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Prepared by Romain Duval, Gee Hee Hong, and Yannick Timmer

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Abstract

We study the role of financial frictions in explaining the sharp and persistent productivity growth slowdown in advanced economies after the 2008 global financial crisis. Using a rich cross-country, firm-level data set and exploiting quasi-experimental variation in firm-level exposure to the crisis, we find that the combination of pre-existing firm-level financial fragilities and tightening credit conditions made an important contribution to the post-crisis productivity slowdown. Specifically: (i) firms that entered the crisis with weaker balance sheets experienced decline in total factor productivity growth relative to their less vulnerable counterparts after the crisis; (ii) this decline was larger for firms located in countries where credit conditions tightened more; (iii) financially fragile firms cut back on intangible capital investment compared to more resilient firms, which is one plausible way through which financial frictions undermined productivity. All of these effects are highly persistent and quantitatively large—possibly accounting on average for about a third of the post-crisis slowdown in within-firm total factor productivity growth. Furthermore, our results are not driven by more vulnerable firms being less productive or having experienced slower productivity growth before the crisis, or differing from less vulnerable firms along other dimensions.

JEL Classification Numbers: E32, E44,O30, O40

Keywords: Productivity, Financial Friction, Financial Vulnerability, Global Financial Crisis, Intangible Investment, Endogenous Growth.

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1. Introduction

Productivity growth has declined in advanced economies since the global financial crisis (GFC) and has remained weak ever since (Adler et al., 2017; OECD 2015). Much attention in academic research has focused on whether the productivity slowdown reflects slowing innovation and technological diffusion (Andrews et al., 2015; Cette et al., 2016; Fernald, 2015; Gordon, 2016), amid declining business dynamism (Decker et al., 2016; Haltiwanger et al., 2014). Yet the abruptness, magnitude and persistence of the fall in total factor productivity (TFP) growth after the GFC makes it difficult to blame the productivity slowdown solely on slow-moving structural forces. A defining feature of the GFC was the sharp unanticipated tightening of credit supply conditions that took place in the aftermath of the collapse of Lehman Brothers in September 2008. This paper argues that the interplay between tighter credit conditions and weak corporate balance sheets played an important role in the post-crisis productivity slowdown.

Our empirical strategy exploits the sharp and unforeseen tightening of credit conditions that took place in the immediate aftermath of the collapse of Lehman Brothers in September 2008. Using an extensive cross-country firm-level dataset put together by merging different waves of ORBIS, we start by showing that the decline in average within-firm TFP growth between the pre- and post-crisis periods was significantly larger for firms with greater pre-existing balance sheet vulnerabilities, even within narrowly defined country-industry cells. We then show that pre-crisis balance sheet weakness was associated with a larger TFP slowdown in countries where credit conditions—as measured by the increase in the average CDS spread of domestic banks, an exogenous event that amounted to a credit supply shock— tightened more right after Lehman. This further suggests that productivity was adversely affected by an *interaction* between a credit supply shock and pre-existing corporate financial vulnerabilities. These effects build up over time: the TFP gap between more and less vulnerable firms opens up in 2009 and further increases in subsequent years, ruling out that we are capturing a cyclical phenomenon. These effects are also large; a simple back-of-the-envelope calculation suggests they may account for up to a third of the within-firm TFP growth slowdown between the six years before and six years after the crisis.

We consider two types of pre-crisis vulnerabilities and find that both mattered. The first one is leverage, which captures debt overhang risk. Giroud and Mueller (2017) argue that U.S firms with a higher pre-crisis leverage ratio faced greater financial constraints when credit conditions tightened after Lehman, and were forced to lay-off more workers as a result. Our findings are in a similar spirit, but they apply to TFP growth across advanced economies—firms with a higher pre-crisis leverage ratio experienced a stronger decline in TFP growth after the crisis, and disproportionately so in countries where credit conditions tightened more. Our second measure of financial vulnerability captures *ex-ante* rollover-risk and is the share of debt prior to the crisis that was scheduled to mature during the crisis, measured as the share of current liabilities (maturing within a year) at the end of 2007. Because the GFC was unforeseen, firms' debt structure prior to the crisis is unlikely to be correlated with other unobserved firm characteristics that might correlate with the magnitude of the decline in their TFP growth post-crisis. For this reason, the share of debt maturing during the crisis is our preferred firm-level measure of financial vulnerability.

