

# **ROLLOVER RISK AND FIRM PRODUCTIVITY**

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**EVIDENCE FROM THE 2008 CREDIT CRUNCH IN THE UNITED  
STATES**

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Bachelor Thesis

Stockholm School of Economics

2025



## **Rollover Risk and Firm Productivity: Evidence from the 2008 Credit Crunch in the United States**

Abstract:

This paper investigates whether refinancing pressures from the 2008 credit supply shock contributed to the post-crisis productivity slowdown among U.S. public firms.

Exploiting the unexpected collapse of Lehman Brothers, we treat each firm's share of long-term debt maturing in 2008 as an exogenous proxy of rollover risk. Using a sample of 3,624 firms, we find that those with higher rollover risk experienced significantly larger declines in post-crisis total factor productivity (TFP) growth. A 10 percentage-point increase in rollover risk is associated with a 0.078 percentage-point larger decline in annual TFP growth. The causal interpretation is strengthened through a placebo test using the 2001 recession, in which rollover risk did not predict subsequent productivity. We also show that firms without credit rating, which typically lack bond-market access, were particularly vulnerable.

Keywords:

Rollover Risk, Financial Frictions, Credit Supply Shock, TFP, Global Financial Crisis

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Bachelor Thesis

Bachelor Program in Business and Economics

Stockholm School of Economics

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# 1 Introduction

The sudden credit supply shock that followed the Lehman Brothers collapse in September 2008 forced firms to scramble for liquidity (Brunnermeier, 2009). Firms with large amounts of debt maturing when the crisis hit faced acute refinancing pressure. Among predominantly European economies, this so-called "rollover risk" accounted for roughly one-third of the observed post-crisis slowdown in total factor productivity (TFP) growth (Duval, Hong, and Timmer, 2020). In the United States, whether rollover risk had comparable impact on firm-level TFP, remains unclear.

The U.S. is commonly classified as a market-based financial system (Levine, 2002), supported by their corporate bond market being the world's largest (Statista, 2024). Because the 2008 credit supply shock mainly affected bank credit (Ivashina and Scharfstein, 2010), one might expect listed U.S. firms to have escaped refinancing pressure by issuing bonds, especially after the U.S. government launched the Troubled Asset Relief Program (TARP) in October 2008. While the volumes of bond issuance did recover to the pre-crisis average already by January 2009 (Becker and Benmelech, 2021), the rebound was almost entirely driven by a small set of high-quality firms (Goel and Zemel, 2018). Most firms without the option to substitute bank credit for bond financing would likely have remained exposed to rollover risk. Almeida, Campello, Laranjeira, and Weisbenner (2009) showed that North American firms with a higher share of debt maturing during the crisis had to cut investment more sharply than less exposed peers. Whether this refinancing pressure also produced a lasting drag on TFP growth is the core question this study seeks to answer.

Our identification strategy adapts the approach in Duval et al. (2020) to the U.S. context, exploiting the unpredictable and exogenous nature of the credit supply shock that followed the 2008 Lehman Brothers collapse. Using Compustat data for U.S. publicly listed companies, our results reveal that ex-ante rollover risk during the crisis persists as a significant driver to TFP slowdown. Specifically, we find that a 10 pp (percentage-point) higher share of long-term debt maturing in 2008 predicts a 0.078 pp decline in average annual TFP-growth between 2008-11 and 2004-07. In contrast to predominantly small, bank-dependent European firms (Duval et al., 2020), this effect is substantially smaller.

Because the 2008 global financial crisis showed how credit constraints can force companies to cut back on research and development (Aghion, Angeletos, Banerjee, and Manova, 2010; Aghion, Askenazy, Berman, Cetto, and Eymard, 2012), investment (Almeida et al., 2009), and employment (Giroud and Mueller, 2017), TFP becomes our natural outcome of interest. It captures all of these cost-cutting adjustments in a single but broader measure of efficiency, which also is well-documented to have aggregate lasting effects on

economic growth (Mankiw, Romer, and Weil, 1992; Solow, 1957). Our findings therefore contribute to the active debate on U.S. productivity slowdown since the crisis (Redmond, Van Zandweghe, et al., 2016). We measure firm-level TFP by following the two-stage control function approach established by Díez, Fan, and Villegas-Sánchez (2021), in which we use a Generalized Methods of Moments (GMM) estimator to address the common issue of simultaneity bias. We construct TFP growth estimates for each firm-year and compare the average annual TFP growth in the pre-crisis (2004-07) and post-crisis (2008-11) periods in response to firms' rollover risk.

We estimate each firm's rollover risk by the share of its long-term debt in late 2006 that was scheduled to mature in 2008 when the credit supply shock hit. Intuitively, a higher value of maturing debt meant that firms were more exposed to either refinance on more expensive credit terms or cut back on growth-enhancing activities. Because no firm in late 2006 could have foreseen the Lehman Brothers bankruptcy, it is reasonable to assume they did not reshape their debt maturities in anticipation of the crisis. This means that the cross-firm variation in long-term debt maturing in 2008 is plausibly exogenous to other contemporaneous firm-level unobservables, such as managerial quality or unanticipated demand shocks (Duval et al., 2020).

We strengthen the casual inference of rollover risk in several ways. First, we show that firms with high respectively low share of long-term debt maturing in 2008 experienced virtually identical TFP level paths in the years before the crisis. This parallel-trends pattern suggests that firms with high rollover risk were not on a faster downward TFP trajectory already before the credit supply shock (Duval et al., 2020). We strengthen this by also controlling for firms' average share of long-term debt due in two years. This ensures that the effect of rollover risk is not driven by other unobserved characteristics correlated with a firm's typical maturity structure. Second, if rollover debt in 2008 did not reflect the effects of credit tightening but rather sensitivity to any economic downturn, we would expect it to also predict annual TFP growth declines around the 2001 U.S. recession. However, when we employ the same identification strategy on this time period, rollover risk does no longer explain differences in TFP growth. Additionally, to rule out the possibility that our rollover risk measure is simply serving as a proxy for other conventional measures of financial constraints, we re-estimate the baseline model by including pre-crisis average cash holdings, book leverage, and debt service ratios. In every augmented specification, the coefficient for rollover risk remains virtually unchanged, whereas the alternative constraint proxies fail to consistently explain differences in TFP growth. This confirms that it is primarily the timing of refinancing need per se, rather than other balance sheet vulnerabilities, that drove firms' average TFP-growth shortfall.

Having established that ex-ante debt rollover risk played an important role in ex-

plaining post-crisis TFP-growth declines, we next explore whether its impact varied systematically with observable firm characteristics. Following standard classifications of firm characteristics that can amplify the effects of financing constraints, we interact each firm’s 2008 rollover risk with its pre-crisis size, age, asset intangibility, and bond-market access (using long-term credit-rating status as a proxy). We find that only bond-market access of all interactions explains differences in rollover risk, consistent with the fact that bond markets were more resilient contra other credit channels. Because credit-rating status is potentially endogenous, we treat these findings as suggestive rather than casual.

## 2 Literature Review

A large body of the literature has documented the aggregate-level effects of financial constraints, showing that tighter credit conditions amplifies misallocation and lowers productivity (Hsieh and Klenow, 2009; Midrigan and Xu, 2014). At the firm level, researchers have often relied on balance-sheet proxies, including book leverage (Hadlock and Pierce, 2010; Whited and Wu, 2006), cash holdings (Denis and Sibilkov, 2010), and interest-coverage ratios (Whited, 1992) to capture financing constraints. Some have linked them to weaker investment (Kaplan and Zingales, 1997). Recent work more closely related to our study has estimated the effects of these proxies on a more theoretically grounded measure of firm-level TFP (Levine and Warusawitharana, 2021). However, because firms’ debt, cash, and interest coverage ratios can themselves respond to unobserved productivity shocks or managerial decisions, such correlations often leave endogeneity concerns open.

