital IQ. The observations are weighted by total sales and standard errors are two-way clusterd at the firm and product group level. Lagged firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, liquidity, inventory-to-sales ratio, sales growth, and cost of goods sold growth. The definition of each variable can be found in Appendix Table A3. The shaded area illustrates the pointwise confidence bands at the 5% and 10% significance levels.

Figure A7: Distribution of Cash-flow Shock



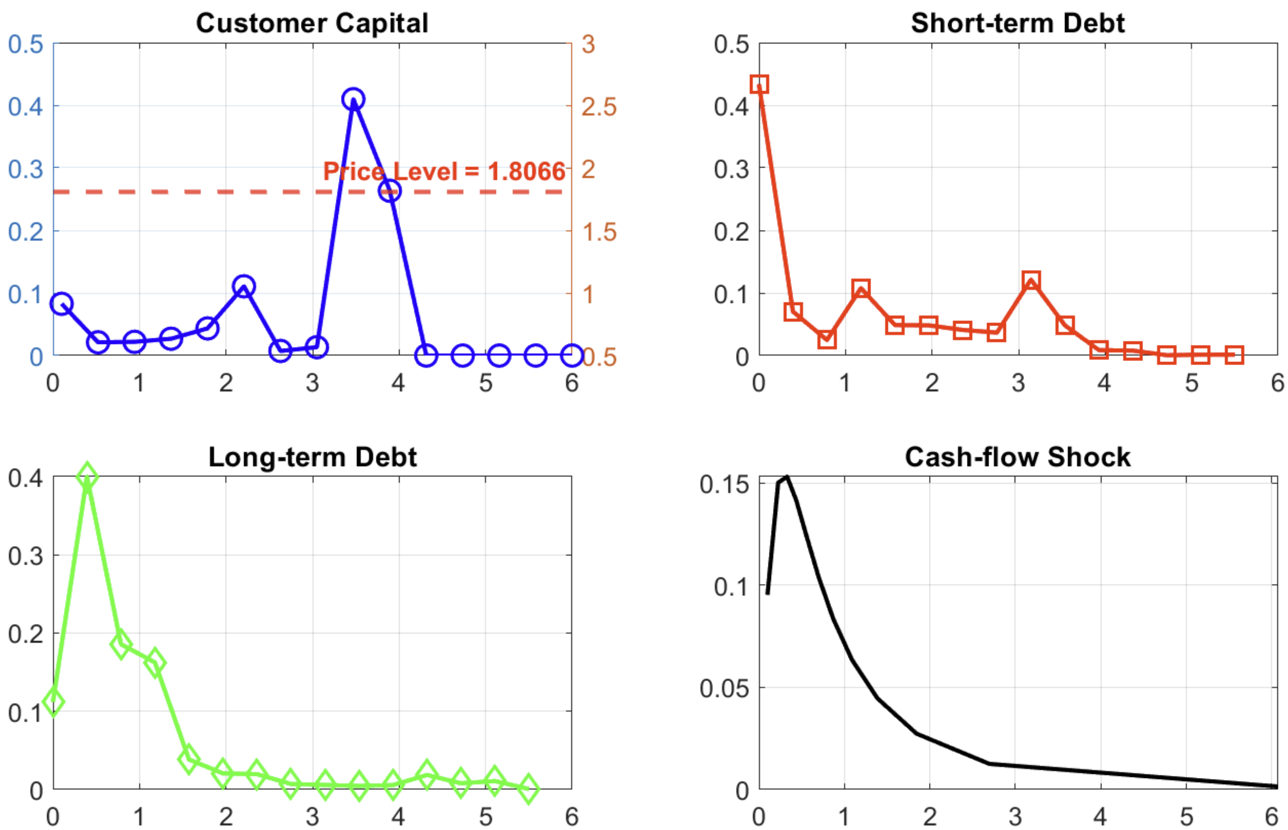
Notes: This figure presents the distribution of cash-flow shocks within the model. The left panel displays the distribution of the cash-flow shock itself, while the right panel illustrates the magnitude of the cash-flow shock faced by the firm when it is adjusted for the firm's level of customer capital.