The causal interpretation of our estimates rests on two further grounds. First, the results are not driven by more vulnerable firms being less productive or having enjoyed slower productivity gains before the crisis—more and less vulnerable firms do not differ significantly along these or other relevant dimensions. Second, in a placebo test, we confirm that the change in within-firm TFP growth between the pre- and post-2000 recession periods was unrelated to pre-2000 balance sheet vulnerabilities. This underlines the peculiar nature of the GFC, which was associated with a massive credit supply shock, unlike the 2000 recession that followed the burst of the dot-com bubble.

Having established that financial frictions mattered for the post-GFC TFP slowdown, we then turn to the question of why they did so. While we do not provide a comprehensive answer to this question, we explore the role of weaker intangible investment as one possible channel. When credit markets froze after September 2008, short-term debt could not be rolled over, or only at a much higher cost. The larger was the amount of short-term debt that could not be rolled over, the greater was the pressure on firms to reduce expenditure. Unlike intangible investment such as R&D or workforce training, most forms of physical capital can be pledged as collateral to obtain a loan, and they can translate more quickly into sales. Firms that had to

roll over larger amounts of short-term debt had therefore a greater incentive to cut back on intangible investment, which in turn could have affected TFP. We find supportive evidence for this conjecture. Using the same empirical strategy as for our productivity analysis, we show that firms with pre-existing balance sheet vulnerabilities cut back on intangible investment more than their less vulnerable counterparts after the crisis, and that this divergence was larger in countries where credit conditions tightened more during Lehman.

Our paper relates to the recent literature on the productivity effects of financial frictions. The dominant strand of this literature focuses on resource misallocation across firms, following Hsieh and Klenow (2009). Some studies highlight that financial frictions can increase misallocation, and thereby weaken TFP, by preventing an optimal allocation of resources toward more credit-constrained firms (Midrigan and Xu, 2014; Moll, 2014). Other papers highlight instead that credit booms due to large capital inflows, and lax credit conditions more broadly, can lead to misallocation of resources and productivity losses (Benigno et al., 2015; Borio et al., 2016; Gopinath et al., 2016). Our paper does not directly relate to this literature, as we ignore misallocation of resources *between* firms and focus instead on the much-less researched impact of financial frictions for *within*-firm productivity growth.

More closely related to our work are papers by Aghion et al. (2010), who show theoretically that credit constraints can lead firms to cut R&D spending—and long-term illiquid investments more broadly—during recessions, as well as by Aghion et al. (2012), who find supportive empirical evidence using French firm-level data. Unlike these papers, we focus on productivity rather than just on R&D, highlight the role of specific firm-level vulnerabilities, and study their role for a broad cross-country firm-level dataset by exploiting the September 2008 collapse of Lehman Brothers as an exogenous credit supply shock. Theoretical models by Garcia-Macia (2016) and Anzoategui et al. (2016) further highlight that reduced investments in intangible assets can slow within-firm productivity growth. Our empirical evidence is consistent with this prediction.

The remainder of this paper is structured as follows. Section 2 outlines our empirical strategy and describes the dataset used for the analysis. Our main results are presented in Section 3.

Section 4 analyzes the dynamics of the productivity effects of the crisis identified in the previous section. Robustness checks are provided in Section 5. Section 6 concludes.

2. Empirical Strategy

2.1. Identification Approach

Our empirical setup is a differences-in-differences strategy that compares the difference in TFP growth between firms with large versus low pre-existing balance sheet vulnerabilities, after versus before the sharp unforeseen credit conditions tightening in 2008 after the collapse of Lehman Brothers. It bears similarities with Giroud and Mueller (2017), who study the impact of this credit supply shock on employment in U.S firms by regressing the change in firm-level employment around the global financial crisis on the pre-crisis leverage ratio, their measure of firm-level credit constraint.[2] Our focus here is on the change in TFP growth—and, subsequently, on the change in investment in intangibles as a potential explanation—rather than the change in employment. Our baseline regression is as follows:

$$\Delta TFP_{isc}^{growth} = \beta_1 Vulnerabilities_i^{pre} + \alpha_{sc} + \gamma' \mathrm{X}_i + \varepsilon_{isc} \quad (1)$$

Where $\Delta TFP_{isc}^{growth}$ is the difference in average TFP growth of firm i, in sector s, and country c between the post-crisis (five years after the crisis 2008) and the pre-crisis (five years until 2008) periods. $Vulnerabilities_i^{pre}$ denote pre-crisis balance sheet vulnerabilities at the firm level discussed below, and X_i is a set of firm-level controls including age, log of total assets and log of earnings (EBITDA) before the financial crisis. Our focus on the difference in firm-level TFP growth between two periods also means that all time-invariant firm characteristics that may affect TFP growth are implicitly controlled for. Standard errors are clustered at the country-sector.