A second strand of the literature pairs firms’ credit needs with sudden, unanticipated credit supply shocks. For example, Giroud and Mueller (2017) show that firms with higher leverage on the eve of the 2008 global financial crisis experienced significantly larger losses in employment when credit dried up. On the more theoretical front, Aghion et al. (2010) developed a model in which credit constraints during recessions force firms to cut back on research and development.

While our study exploits an exogenous credit freeze in a similar way, we focus specifically on rollover risk as a particular clean measure of financing constraint. In doing so, we build on the work of Almeida et al. (2009). We extend their design by moving the outcome from investment to productivity, a broader measure of efficiency and long-term economic growth. In this way, we also add a new, maturity-based channel to why U.S. aggregate TFP growth fell sharply after the global financial crisis (Redmond et al., 2016).

The closest antecedent to our study is Duval et al. (2020), who showed that rollover

risk played a significant role in explaining the post-crisis productivity slowdown in 11 advanced economies. We apply their empirical strategy to the U.S., a setting which they do not cover.

### 3 Data Description and Summary Statistics

We obtain our firm-level financial data from the Compustat North American annual file, focusing on U.S publicly listed firms. To ensure comparability across companies, we follow standard practice and exclude those belonging to the financial sector (SIC codes starting with 6) and regulated utilities (SIC codes starting with 49). After all cleaning steps, our final sample consists of 3,624 unique firms.

We compute our primary ex-ante rollover risk measure in 2006 as the portion of long-term debt that will come due in 2008 ( $dd2$ ) divided by total long-term debt due beyond one year ( $dltt$ ). The denominator excludes the long-term debt portion due in 2007 ( $dd1$ ), because that tranche could have been refinanced before the 2008 credit freeze, and therefore does not contribute to the exposure to the Lehman Brothers shock. Using long-term debt balances recorded at the fiscal year-end 2006 ensures that the measure is predetermined, as companies could not have foreseen the global financial crises two years in advance and deliberately re-profiled debt maturities.

To ensure that our estimates of rollover risk on average TFP growth are not confounded by other firm characteristics, we augment every specification with five additional pre-crisis firm-level controls.

We define firm size as the natural logarithm of total assets ( $at$ ) (Dang, Li, and Yang, 2018). Since Compustat does not report incorporation date, we proxy firm age as the difference between 2007 and the firm's first year of reporting. Because this will understate age for firms that enter Compustat later, its coefficient may be biased toward zero. Although using the date of each company's initial public offering ( $ipodate$ ) would likely serve as a better proxy for firm age, it contains missing values for about one-third of the companies. Thus, for consistency and to avoid selection bias, we stay with the former proxy of firm age.

Profitability is defined as earnings before interest, tax, depreciation, and amortization ( $ebitda$ ) divided by the firm's total assets ( $at$ ) (Hu, 2020). We winsorize profitability at the bottom 1 and top 99 percentile. Book leverage is defined as the ratio of total debt (both short-term debt and long-term debt) ( $dlc + dltt$ ) to total assets ( $at$ ). To ensure consistent sample size across our specifications, we drop the only four firms with missing values on any of these controls.

For the heterogeneity analysis, we follow the approach by Ebrahimian and Firooz (2023) and define each firm’s level of asset intangibility as one minus the pre-crisis sum of net property, plant, and equipment (*ppent*) divided by total assets (*at*). By construction, firms that invest more in research and development, brands, and other intangibles (relative to tangible assets) have a higher intangible asset base. The nominal components for asset intangibility are first deflated by the U.S. GDP price deflator (FRED:GDPDEF) to ensure comparability over time.

We follow standard practice in the literature (Faulkender and Petersen, 2006) and indicate firms’ bond market access with its long-term credit rating. Specifically, we use S&P Domestic Long-Term Issuer Credit Rating (*splticrm*) and classify firms as rated or unrated in 2007. One concern with this approach is that some otherwise qualified firms (those with sufficient size, creditworthiness, etc.) may still be unrated. However, Faulkender and Petersen (2006) show that this is mainly a supply-side phenomenon. That is, rating agencies simply did not cover certain eligible firms, rather than those firms actively refusing to avoid fees or extra disclosure (demand-side). By assuming the supply-side view, we treat firms’ unrated status as largely exogenous to the firm’s characteristics and choices, and hence serves as a plausible proxy for involuntary lack of bond-market access.

For alternative proxies of financial frictions, we compute the pre-crisis average of cash holdings as cash and short-term investments (*che*) divided by total assets (*at*). We compute pre-crisis average book leverage as the average of total debt (*dlc + dltt*) to total assets (*at*). We also use an alternative but similar measure to interest coverage ratio. That is, debt service ratio, defined as pre-crisis average total interest and related expense (*xint*) divided by lagged total long-term and short-term debt (*dlc + dltt*). This ensures that the variable is well-behaved and interpretable for firms with negative earnings (Levine and Warusawitharana, 2021). Debt service ratio is winsorized at the 1st and 99th percentiles. Average rollover debt is calculated by taking the firm’s pre-crisis average portion of long-term debt maturing in two years (*dd2*) divided by total long-term debt maturing beyond one year (*dltt*).

Following the discussion in Díez et al. (2021) and Syverson (2011) on common measures used for TFP estimation, we treat cost of goods sold (*cogs*) as the flexible input  $\nu_{it}$ , sales (*sale*) as the output  $q_{it}$ , and gross property, plant, and equipment (*ppegt*) as the capital proxy  $k_{it}$ . Because cost of goods sold in Compustat typically bundles all sub-costs related to production of sold goods, such as intermediate inputs, materials, electricity, and labor costs, we are effectively estimating the output elasticity  $\beta_{cogs}$  as a value-weighted average of all those sub-inputs. However, because Compustat does not directly decompose these components, cost of goods sold is the natural proxy to avoid

making uncertain cost-component assumptions (De Loecker, Eeckhout, and Unger, 2020).

Following the data-quality screens in Díez et al. (2021), we drop observations with missing values for the inputs needed for our two-stage control-function TFP procedure. We also drop observations when firms report zero capital stock, or cost shares ( $\frac{cogs}{sale}$ ) that are smaller than 0.01, larger than one, or negative. The nominal values are deflated and converted into real terms to adjust for inflation. We use the U.S. investment deflator (FRED:INVDEF) as the price index to deflate the capital stock and we deflate cost of goods sold and sales using the U.S. consumer price index excluding food and energy (FRED:CPILFESL) (Levine and Warusawitharana, 2021). While using broad price deflators is the usual approach (Duval et al., 2020; Levine and Warusawitharana, 2021), it does not capture firm-specific price variations, which can potentially bias TFP estimates. For instance, if a firm with market power raises output prices, its revenue-based TFP rises mechanically irrespective of actual productivity gains (Duval et al., 2020). Indeed, according to Gilchrist, Schoenle, Sim, and Zakrajšek (2017), financially constrained firms were more likely to increase prices during the 2008 global financial crises, implying that we potentially overstate TFP growth for firms with higher rollover risk. However, this also means that any mis-measurement caused by firm-specific pricing would if anything bias our estimated effects downward, making firms with higher rollover risk to look artificially strong (Duval et al., 2020). Consequently, the true impact of rollover risk on firm productivity is likely larger than what we report.

Table 1 provides summary statistics for our main variables of interest. Firms' pre-crisis productivity was growing modestly by 0.57 pp per year on average, while post-crisis that figure turned into a small annual average decline of 0.35 pp. The implied unconditional decline of 0.91 pp between the periods indicates that U.S. public firms, despite resilience compared to other economies (Duval et al., 2020), were not immune to the adverse effects of the financial crisis.