Figure A8: Stationary Distribution of Firms ($\gamma = 0.09$)



Notes: This figure displays the stationary distribution of firms when the debt repayment ratio, γ, is set to 0.09. Beginning with the upper-left panel and moving clockwise, each panel displays the stationary distribution of customer capital, outstanding short-term debt, outstanding long-term debt, and cash-flow shock, respectively. The upper-left panel also includes the aggregate price level.

Figure A9: Stationary Distribution of Firms ($\gamma = 0.13$)



Notes: This figure displays the stationary distribution of firms when the debt repayment ratio, γ, is set to 0.13. Beginning with the upper-left panel and moving clockwise, each panel displays the stationary distribution of customer capital, outstanding short-term debt, outstanding long-term debt, and cash-flow shock, respectively. The upper-left panel also includes the aggregate price level.

Table A1: Example of a Syndicated Loan

Administrative agent	citi
Syndication agent	J.P.Morgan
Documentation	Deutsche Bank, Royal Bank of Scotland, HSBC
Participants	BofA SECURITIES, Morgan Stanley, GE Capital, Goldman Sachs

Loan-level Information from Dealscan

Borrower Name:	Procter & Gamble Co	**Lender Share (%)**	
Tracneh Active Date:	2007.Aug.17	Citi	16.76
Tranche Amount (million):	17,000	JP Morgan	11.76
Tranche Currency:	USD	Deutsche Bank AG	11.76
All In Spread Drawn (bps):	9.5	Royal Bank of Scotland Plc [RBS]	16.47
Base Reference Rate:	LIBOR	HSBC Banking Group	11.76
Deal Purpose:	General Purpose	BofA Securities	5.00
Tranche Maturity Date:	2008.Aug.15	Morgan Stanley	11.76
Seniority Type:	Senior	General Electric Capital Corp	6.76
Secured:	No	Goldman Sachs & Co	7.94

Notes: This table provides an example of a syndicated loan sourced from Dealscan data. It highlights P&G's borrowing in the syndicated loan market, with the deal initiated on August 17, 2007. The table details the participants in this syndicated loan and specifies each lender's role. Additional information includes the total loan amount, each lender's share, interest rate, and other relevant loan details.

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.

Table A3: Description of Main Variables

Variables	Construction	Source	Reference
Firm Size	$log(total\ assets_{i,t}) = log(ATQ_{i,t})$	Compustat	Alfaro et al. (2024)
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. (2024)
Market Value	$shares\ outstanding_{i,t} \times stock\ price_{i,t} = CSHOQ_{i,t} \times PRCCQ_{i,t}$	Compustat	Alfaro et al. (2024)
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. (2024)
Cash Holding	$log(cash\ and\ short-term\ investments_{i,t}) = log(CHEQ_{i,t})$	Compustat	Alfaro et al. (2024)
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. (2024)
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 describes the primary firm-level variables used in the main specifications. Our main data sources are Compustat and Capital IQ. The construction of key firm variables capturing basic firm characteristics follows the methodology of Alfaro et al. (2024). For robustness, we also include core variables defined by Gilchrist et al. (2017), adhering to their definitions of firm variables. Variables related to the debt maturity structure are constructed according to Choi et al. (2018).

Table A4: Effects of Debts with Various Maturities on Price Change

	(1)	(2)	(3)	(4)	(5)
Debt Due in 1 Year	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)
Firm Controls	Y	Y	Y	Y	Y
Store Fixed Effects	Y	Y	Y	Y	Y
Product Group Fixed Effects	Y	Y	Y	Y	Y
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). Firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, 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. The definition of each variable can be found in Appendix Table A3.

Table A5: Effects of Debts with Various Maturities on Price Change (Credit Supply Shock)

	(1)	(2)	(3)	(4)	(5)
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)
Firm Controls	Y	Y	Y	Y	Y
Store Fixed Effects	Y	Y	Y	Y	Y
Product Group Fixed Effects	Y	Y	Y	Y	Y
Observations	3,708,820	3,708,820	3,708,820	3,708,820	3,708,820
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). Firm controls include firm size, book leverage, Tobin's Q, cash holding, total debt-to-asset ratio, 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. The definition of each variable can be found in Appendix Table A3. The shock variable is defined as in Equation 5 and Equation 8.