[2] One advantage of comparing the five years after versus the five years before the crisis is that we allow for a dynamic TFP response instead of restricting it to be contemporaneous. Papers by Mian and Sufi (2014) and Khawja and Mian (2008) are other examples of recent examples of approaches that collapse the data around events. See Betrand et al. (2004) for a discussion of differences-in-differences strategies.

Importantly, our specification includes country-sector fixed effects. This implies that we compare the change in average TFP growth between more and less vulnerable firms within narrowly defined country-sector cells. This control is crucial because it is well established, for instance, that some sectors rely more heavily on external finance than others, and tend to have higher leverage ratios as a result (Rajan and Zingales, 1998). It could also be that firms' productivity in trade-intensive sectors in export-oriented countries may have suffered more than others from the trade slowdown after the crisis (Alcalá and Ciccone, 2004). Likewise, in certain countries the crisis-related decline in demand and its cyclical impact on measured productivity may have been greater in certain sectors, such as construction, than in others. Finally, policy changes such as tax, product or labor market reforms in some countries in the aftermath of the crisis might have affected productivity growth in certain sectors more than in others. By including country-sector fixed effects, we rule out that our results may capture such factors.

In order to identify the impact of tighter credit conditions on the post-crisis decline in TFP growth in firms with pre-existing balance sheet vulnerabilities, we also exploit the fact that the magnitude of the credit supply shock that followed the collapse of Lehman Brothers in September 2008 varied across countries. If balance sheet vulnerabilities indeed contributed to weaken within-firm TFP growth when credit conditions tightened, we should expect this effect to have been larger in countries where credit conditions tightened more. We test for this conjecture by augmenting our baseline regression (1) with an interaction term as follows:

$$\Delta TFP_{isc}^{growth} = \beta_1 Vulnerabilities_i^{pre} + \beta_2 Vulnerabilities_i^{pre} * \Delta CDS_c + \alpha_{sc} + \gamma' X_i + \varepsilon_{isc} \quad (2)$$

Where ΔCDS_c is the change in the average CDS spread of domestic banks in country c between the first and second halves of 2008. All else equal, banking systems whose CDS spreads rose more around the collapse of Lehman Brothers experienced a larger increase in perceived vulnerabilities, and a more adverse shock to credit supply as banks sought to strengthen their balance sheets. We argue that a greater exposure to the Lehman bankruptcy as reflected in a larger increase in domestic bank CDS spreads captures the exogenous tightening of credit conditions in the country considered. In other words, we use the variation in the exposure to the Lehman bankruptcy as it is a pre-determined variable that cannot be caused by the change

in productivity growth around the crisis. Note that using the change in domestic bank CDS spreads as a measure of the tightening of credit conditions for domestic firms implicitly assumes that the latter rely heavily upon banks in their home country for their funding needs, and cannot fully tap other sources of credit as a substitute. This is a reasonable assumption given that our sample is dominated by small European firms that typically do have access to corporate bond markets, syndicated lending or cross-border bank lending.

We consider two distinct types of firm-level balance sheet vulnerabilities. The first one is leverage, which captures debt overhang risk. Giroud and Mueller (2017) argue that U.S firms with a higher pre-crisis leverage ratio faced greater financial constraints when credit conditions tightened after Lehman, and were forced to lay-off more workers as a result. Our focus here is instead on a possible impact of TFP growth. Our second measure of financial vulnerability captures *ex-ante* rollover-risk and is the share of debt prior to the crisis that was scheduled to mature during the crisis, measured as the share of current liabilities (maturing within a year) at the end of 2007. Because the September 2008 shock to credit conditions was unforeseen, firms' debt structure prior to this event is unlikely to be correlated with other unobserved firm characteristics that might correlate with the magnitude of the decline in their TFP growth post-crisis. For this reason, the share of pre-crisis debt maturing during the crisis is our preferred firm-level measure of financial vulnerability. This is in similar spirit as Almeida et al. (2009) who exploit heterogeneity in pre-crisis long-term debt maturity structure.