There is a wide cross-firm dispersion in TFP, rollover debt exposure, and alternative financial frictions proxies. While many firms did not carry any long-term debt maturing during the crisis, a smaller set faced rather large portions of debt due in 2008. One concern about the distribution of the TFP-growth differential is that it contains a set of extreme outliers. While these could indicate noisy estimates, they could also reflect true productivity swings of e.g. small and volatile firms. To address this, we also re-estimate our baseline DiD after first winsorizing at the 1st and 99th percentiles (see Appendix G). This leaves the median virtually unchanged while only trimming the tails modestly.

The median firm is about 13 years old, and most firms are profitable and not highly levered. The typical firm in the interquartile range of asset intangibility has between 60 and 91 percent of its capital in intangible form, which aligns with the trend that modern

manufacturing has become more intangible-intensive (Corrado, Hulten, and Sichel, 2009)

**Table 1:** Summary Statistics

	Obs.	Mean	Median	P25	P75	SD
$\Delta TFP^{growth}$	3,624	-0.0091	-0.0094	-0.0194	-0.0026	0.0401
$\overline{TFP}_{pre}^{growth}$	3,624	0.0057	0.0044	0.0007	0.0114	0.0262
$\overline{TFP}_{post}^{growth}$	3,624	-0.0035	-0.0056	-0.0110	0.0010	0.0307
<i>Rollover Risk</i>	3,624	0.1648	0.0148	0.0000	0.1985	0.2787
<i>Assets</i>	3,624	6.0130	6.0252	4.4483	7.5905	2.3675
<i>EBITDA</i>	3,624	0.0673	0.1104	0.0492	0.1662	0.2553
<i>Age</i>	3,624	17.9415	13.0000	8.0000	24.0000	14.2667
<i>Book Leverage</i>	3,624	0.2208	0.1645	0.0067	0.3444	0.2347
<i>Asset Intangibility</i>	3,624	0.7290	0.8019	0.6048	0.9134	0.2274
<i>Average Rollover Debt</i>	3,397	0.1979	0.1502	0.0639	0.2847	0.1875
<i>Average Cash Holdings</i>	3,624	0.1965	0.1280	0.0469	0.2921	0.1917
<i>Average Book Leverage</i>	3,624	0.2173	0.1690	0.0359	0.3268	0.2147
<i>Debt Service Ratio</i>	3,014	0.2083	0.0831	0.0635	0.1258	0.5033

*Notes:*  $\Delta TFP^{growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008-11) and pre-crisis (2004-07) periods.  $\overline{TFP}_{pre}^{growth}$  is the average annual TFP growth rate pre-crisis.  $\overline{TFP}_{post}^{growth}$  is the average annual TFP growth rate post-crisis. *Rollover Risk* is the share of long-term debt maturing in 2008. *Assets* is the log of total assets. *Age* is 2007 minus the first observation year. *Book Leverage* is total debt divided by total assets. *Asset Intangibility* is one minus the ratio of total net property, plant, and equipment to total assets. *Average Rollover Debt* is a firm's average share of long-term debt maturing in two years. *Average Cash Holdings* is the pre-crisis average of cash and short-term investments divided by total assets. *Average Book Leverage* is the pre-crisis average total debt divided by total assets. *Debt Service Ratio* is the pre-crisis average of interest expense divided by lagged total debt.

## 4 Methodology

### 4.1 Identification Strategy

Our identification strategy follows the cross cross-sectional Differences-in-Differences (DiD) framework of Duval et al. (2020), linking firm's ex-ante debt rollover exposure to their TFP growth following the credit supply shock triggered by the Lehman Brothers collapse in September 2008. It evaluates whether firms with a higher proportion of long-term

debt maturing in 2008 were subject to a larger decline in TFP growth after the credit freeze compared to peers with smaller proportion of maturing debt. Importantly, comparing differences in TFP growth across two periods in the cross-section, allows us to implicitly control for all time-invariant firm-level factors (e.g. managerial skill or long-run technology growth) that may influence TFP growth (Duval et al., 2020). The baseline specification is:

$$\Delta\text{TFP}_i^{\text{Growth}} = \beta_1 \text{RolloverRisk}_i^{\text{Pre}} + \gamma X_i + \alpha_{\text{ind}(i)} + \epsilon_i \quad (1)$$

where  $\Delta\text{TFP}_i^{\text{Growth}}$  denotes the difference in average TFP growth for firm  $i$  between the four-year post-crisis (2008 to 2011) and pre-crisis periods (2004 to 2007). To ensure that our results are not sensitive to our specified windows, we test our baseline specification with alternative window lengths (see Appendix F). The variable  $\text{RolloverRisk}_i^{\text{Pre}}$  represents exposure to refinancing pressure on the eve of the crisis. For firm-specific controls  $X_i$ , we include size, age, EBITDA, and book leverage.  $\alpha_{\text{ind}(i)}$  denotes the industry level fixed effect for firm  $i$ , where  $\text{ind}(i)$  maps each firm to its 2-digit SIC industry code.  $\epsilon_i$  is the error term, with standard errors clustered at the 4-digit sector level. Firms in narrowly-defined industries are likely to face common demand and technology shocks, as well as bank- or bond-market frictions. Clustering at the 4-digit SIC code allows us to capture this variability.

Our identification exploits the fact that the collapse of Lehman Brothers and the subsequent credit supply shock were widely unanticipated (Cheng, Raina, and Xiong, 2014) and exogenous to individual firms' decisions. Moreover, our main regressor  $\text{RolloverRisk}_i^{\text{Pre}}$  is measured at the end of 2006, which makes it largely predetermined and immune to any late short-term debt adjustments that manager might have undertaken in late 2007 based on their expectations of future economic conditions. This timing therefore, avoids the reverse-causality concerns raised by Duval et al. (2020), who warns against using 2007 short-term debt as a proxy for rollover risk.

Because our defined rollover risk measures the composition of long-term debt maturing in 2008, including book leverage as a control ensures that the effect of rollover risk is isolated from overall indebtedness. Regarding profitability, while Duval et al. (2020) use the log of EBITDA, we opt for an EBITDA-to-assets ratio instead. Two considerations drive this choice. First, the correlation between log of total assets and log of EBITDA is 0.95 in our sample, which amplifies multicollinearity issues. Second, since log of EBITDA is undefined for loss-making firms, including it would mechanically drop every firm with negative EBITDA in our specifications. This risks introducing selection bias as these firms are found to differ systematically in e.g. size and age from those with positive earnings. By normalizing EBITDA by assets, we retain both profitable and unprofitable

firms and avoid collinearity while still capturing differences in operating profitability.

Including sector fixed effects allows us to account for unobserved, time-invariant differences across industries. According to Rajan and Zingales (1998), some industries rely more heavily on external finance, and may hence be more exposed to tighter credit conditions than others. Therefore, including these fixed effects allows for meaningful comparisons between firms with high versus low rollover risk within the same industry (Duval et al., 2020). In this way, we isolate the effect of rollover risk on TFP growth from broader, sector-level financial environments.

To understand which types of firms are most exposed to rollover risk, we extend our baseline specification with interaction terms that pair rollover risk with firm characteristics that the literature has shown to attenuate the effects of financing frictions. In particular, small and young firms are often more vulnerable than their older and larger peers (Hadlock and Pierce, 2010). Likewise, firms with more tangible assets can more easily secure borrowing by pledging tangible collateral (Almeida and Campello, 2007).

We also include a proxy for each firm’s bond-market access. Concretely, we construct a dummy equal to one if they had a credit rating (bond-market access) in 2007 or zero otherwise (no bond-market access). Literature has shown that bank-dependent firms contra those with access to public debt markets suffered larger valuation losses, deeper cuts in capital expenditures, and weaker profitability during banking crises (Chava and Purnanandam, 2011). Formally, we estimate the following specification:

$$\Delta\text{TFP}_i^{\text{Growth}} = \beta_1 \text{RolloverRisk}_i^{\text{Pre}} + \beta_2 Z_i + \beta_3 \text{RolloverRisk}_i^{\text{Pre}} Z_i + \gamma X_i + \alpha_{\text{ind}(i)} + \varepsilon_i. \quad (2)$$

where  $Z_i$  includes firm size, age, and asset intangibility, and dummy variable for credit rating. To reduce multicollinearity we mean-center each continuous moderator before forming its interaction with our rollover risk measure. Significant interaction coefficients would reveal which characteristics exacerbate or mitigate the productivity drag of rollover risk.

We also subject our baseline findings to several robustness exercises. First, we augment specification (1) with each firm’s pre-crisis average share of long-term debt maturing in two years to rule out that high- and low-rollover debt firms may vary systematically along other unobserved firm characteristics that explain differences in TFP growth. Second, we re-estimate specification (1) using the mild 2001 U.S. recession as a pseudo credit supply crisis, with the pre-period and post-period spanning from 1997-2000 and 2001-2004 respectively. We do this to verify that the effect of rollover risk truly reflects refinancing pressures in times of credit tightening. Third, we add three alternative and commonly used balance-sheet proxies for financial constraints, namely book leverage, cash holdings,

and debt service ratio. This allows us to test whether rollover risk uniquely affected TFP growth during the 2008 global financial crisis or if other constraints amplified productivity slowdowns.

Finally, after estimating the regression coefficient on rollover risk, we gauge its macroeconomic relevance by aggregating the predicted firm-level shocks using value-added weights, akin to Duval et al. (2020), to make our results more comparable. Value added is defined as the difference between revenue and cost of goods sold. Weighting by value added ensures that larger firms, which contribute more to GDP individually, have a proportionally greater impact.

## 4.2 TFP Estimation

To measure our dependent variable of interest firm-level TFP, we estimate a Cobb-Douglas production function of the form:

$$q_{it} = \beta_{\nu}^s \nu_{it} + \beta_k^s k_{it} + \omega_{it} + \varepsilon_{it}$$

Where output  $q_{it}$  is the log of real sales, flexible input  $\nu_{it}$  is the log of real cost of goods sold, capital stock  $k_{it}$  is the log of real gross property, plant, and equipment,  $\omega_{it}$  is firm-specific productivity, and  $\varepsilon_{it}$  is the error term capturing measurement error and unanticipated shocks. The applied methodology follows the approach by Díez et al. (2021), which builds on established techniques from the literature to address the common challenge of simultaneity bias (Akerberg, Caves, and Frazer, 2015; Loecker and Warzynski, 2012; Olley and Pakes, 1992), which arises when unobserved productivity influences firms' input choices. Specifically, we use the two-stage control function from Díez et al. (2021) (see Appendix A for the full algorithm and instruments).

In stage two, the output elasticities ( $\beta_{\nu}^s, \beta_k^s$ ) are estimated using a Generalized Methods of Moments (GMM) procedure. The instruments include a constant, current and lagged values of cost of goods sold, and lagged capital stock, which leverages the timing assumption that flexible inputs are chosen after capital is fixed (Akerberg et al., 2015; Díez et al., 2021)

To account for technological differences across industries, we estimate the production function separately for each 1-digit SIC industry group, while still ensuring a sufficient sample size within each group. This approach assumes that firms within the same industry group share common production technology and allows us to capture industry-specific output elasticities.

Using the estimated elasticities for each industry group, we calculate firm-level TFP as the residual:

$$\widehat{\text{TFP}}_{it} = q_{it} - \hat{\beta}_\nu^s \nu_{it} - \hat{\beta}_k^s k_{it}.$$

Given potential methodological and data problems with estimating firm-level TFP (Duval et al., 2020), we re-compute this measure using simple Ordinary Least Squares (OLS) regression (see Appendix B). The tests unfold that the coefficient on rollover risk remains similar in magnitude, but loses statistical significance, indicating that the straight-forward OLS is more susceptible to simultaneity bias.

## 5 Results

In this section we subject our cross-sectional DiD design to a series of empirical tests. First, Section 5.1 presents the results from the baseline specification (1), which regresses the change in average annual TFP growth across the crisis on firms' pre-crisis rollover risk. In Figure 2, we plot year-by-year TFP level trajectories for high- versus low-rollover risk firms to illustrate parallel trends. To gauge the overall economic importance of rollover risk, we aggregate the firm-level TFP-growth losses and estimate the share of the total TFP slowdown that is accounted for by rollover risk. To further strengthen causal inference, we begin by adding pre-crisis average rollover debt and then alternative financing constraint measures. We also perform a placebo test using the 2001 recession, which lacks a credit supply shock. In Section 5.2, we explore whether rollover risk varies with certain firm characteristics by establishing interactions with size, age, asset intangibility, and bond-market access. Overall, the evidence confirms that higher rollover risk during the 2008 credit tightening imposed a significant restraint on firms' productivity growth.

### 5.1 Baseline Specification Results

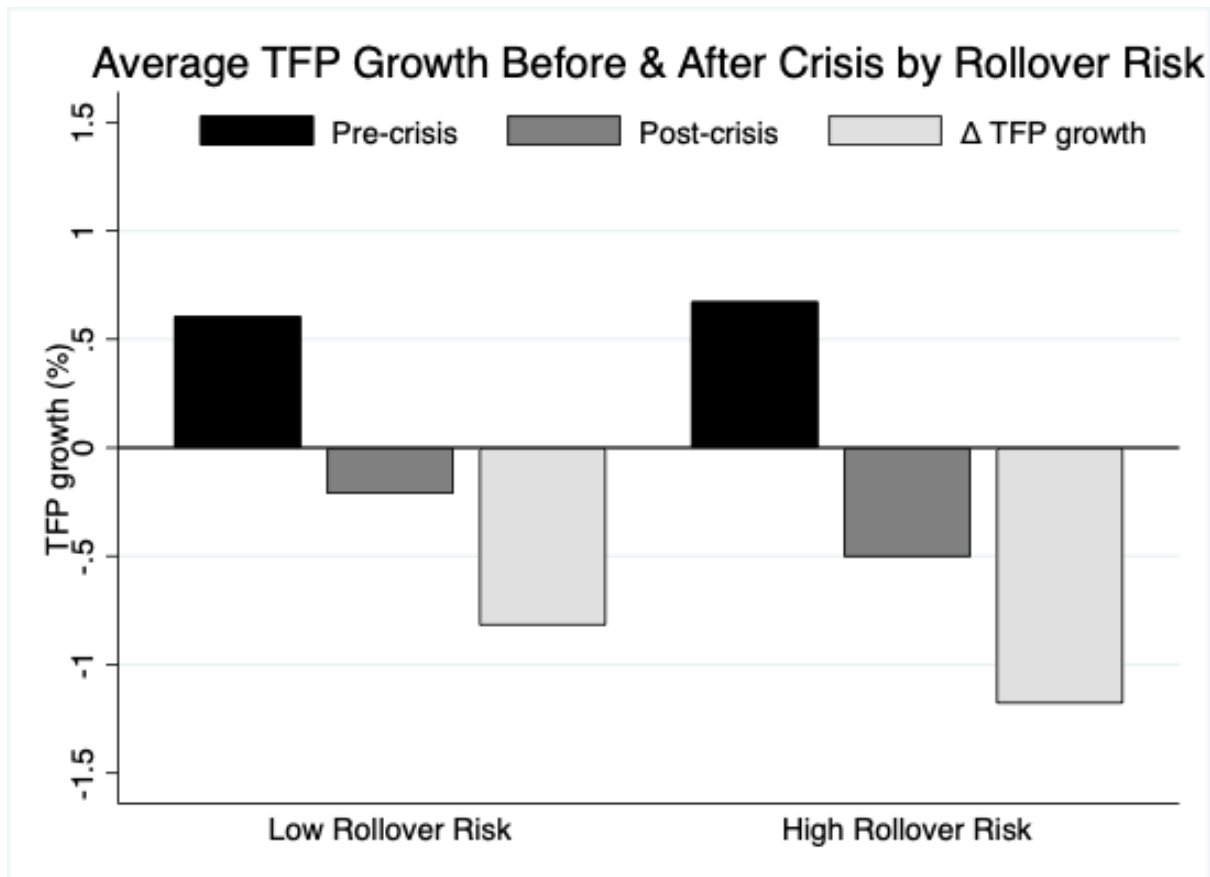
Table 2 reports our preferred estimates of specification (1). We use 2-digit SIC fixed effects and column (1) presents the results when we only include sector-fixed effects, while in column (2) we also add our set of pre-crisis firm controls. We find that the coefficient on rollover risk is negative and statistically significant at the 1 percent level, yet small in magnitude. More specifically, after controlling for firm size, profitability, age, and leverage, a 10 percentage-point increase in the share of long-term debt falling due in