2.2. Data and stylized facts

Our firm-level variables are drawn from ORBIS, a unique cross-country longitudinal dataset of both listed and unlisted firms provided by Bureau van Dijk. The dataset features harmonized and rich information on firms' productive activities (for instance, value-added output, capital stock, employment) and financial situation based on balance sheets and income statements (for instance, debt, assets, tangible and intangible fixed assets, long-term debt).[3]

[3] See Gal (2013), Kalemli-Özcan et al. (2015) and Gal and Hijzen (2016) for a more detailed description of the dataset.

We focus on 15 advanced economies for which we also have information on aggregate financial and credit conditions over this period, namely Austria, Belgium, Denmark, Germany, Spain, France, Greece, Italy, Japan, Korea, the Netherlands, Portugal, Slovenia, the United Kingdom and the United States. We study firms in the non-farm, non-financial business sector, which corresponds to the two-digit industry codes 5-82 in NACE Rev.2., covering both manufacturing and a number of service sectors including for example real estate and profession/scientific/technical activities.[4]

To ensure consistency and comparability of monetary variables across countries and over time, we adopt the methodology followed in particular by Gal and Hijzen (2016). First, the original data recorded in USD are converted into local currency. Subsequently, nominal variables are turned into real variables by applying local currency deflators obtained from OECD STAN (ISIC4 version), which are rebased to 2005 US dollars using country-industry level PPPs obtained from Timmer and Inklaar (2014). In addition, we exclude very small firms (less than 3 employees), a common practice in studies using firm-level data, due to concerns regarding the reliability of the data as well as the consistency of variables over time. Also, we restrict our analysis to firms that report at least four consecutive periods.

Matched with these firm-level variables are aggregate, country-level financial and credit conditions variables drawn from other sources. The main one is an economy-wide measure of bank CDS spreads in each country in our sample, which is computed as the simple average of CDS spreads across the country's banks.[5] The change in the average CDS spread featured in equation (2) is computed as difference in the average CDS spread between the two quarters before and the two quarters after the Lehman bankruptcy.

The main dependent variable used in the analysis is firm-level TFP growth, which we compute using real value added, real capital stock and the number of employees available in each firm's

[4] See Eurostat (2008) for further information on the categorization and correspondence with other sector classifications (http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF).

[5] Results are robust to considering the principal component instead.

(continued…)

balance sheet, and applying the control function proposed by Wooldridge (2009).[6] The real capital stock and investment series for each firm are derived from the dynamic evolution of the capital stock following the perpetual inventory method (PIM), using information on depreciation and tangible fixed assets in the balance sheet (for more details, see Gal, 2013; Gal and Hijzen, 2016). As a robustness check for our results, we also use labor productivity, which is measured as the total real value added output per employed worker.

As regards our measures of pre-crisis financial vulnerabilities, the leverage ratio is calculated as the ratio of the sum of current liabilities and long-term debt to total assets, averaged from 2003 to 2007. Our rollover risk variable is computed as the ratio of current liabilities (i.e. debt maturing within a year) to total sales in the 2007 balance sheet.

Summary statistics for the dataset are provided in Table 1. It shows that the median firm experienced a large drop in within TFP growth after the financial crisis of 2008, from 1.77 percent to -4.35 percent.[7] The two financial vulnerability variables show substantial variation across firms. The median leverage ratio is 8.71% with a standard deviation of 17.83%. The amount of debt maturing in 2008 as a ratio of 2007 sales is 26.64% for the median firm, with a standard deviation of 23.95%.

Table 1. Summary Statistics

	Median	25th Percentile	75th Percentile	Standard Deviation
Average TFP Growth Pre-Crisis	1.77	-7.50	11.50	17.38

[6] Building on the identification of production function as proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003), Wooldridge (2009) provides a single-equation instrumental variable approach to control for the correlation between factor inputs (intermediates) and unobserved firm productivity by proxying the latter with a function of observed firm characteristics that reflect a firm's reaction to productivity changes. The use of revenue productivity implies that firm-specific price variations within each sector affect our productivity estimates. While these can, all else equal, reflect quality changes, they can also reflect market power of the firm. If more resilent firms increased prices since the crisis, this would mechanically result in relatively higher measured productivity growth for these firms. However, since Gilchrist et al. (2017) show that financially constrained firms raised prices during the financial crisis, our results would be if anything, downward biased. See also Syverson (2011) for a discussion of these pros and cons of using revenue-based productivity.