2008 is associated with a 0.078 percentage-point larger drop in annual post-crisis TFP growth. Apart from any aforementioned mechanical bias in revenue-based TFP measures for constrained firms, our estimates make sense relatively to Duval et al. (2020). Our sample consists of large publicly listed firms with a median asset base of around 400 million dollars. Such entities typically have greater access to diversified funding sources, face less information asymmetry, and have stronger internal cash flows.

Aggregating the predicted firm-level TFP growth using value-added weights, we find that pre-crisis rollover risk accounts for approximately 12.12 percent of the total observed within-drop in TFP growth between the pre- and post-crisis periods. This is notably lower than the 37 percent figure reported by Duval et al. (2020). That said, the fact that average TFP growth changes appear to be pulled to a large extent by a handful of extreme firms may bias our economy-wide estimate upward. In fact, winsorizing at the 1 percent thresholds reduces the effect remarkably (see Appendix G). In this sense, true productivity swings of highly volatile firms does not generalize to the broader corporate population.

Figure 1 visualizes the core pattern of our analysis and compares the average annual TFP growth between firms with high versus low exposure to rollover risk during the crisis. Both high- and low-rollover risk firms experienced positive TFP growth before the crisis. Notably, firms with higher rollover risk had marginally higher average TFP growth, which suggests that they were not systematically less productive before the crisis. The bar charts also indicate that decline was notably larger for firms with high rollover risk during the post-crisis period, which illustrates our baseline findings. However, to ensure that firms with high rollover risk did not simply experience a mean reversion regardless of the credit supply shock, we run specification (1) including pre-crisis average TFP level as a further control (see Appendix C). The baseline results remain robust and statistically significant to this test and we also verify that the correlation between rollover risk and pre-crisis average TFP level is only 0.004 and statistically insignificant.

The magnitude of the point estimate on rollover risk becomes more negative when including firm-level controls (from -0.0067 to -0.0078). This increase in magnitude is what one would expect if firms with higher rollover risk are on average smaller, younger, or less profitable, which in turn correlate with larger post-crisis TFP-growth declines. While R-squared increases slightly after including controls, the absolute levels stay low, suggesting that the variables in the model do not explain much of the effect. However, this is not necessarily surprising. Cross-sectional DiD regressions, especially with firm-level TFP as the outcome, typically explain only a small fraction of the total variation. This is because firm-level productivity reflects many unobserved factors, including managerial quality, technological adoption, demand shocks etc., beyond observable balance-sheet



**Figure 1:** "Pre-crisis" is the average pre-crisis TFP growth for low respectively high rollover-risk firms. "Post-crisis" is the average post-crisis TFP growth for low respectively high rollover-risk firms. " $\Delta TFP$  growth" is the difference in average TFP growth between the pre- and post-crisis periods for low respectively high-rollover risk firms. "High Rollover Risk" represents firms belonging to the top 25 percentile of the 2006 distribution of the share of long-term debt maturing in 2008. "Low Rollover Risk" represents firms belonging to the bottom 25 percentile of the distribution of the share of long-term debt maturing in 2008. Rollover Risk is the share of long-term debt maturing in 2008 estimated in 2006.

items (Griliches and Mairesse, 1995).

Figure 2 displays that firms with high respectively low amount of maturing debt in 2008 follow virtually the same productivity path from 2005 through 2007. Then, in 2008, we see that high rollover risk firms experienced a modestly larger decline in productivity than their low-rollover risk counterparts. While both groups started to recover in the subsequent years, the gap created at the crisis never really closes nor widens further. This pattern tells us two things. First, the parallel slopes until 2008 strengthens causality in our identification, as firms with higher rollover risk did not systematically trend downwards before the crisis, consistent with the results in Figure 1. Second, while rollover risk exacerbated the 2008-09 drop in TFP, its effect indicates mostly a "one-off" divergence.

**Table 2:** Effect of Rollover Risk on Average TFP Growth

	<b>Dependent Variable: <math>\Delta TFP^{Growth}</math> (2008–11 – 2004–07)</b>	
	(1)	(2)
Rollover Risk <sub>2008</sub>	−0.0067*** (0.0026)	−0.0078*** (0.0027)
Industry FE (SIC-2)	Yes	Yes
Firm Controls	No	Yes
Observations	3 624	3 624
$R^2$	0.0425	0.0546

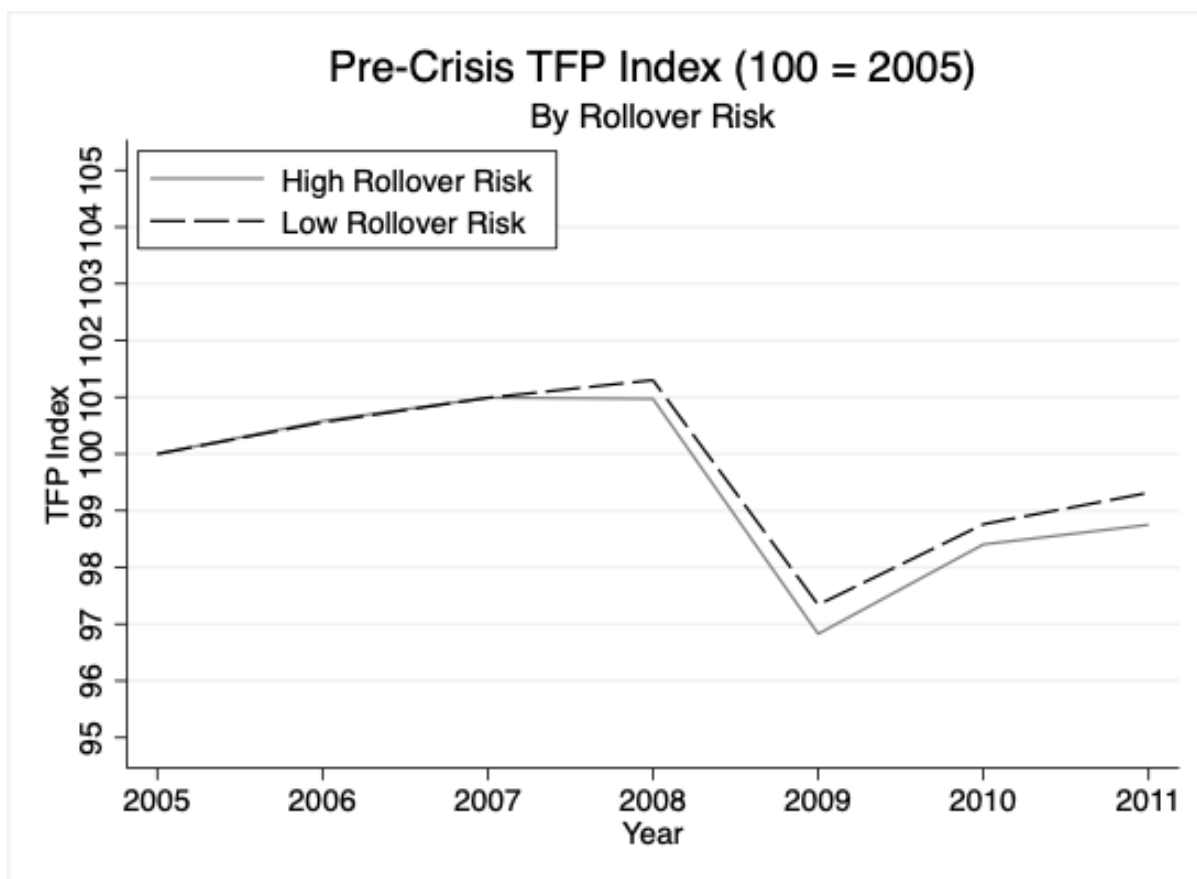
*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–11) and pre-crisis (2004–07) periods. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

This is evidenced by that firms with high rollover risk recovered at roughly the same pace as firms with low rollover risk in the subsequent years.

By contrast, Duval et al. (2020) find that the productivity divergence continued to widen beyond 2009 between high- and low-rollover-risk cohorts. Apart from the resilient U.S. corporate bond markets (Becker and Benmelech, 2021), the limited divergence in our graph could reflect policymakers’ large coordinated responses to the credit freeze, including the Federal Reserve’s emergency liquidity facilities and Treasury’s capital injections. On the other hand, it also contrasts findings that recessions associated with financial crises often lead to long-lasting declines in investment and real GDP (Cerra and Saxena, 2008).

One concern that could bias our baseline results is that firms with high share of long-term debt maturing in 2008 also tend to have high two-year maturing debt profiles in general (Duval et al., 2020). These firms may in turn differ in unobserved ways, such as managerial quality, growth orientation, or cyclical exposure. For instance, firms with longer maturity lengths tend to be larger, more regulated and have less growth opportunities (Barclay and Smith Jr, 1995). These firm characteristics may in turn be the true underlying forces for rollover-risk effect on post-crisis decline in TFP growth. To rule out this possibility, we add each firm’s pre-crisis average two-year maturing debt share as a further control.

Table 3 shows that even after controlling for firms average pre-crisis rollover debt profile, the share of debt maturing in 2008 remains as a significant but economically small drag on productivity. When including firm controls, Column (2) shows that the coefficient



**Figure 2:** Pre-crisis TFP level trajectories for firms with high versus low share of debt maturing in 2008. "High Rollover Risk" represents the TFP level trajectories for firms belonging to the top 25 percentile of the 2006 distribution of the share of long-term debt maturing in 2008. "Low Rollover Risk" represents the TFP level path for firms belonging to the bottom 25 percentile of the distribution of the share of long-term debt maturing in 2008. TFP level trajectory is normalized to index 100 in 2005. Rollover Risk is the share of long-term debt maturing in 2008 estimated in 2006.

falls from -0.0079 to -0.0063 compared to the baseline results. This removes the variation in 2008 rollover risk that simply reflects a firm's typical debt-maturity structure, and the smaller remaining component hence isolates only the unexpected refinancing pressure. In contrast, the coefficient on pre-crisis average two-year maturing debt share is statistically insignificant and smaller in magnitude. This indicates that debt due in 2008 indeed carried information above and beyond firms' typical maturity structures (Duval et al., 2020).

Our identification hinges on the fact that the Lehman Brothers collapse and the subsequent credit supply shock were exogenous to firms' refinancing pressure. This means that our measure of rollover risk should only explain TFP differences in presence of an unanticipated banking crisis (Duval et al., 2020). If rollover risk would simply capture

**Table 3:** Effect of Rollover Risk on Average TFP Growth: Controlling for Average Rollover Debt

	Dependent Variable: $\Delta TFP^{Growth}$ (2008–11 – 2004–07)	
	(1)	(2)
Rollover Risk <sub>2008</sub>	−0.0059** (0.0025)	−0.0063** (0.0025)
Average Rollover Debt	0.0007 (0.0046)	−0.0005 (0.0049)
Industry FE (SIC-2)	Yes	Yes
Firm Controls	No	Yes
Observations	3,397	3,397
$R^2$	0.0423	0.0514

*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–11) and pre-crisis (2004–07) periods. Rollover Risk<sub>2008</sub> is the amount of 2006 long-term debt maturing in 2008. Average Rollover Debt is the pre-2006 average share of long-term debt maturing in two years divided by total long-term debt maturing beyond one year. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

firms’ sensitivity to any economic downturn, it should also predict productivity drops around the 2001 U.S. recession when no comparable credit supply shock took place. Thus, testing the baseline specification around a ”pseudo-crisis” helps us rule to that our rollover risk measure simply reflects sensitivity to general demand or sector-cycle economic swings.

Columns (1) and (2) in Table 4 replicate specification (1) but uses 1997–2000 and 2001–2004 as the pre- and post-”crisis” periods respectively, with debt maturing in 2001 as our main measure of rollover debt. The estimated coefficients are statistically insignificant, whether or not we include firm-level controls. This suggests that rollover risk does not have any generic economic downturn effect on firm-level TFP. Instead, it strengthens the casual link and further confirms that our findings in 2008 are not driven by unobserved firm characteristics (such as sensitivity to recessions), but by the timing of refinancing pressure during a true credit freeze.

Prior literature has shown that traditional balance sheet vulnerabilities can negatively impact firm performance, including firm-level TFP (Levine and Warusawitharana, 2021). Therefore, another concern is that the effect of rollover risk may simply reflect other well-known balance sheet weaknesses rather than true refinancing pressure. To rule out this

**Table 4:** Placebo Test – 2001 U.S. Recession as Pseudo-Crisis

	<b>Dependent Variable: <math>\Delta TFP^{Growth}</math> (2001–04 – 1997–2000)</b>	
	(1)	(2)
Rollover Risk <sub>2001</sub>	–0.0037 (0.0032)	–0.0032 (0.0032)
Industry FE (SIC-2)	Yes	Yes
Firm Controls	No	Yes
Observations	4,418	4,418
$R^2$	0.0946	0.0953

*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth between the placebo post-crisis (2001–04) and pre-crisis (1997–2000) periods. Rollover Risk<sub>2001</sub> is the share of long-term debt in 1999 maturing in 2001. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

possibility, we further augment our baseline regression with alternative financial frictions, first individually and then jointly. Each alternative friction is averaged over the 2004-07 pre-crisis period to smooth out any year-to-year volatility.

Table 5 presents the results. Across all regressions, our key finding remains intact. The estimated effect of rollover risk remains stable, explaining between 0.073 pp and 0.078 pp decline in average annual TFP growth per each 10 pp increase in rollover risk.

Yet, all standard proxies for financial frictions stay statistically insignificant. We should, however, be cautious in interpreting the results as each of these average balance-sheet vulnerabilities may itself be endogenous to unobserved firm characteristics that also shape both debt-maturity structures and productivity outcomes. What is nevertheless clear is that even allowing for these potential biases, only the effect of rollover risk survives.

**Table 5:** Rollover Risk and Alternative Financial Frictions

	<b>Dependent Variable: <math>\Delta TFP^{Growth}</math> (2008–11 – 2004–07)</b>				
	(1) <i>+ Leverage</i>	(2) <i>+ Cash</i>	(3) <i>+ DSR</i>	(4) <i>+ Lev. and Cash</i>	(5) <i>+ All</i>
Rollover Risk <sub>2008</sub>	−0.0078*** (0.0027)	−0.0075*** (0.0027)	−0.0074** (0.0033)	−0.0075*** (0.0027)	−0.0073** (0.0034)
Avg. Book Leverage <sub>pre</sub>	0.0039 (0.0057)	—	—	0.0056 (0.0055)	0.0052 (0.0057)
Avg. Cash Holdings <sub>pre</sub>	—	0.0044 (0.0054)	—	0.0054 (0.0053)	0.0049 (0.0054)
Avg. DSR <sub>pre</sub>	—	—	−0.0013 (0.0025)	—	−0.0000 (0.0025)
Industry FE (SIC-2)	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes
Observations	3,624	3,624	3,014	3,624	3,014
$R^2$	0.0548	0.0549	0.0653	0.0552	0.0657

*Notes:* Each column adds one financial-friction control (average pre-crisis 2004–07): cash holdings, book leverage, debt service ratio (DSR), cash holdings and book leverage jointly, or all three together. The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–11) and pre-crisis (2004–07) periods. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Average cash holdings is the average pre-crisis ratio of cash and short-term investments to total assets. Average book leverage is the pre-crisis average ratio of total debt to total assets. Average debt service ratio is the pre-crisis average ratio of interest expense to lagged total debt. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## 5.2 Heterogeneity Analysis

Having established that rollover risk explains post-crisis annual TFP-growth declines, we next turn to examine whether some firms were more or less vulnerable than others.