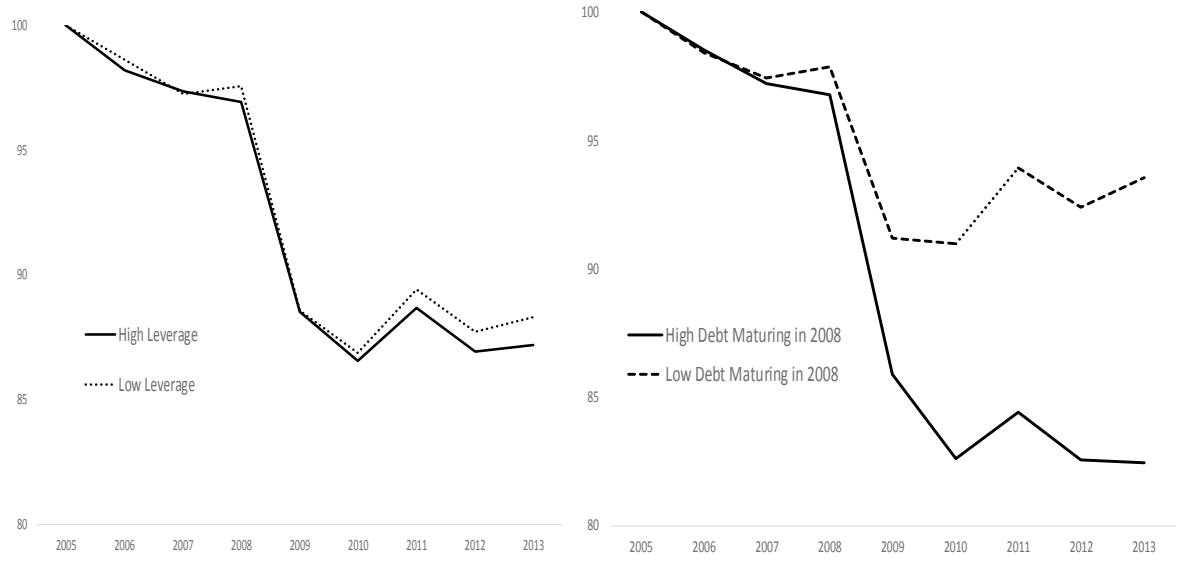
[7] Since we only focus on within-firm TFP growth and the summary statistics are not weighted, the numbers are very large.

Average TFP Growth Post-Crisis	-4.35	-17.0	4.73	17.19
ΔTFP Growth	-7.12	-27.67	9.22	32.80
Leverage Pre-Crisis	8.71	1.23	23.11	17.83
Debt Maturing 2008	26.64	16.66	42.84	23.95

Note: `Average TFP Growth Pre-Crisis' is the average TFP growth rate pre-crisis. `Average TFP Growth Post-Crisis' is the average TFP growth rate post-crisis. `ΔTFP Growth' is the difference in the TFP growth rate post vs. pre-crisis. `Percentage Change in Leverage Ratio' is the percentage change in the leverage ratio. `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. The post-crisis sample starts in 2008.

Figure 1 shows the TFP level path for firms with different degrees of financial vulnerability at the onset of the crisis. Before the crisis, both panels show that "weak" firms (solid lines) experienced just as strong productivity growth as "resilient" firms (dotted lines). However, after 2008, trajectories differed, particularly between firms facing different degrees of ex-ante rollover risk. It is worth noting that the large gap between weak and resilient firms that opens up in 2009 is not closed by 2013 (the last available year in our sample) and indeed seems to keep on rising.

Figure 1. TFP Growth Rate Path for Firms with Different Leverage Ratios and Rollover Risks (Index 100 = 2005)



Note: The TFP level path is shown as an index taking value 100 in 2005. `High Leverage' corresponds to the 75th percentile of the distribution of `Leverage Pre-Crisis' across all firms in our sample. `Low Leverage' corresponds to the 25th percentile of the distribution of `Leverage Pre-Crisis'. 'Leverage Pre-Crisis' is the average pre-crisis debt over assets ratio. `High Debt Maturing in 2008' corresponds to the 75th percentile of the distribution of `Debt Maturing in 2008'. `Low Debt Maturing in 2008' corresponds to the 25th percentile of the distribution of `Debt Maturing in 2008'. `Debt Maturing in 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis.

3. Empirical Results

This section first presents our productivity growth regression results and then investigates the role of intangible investment as one possible channel through which tighter credit conditions may have affected post-crisis TFP growth in more vulnerable firms. We start with estimates of our baseline regression (1), followed by estimates of our extended specification (2) that exploits the cross-country heterogeneity in the degree of tightening of credit conditions around the collapse of Lehman Brothers (Section 3.1). Section 3.2 runs a placebo test that checks whether the effects of financial frictions vanish when focusing instead on the recession of the early 2000s—a "regular" recession that was not accompanied by a financial crisis. In Section 3.3, we investigate the role of weaker intangible investment as one channel through which financial frictions may have contributed to the post-crisis productivity slowdown.

3.1. Baseline and extended specifications

Table 2 shows our baseline regression results. Firms with more vulnerable balance sheets experienced a stronger decline in TFP growth, with both the leverage ratio and the share of debt maturing in 2008 coming out as highly significant (columns 1 and 2) Both variables remain statistically significant at the 1% confidence level when entered simultaneously, with almost no change in coefficients (column 3). This reflects that the share of debt maturing in 2008 is uncorrelated with the leverage ratio, and that both sources of financial friction played a distinct role in the post-crisis TFP slowdown. Their estimated impact is quantitatively large: a 10 percentage point higher leverage ratio was associated with a 0.36 percentage point decline in average annual TFP growth after the crisis, while a 10 percentage points increase in the share of debt maturing in 2008 was associated with a 0.9 percentage point drop in annual TFP growth.[8]

[8] These results are quantitatively and statistically robust to controlling additionally for each firms' average rollover risk over the years 2003-2007. This further shows that our results are not driven by the fact that firms that had balance sheet vulnerabilities on the eve of the financial crisis were intrinsically weak firms that were structurally forced to raise short-term debt as a result.

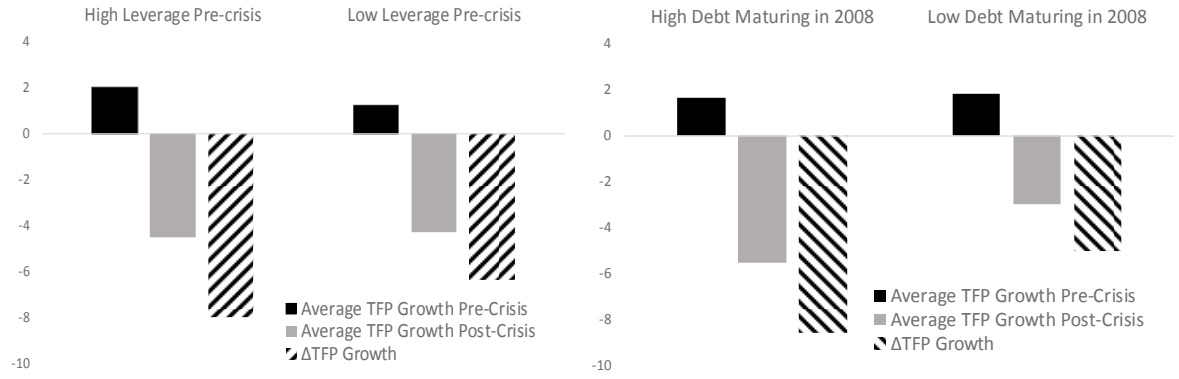
These results are illustrated graphically in Figure 2, which shows the implied difference in average TFP growth between pre- and post-crisis periods for firms at the 75th and 25th percentiles of the cross-firm distribution of the indicators of financial vulnerability (strong and weak firms, respectively). While both types of firms experienced comparable TFP growth until 2008 (black bars), the post-crisis drop in TFP growth was much less in the former (grey bars) than in the latter (shaded bars).

Table 2: Baseline Regression Results

	(1)	(2)	(3)
		ΔTFP Growth	
Leverage Pre-Crisis	-0.047***		-0.036***
	(0.008)		(0.006)
Debt Maturing 2008		-0.094***	-0.091***
		(0.010)	(0.010)
Controls	Yes	Yes	Yes
R-squared	0.149	0.151	0.151
N	134,838	134,838	134,838
Country*Sector FE	Yes	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between post- and pre-crisis periods. `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `Debt Maturing in 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. The post-crisis period starts in 2008. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Figure 2. Estimated TFP Growth Decline for Firms with Different Leverage Ratios and Rollover Risks



Note: `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. `Average TFP Growth Pre (Post) -Crisis' is the average TFP growth rate pre-crisis (post-crisis). 'Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `High (Low) Leverage Pre-crisis' corresponds to the 75$^{th}$ percentile (25$^{th}$ percentile) of the cross-firm distribution of `Leverage Pre-Crisis'. `Debt Maturing in 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. `High (Low) Debt Maturing 2008' corresponds to the 75th percentile (25th percentile) of the cross-firm distribution of `Debt Maturing 2008'. The post-crisis sample starts in 2008. Estimates are obtained from Table 2 column (3).