Table 6 presents the effect of rollover risk across a range of firm characteristics that literature has shown to alleviate differences in financial frictions. We provide eight versions of specification (2), each augmented by an interaction term between rollover risk and one of four moderators: size, age, asset intangibility, and bond-market access (credit rating). Across Column (1) to Column (6), the interaction term is small, statistically insignificant, and economically negligible. In other words, we find no evidence that firms of various size, age, and asset intangibility, explain differences in the effect of rollover risk

on TFP-growth shortfalls.

We offer some possible explanations for this uniformity. First, the firms in our sample are generally larger, where the median firm age is 13 years and median size is 400 million dollars. This, coupled with public firms being generally more homogeneous in terms of e.g. diversified finance channels, may dampen cross-sectional differences in constraints across these characteristics. Second, the credit supply shock resulted in an immediate need for refinancing for all firms with maturing debt, regardless of size, age, or collateral availability. In such an acute credit shock, the advantages of size, age, or access to collateral that normally confer on longer-term credit access, may have become largely irrelevant. All firms were scrambling for liquidity at once, and hence rollover risk may have hurt firms almost equally.

On the other hand, the interaction term for bond-market access in Column (7) and Column (8) is statistically significant and positive. This suggests that firms with bond-market access are more protected from the adverse effects of rollover risk. For firms with no access to bond markets, a 10 percentage point increase in rollover risk translates into a 0.092 pp decline in annual post-crisis TFP growth.

However, we encourage caution in interpreting these results for mainly two reasons. First, while it is common practice to proxy bond-market access with credit rating (Chava and Purnanandam, 2011) we solely rely on S&P long-term credit rating to categorize firms. Thus, firms that are rated by Moody's, Fitch, or other agencies will be misclassified as unrated. However, misclassifying firms as unrated would, if anything, bias the difference between groups toward zero. Therefore, finding a significant interaction despite potential misclassification would actually strengthen the case that bond-market access matters.

The second issue is that credit rating status may itself be endogenous. That is, firms with stronger unobserved fundamentals may be more likely to both obtain a credit rating and to be more resilient to rollover risk when credit markets tighten. Indeed, we find that rated firms differ across our firm-level controls and are on average larger, more profitable, older, more levered, and have lower shares of long-term debt maturing in 2008 (see Appendix D). Chava and Purnanandam (2011) address that controlling for such characteristics is one approach to partly deal with endogeneity, which we also do, alongside using industry-fixed effects. In Appendix E we augment specification (1) with a dummy control for bond-market access and verify that rollover risk remains robust. We also measure credit ratings as of end-2007, that is, before the Lehman Brothers collapse. Whatever unobserved firm characteristics that led to a rating decision (e.g., manager quality, corporate governance, industry ties) are time-invariant at the time of the credit freeze and therefore differenced out by our cross-sectional DiD. Yet, we cannot rule out

residual selection on unobservables. For these reasons, this heterogeneity result should be interpreted as suggestive evidence that bond-market access may mitigate the effect of rollover risk on post-crisis TFP growth, rather than definitive proof of causality.

**Table 6:** Heterogeneity in the Effect of Rollover Risk on Average TFP Growth

	Dependent Variable: $\Delta TFP^{Growth}$ (2008–11 – 2004–07)							
	Size		Age		Asset Intang.		Credit Rating	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rollover Risk <sub>2008</sub>	-0.0052* (0.0029)	-0.0048 (0.0029)	-0.0068*** (0.0024)	-0.0076*** (0.0025)	-0.0069** (0.0031)	-0.0082** (0.0032)	-0.0085*** (0.0030)	-0.0092*** (0.0030)
Level of $X$	-0.0012** (0.0005)	-0.0005 (0.0004)	-0.0001** (0.0000)	-0.0001 (0.0000)	-0.0092 (0.0064)	-0.0143** (0.0067)	-0.0042*** (0.0014)	-0.0015 (0.0018)
Rollover Risk <sub>2008</sub> $\times$ $X$	0.0027 (0.0023)	0.0028 (0.0024)	0.0000 (0.0002)	0.0000 (0.0002)	0.0047 (0.0198)	0.0052 (0.0200)	0.0123*** (0.0047)	0.0146*** (0.0052)
Industry FE (SIC-2)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	3,624	3,624	3,624	3,624	3,624	3,624	3,624	3,624
$R^2$	0.0486	0.0563	0.0438	0.0546	0.0438	0.0574	0.0440	0.0554

*Notes:* Each pair of columns reports one regression of  $\Delta TFP$  growth (2008–11 vs. 2004–07) on Rollover Risk<sub>2008</sub>, a moderator  $X$ , and their interaction. The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–11) and pre-crisis (2004–07) periods. Moderators include firm size, age, asset intangibility, and credit rating. Size is log of total assets. Age is 2007 minus firms' first year of reporting. Asset intangibility is one minus total net property, plant, and equipment over total assets for the pre-crisis period. Credit rating is a dummy variable and equal to one when a firm has long-term credit rating. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

To increase transparency of our findings on bond-market access and to show directly the estimated effect of rollover risk, we next re-estimate specification (1) separately for the two groups.

Table 7 confirms that the negative impact of rollover risk on post-crisis annual TFP growth is entirely driven by firms who lack bond-market access. Consistent with the interaction results, the negative coefficient on rollover risk is relatively large and significant at the 1 percent level for the former group, but small and statistically insignificant for the latter.

With suggestive evidence, these patterns strengthen our interpretation that bond-market access appears to insulate firms from refinancing pressures, while those shut out were hit hard.

**Table 7:** Subsample Estimates: Rollover Risk and Average TFP Growth by Bond-Market Access

	Dependent Variable: $\Delta TFP^{Growth}$ (2008–11 – 2004–07)			
	Unrated		Rated	
	(1)	(2)	(3)	(4)
Rollover Risk <sub>2008</sub>	-0.0087*** (0.0030)	-0.0094*** (0.0031)	0.0034 (0.0040)	0.0042 (0.0045)
Industry FE (SIC-2)	Yes	Yes	Yes	Yes
Firm Controls	No	Yes	No	Yes
Observations	2,623	2,623	1,001	1,001
$R^2$	0.0441	0.0571	0.1205	0.1241

*Notes:* Each column reports a regression of  $\Delta TFP$  growth (2008–11 vs. 2004–07) on Rollover Risk<sub>2008</sub>. The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–11) and pre-crisis (2004–07) periods. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Rated firms do have long-term credit rating whereas unrated do not. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## 6 Conclusion

This paper has documented the impact of rollover risk on firm-level productivity for U.S. public firms during the credit supply shock that took place after the fall of Lehman Brothers in 2008. Exploiting cross-firm variation in predetermined maturing debt we find that firms with higher debt shares due at the onset of the crisis face larger declines in TFP growth. This effect emerges in 2008 and the gap neither widens nor closes through 2011, pointing to a one-off but persistent productivity drag. This indicates that U.S.’s implemented policy backstops and resilient corporate bond markets did not fully protect firms from refinancing pressure. Casual inference is bolstered by showing that rollover risk is a unique feature of the credit supply shock, and is not observed during the U.S. 2001 recession. Lastly, we explore cross-firm variation in the rollover-risk effect. Interactions with size, age, and asset intangibility are all statistically insignificant, which suggests that the impact of the sudden refinancing pressure was a uniform shock. In contrast, we find that bond-market access explains differences in rollover risk and is suggested to be an important channel to insulate firms. We interpret these results with cautious considering any potential underlying endogeneity. We suggest future research to explore the interplay between bond-market access and rollover risk in more depth, as well as the

broader implications on the U.S. economy.