In order to explore whether this relationship is stronger for firms in locations where banks were exposed more to the Lehman bankruptcy, we estimate our extended specification (2)

interacting our pre-crisis measures of firm-level vulnerabilities with the change in the average CDS spread of domestic banks between the first and second halves of 2008.[9] We demean the latter variable (ΔCDS) by its country sample mean. Hence, a one unit change in ΔCDS reflects a 1 percentage point or 100 basis point larger increase in the CDS spread after the Lehman bankruptcy than in the average country in our sample. Demeaning ΔCDS also allows us to interpret the direct effect of firm-level vulnerabilities (coefficient β_1) as their effect on the change in TFP growth in the average firm in the average country.[10]

The results reported in Table 3 confirm the role played by tighter credit conditions in the post-crisis TFP slowdown of firms with pre-existing balance sheet vulnerabilities vis-à-vis their less vulnerable counterparts. Interaction terms between both firm-level vulnerability measures and the country-wide change in bank CDS spreads are statistically significant at the 1% confidence level, as are the direct effects. Based on the results in column (3), in a country that experienced an average increase in bank CDS spreads, a 10 percentage point higher leverage ratio was associated with a 0.46 percentage point post-crisis decline in average annual TFP growth in the firm considered, while a 10 percentage points increase in the share of debt maturing in 2008 was associated with a 1.08 percentage point drop in annual TFP growth. But in a country where the increase in CDS spreads was 100 basis points larger than the average, the corresponding figures were 0.51 (rising to 0.97) and 0.64 (rising to 1.72) percentage points higher.

This cross-country heterogeneity is illustrated graphically in Figure 3, also using the estimates from column (3) in Table 3. The two bars from the left compares the post-crisis decline in TFP growth for firms that lie on the 25th (low leverage) and 75th (high leverage) percentiles of the

[9] All results below are robust to considering the change in the average bank CDS spread over a narrower window, namely between the week before and the week after the collapse of Lehman Brothers (sourced from Datastream again). This is because the exogenous spike in CDS spreads seen in the aftermath of the Lehman was much larger than any other changes that took place during the year 2008, and as a result correlates strongly with the change in the average CDS between the first and second halves of 2008 we use in the regressions presented in this paper. In addition, the results are robust to using the principal component of the change in bank CDS spreads, rather than their simple average, for each country.

[10] The difference in coefficients on the direct effects of vulnerabilities between Tables 2 and 3 partly is due to the fact that the coefficient in Table 2 captures the impact in the average firm (not necessarily in the average country) while the coefficient in Table 3 captures the impact in the average firm in the average country.

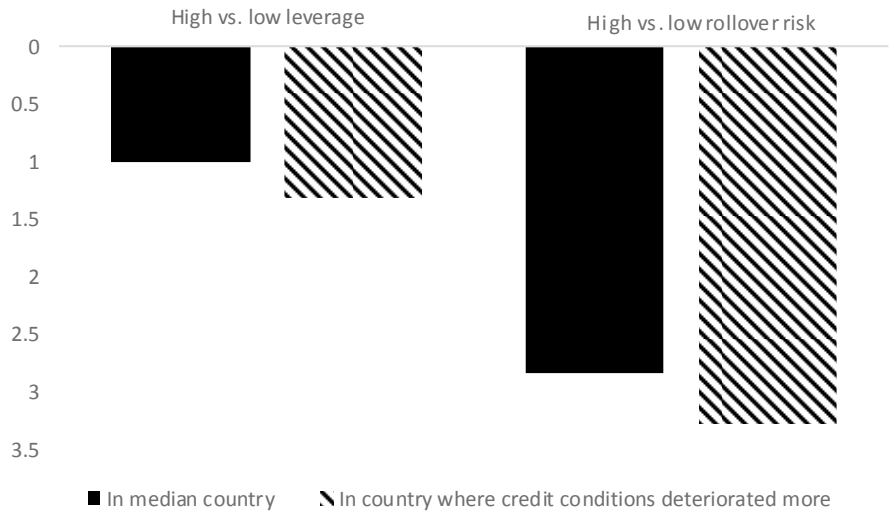
pre-crisis leverage distribution for two hypothetical countries. These two hypothetical countries differ from one another by the degree of credit conditions tightening. Namely, a median country is compared to a country with tighter credit conditions where the change in CDS spreads around the Lehman bankruptcy lies on the 75th percentile of the cross-country distribution of the change in CDS spreads. The difference is sizeable—higher pre-crisis leverage is associated with a substantially larger post-crisis decline in TFP growth if the firm was located in the country that faced a larger increase in bank CDS spreads. A higher share of debt maturing in 2008 (or rollover risk) was also associated with a larger decline in post-crisis TFP growth in the country where CDS spreads increased more (right two bars).