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# Appendix

## A Two-Stage Control-Function Estimation of Firm-Level TFP

Stage 1:

Because the flexible input  $\nu_{it}$  is chosen after capital, it is monotonically increasing in  $\omega_{it}$ . We approximate expected output with a third-order polynomial in inputs and including fixed year effects:

$$q_{it} = \phi_{it}(\nu_{it}, k_{it}) + \varepsilon_{it}, \quad \phi_{it} = \sum_{j=0}^3 \sum_{l=0}^{3-j} \gamma_{jl} \nu_{it}^j k_{it}^l + \lambda_t.$$

The fitted value  $\hat{\phi}_{it}$  is the predictable component. The residual contains measurement error and innovation shocks.

Stage 2:

We assume productivity follows a first-order Markov process:

$$\omega_{it} = g(\omega_{i,t-1}) + \xi_{it}, \quad g(\cdot) = \text{cubic poly}; \mathbb{E}[\xi_{it} | \nu_{i,t-1}, k_{i,t-1}] = 0.$$

Where the moment conditions are:

$$E[\xi_{it}(1, \nu_{i,t-1}, k_{i,t-1})'] = 0.$$

## B OLS Estimates of Rollover-Risk Effect on Firm-Level TFP Growth

**Table 8:** Rollover-Risk Effect on Average TFP Growth Using OLS Estimation for Firm-Level TFP

	Dependent Variable: $\Delta TFP_{OLS}^{Growth}$ (2008–11 – 2004–07)	
	(1)	(2)
Rollover Risk <sub>2008</sub>	–0.0103 (0.0098)	–0.0078 (0.0101)
Industry FE (SIC-2)	Yes	Yes
Firm controls	No	Yes
Observations	3,624	3,624
$R^2$	0.0104	0.0313

*Notes:* The dependent variable  $\Delta TFP_{OLS}^{Growth}$  is the difference in average annual TFP growth estimated using OLS between post-crisis (2008–11) and pre-crisis (2004–07) periods. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## C Rollover-Risk Effect while Controlling for Pre-Crisis TFP Level

**Table 9:** Rollover-Risk Effect on Average TFP Growth: Controlling for Average Pre-Crisis TFP Level

	Dependent Variable: $\Delta TFP^{Growth}$ (2008–11 – 2004–07)	
	(1)	(2)
Rollover Risk <sub>2008</sub>	–0.0067** (0.0026)	–0.0078*** (0.0027)
TFP <sub>pre</sub>	0.0038 (0.0138)	0.0065 (0.0142)
Industry FE (SIC-2)	Yes	Yes
Firm controls	No	Yes
Observations	3,624	3,624
$R^2$	0.0426	0.0548

*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth between the post-crisis (2008–11) and pre-crisis (2004–07) periods. Rollover Risk<sub>2008</sub> is the share of long-term debt maturing in 2008. TFP<sub>pre</sub> is the pre-crisis average TFP level. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## D Summary Statistics by Credit–Rating Status

**Table 10:** Summary Statistics by Credit–Rating Status

	Obs.	Mean	SD	Min	Max
<b>Unrated Firms</b>					
Assets	2,623	5.1068	1.9775	-2.9957	12.2774
Age	2,623	15.2936	11.6482	1	57
EBITDA	2,623	0.0383	0.2916	-1.8559	0.4461
Book Leverage	2,623	0.1713	0.2226	0	1
Rollover Risk <sub>2008</sub>	2,623	0.1917	0.3075	0	1
<b>Rated Firms</b>					
Assets	1,001	8.3873	1.5019	4.8010	13.5865
Age	1,001	24.8801	17.7506	1	57
EBITDA	1,001	0.1435	0.0727	-0.1492	0.4461
Book Leverage	1,001	0.3507	0.2153	0	1
Rollover Risk <sub>2008</sub>	1,001	0.0942	0.1627	0	1

*Notes:* Summary statistics for all key pre–crisis controls and main regressor, separately for firms without a credit rating and with a credit rating. Assets is the log of total assets. Age is 2007 minus the first observation year. Book Leverage is total debt divided by total assets. EBITDA is earnings before interest, tax, depreciation, and amortization divided by the total assets. Rollover Risk<sub>2008</sub> is the share of long-term debt maturing in 2008.

## E Effect of Rollover Risk and Credit Rating on Average TFP Growth

**Table 11:** Effect of Rollover Risk and Credit Rating on Average TFP Growth

	Dependent Variable: $\Delta TFP^{Growth}$ (2008–11 – 2004–07)	
	(1)	(2)
Rollover Risk <sub>2008</sub>	−0.0073*** (0.0026)	−0.0078*** (0.0027)
Has Credit Rating	−0.0029** (0.0013)	−0.0001 (0.0018)
Industry FE (SIC-2)	Yes	Yes
Firm controls	No	Yes
Observations	3,624	3,624
$R^2$	0.0434	0.0546

*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–11) and pre-crisis (2004–07) periods. "Has Credit Rating" is a dummy variable, that takes on the value 1 if the company has a credit rating. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## F Effect of Rollover Risk on Average TFP Growth with Extended Pre- and Post-Crisis Windows

**Table 12:** Effect of Rollover Risk on Average TFP Growth with Extended Pre- and Post-Crisis Windows (2003–2012)

	Dependent Variable: $\Delta TFP^{Growth}$ (2008–12 – 2003–07)	
	(1)	(2)
Rollover Risk <sub>2008</sub>	–0.0063** (0.0026)	–0.0075*** (0.0027)
Industry FE (SIC-2)	Yes	Yes
Firm controls	No	Yes
Observations	3,628	3,628
$R^2$	0.0470	0.0611

*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth rate between the post-crisis (2008–12) and pre-crisis (2003–07) periods. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Firm-level controls include log of total assets, age, normalized EBITDA, and book leverage. All specifications include a full set of 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## G Effect of Rollover Risk on Average TFP Growth after 1-99 Percentile Winsorization

**Table 13:** Effect of Rollover Risk on Average TFP Growth (2004–2011) after 1-99 Percentile Winsorization

	Dependent Variable: $\Delta$ TFP (2008–11 – 2004–07)	
	(1)	(2)
Rollover Risk <sub>2008</sub>	–0.0041** (0.0018)	–0.0047** (0.0019)
Industry FE (SIC-2)	Yes	Yes
Firm controls	No	Yes
Observations	3,624	3,624
$R^2$	0.0633	0.0689

*Notes:* The dependent variable  $\Delta TFP^{Growth}$  is the difference in average annual TFP growth between the 2004-07 and 2008-11 periods. The variable is winsorized at the 1st and 99th percentiles. Rollover Risk<sub>2008</sub> is the share of long-term debt in 2006 maturing in 2008. Firm controls include log of total assets, normalized EBITDA, age, and book leverage. All specifications include 2-digit SIC fixed effects. Standard errors clustered at the 4-digit SIC code in parentheses. \*\*\* $p < 0.01$ , \*\* $p < 0.05$ , \* $p < 0.10$ .

## Acknowledgment of Generative AI Usage

In this paper, Generative AI tools were used only for proofreading, style refinement, minor code editing and layout adjustments (e.g., spelling, grammar, L<sup>A</sup>T<sub>E</sub>X templates). The research design, analyses and conclusions are solely the authors' own.