Table 3: Extended Specification: Accounting for the Cross-Country Heterogeneity in Exposure to the Collapse of Lehman Brothers

	(1)	(2)	(3)
		ΔTFP Growth	
Leverage Pre-Crisis	-0.057***		-0.046***
	(0.009)		(0.010)
Leverage Pre-Crisis * ΔCDS	-0.056***		-0.051***
	(0.015)		(0.021)
Debt Maturing 2008		-0.111***	-0.108***
		(0.008)	(0.008)
Debt Maturing 2008 * ΔCDS		-0.068***	-0.064***
		(0.017)	(0.017)
Controls	Yes	Yes	Yes
R-squared	0.163	0.167	0.167
N	104,275	104,275	104,275
Country*Sector FE	Yes	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. The post-crisis period starts in 2008. `ΔCDS' is the difference in the average CDS spread of banks in each country between the two quarters after and the two quarters before the Lehman bankruptcy. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Figure 3. Estimated TFP Growth Decline for Firms with Different Leverage Ratios and Rollover Risks: The Role of Country Exposure to the Collapse of Lehman Brothers



Note: `ΔTFP Growth' is the difference in the average TFP growth rate between post- and pre-crisis periods. 'Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `High (Low) Leverage Pre-crisis' corresponds to the 75th (25th) percentile of the cross-firm distribution of `Leverage Pre-Crisis'. `Rollover risk' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. `High (Low) Debt Maturing 2008' corresponds to the 75$^{th}$ (25$^{th}$) percentile of the cross-firm distribution of `Debt Maturing in 2008'. The `country where credit conditions deteriorated more' corresponds to the 75th percentile of the cross-country distribution of changes in the average bank CDS spreads between the two quarters after and the two quarters before the Lehman bankruptcy. The post-crisis sample starts in 2008. Estimates are obtained from Table 3 column (3).

How much of the total (firm-level) TFP growth slowdown can our findings account for? A simple back-of the-envelope calculation can provide an illustrative estimate. Let us assume that firms that did not have any debt maturing in 2008 did not face financial frictions and therefore did not experience any related slowdown in TFP growth. Using the coefficient of debt maturity 2008 in column (3) of Table 2 (-0.091) and multiplying it by each firm's share of debt maturing in 2008 yields each firm's estimated TFP growth loss due to pre-existing financial vulnerabilities. We then aggregate each individual firm's TFP growth loss, using their value added levels as weights, to derive the overall effect. This illustrative calculation yields an aggregate TFP growth loss of about 2.39 percentage points compared to a state in which there would have been no financial frictions. By comparison, the aggregate TFP growth drop observed in our sample, which can be calculated as the weighted sum of each firm's change in TFP growth between the pre- and post-crisis periods, is about of 6.37 percentage points. This tentatively suggests that the interplay between tighter credit conditions and firms' pre-existing financial vulnerabilities may account for some 37% (~2.39/6.37) of the total within-firm TFP growth loss after the GFC.

3.2. Placebo Test

In order to confirm that our results reflect the peculiar nature of the GFC, which was associated with a massive credit supply shock, we run a placebo test under which we estimate the impact of firm-level financial vulnerabilities on the change in within-firm TFP growth after the 2000 recession that followed the burst of the dot-com bubble. Because this was a regular recession that was not associated with a financial crisis, when re-running regressions (1) and (2) with 2000 instead of 2008 as the assumed crisis year, we should not find any statistically significant impact of pre-2000 leverage and the share of debt maturing in 2000 on the change in firm-level TFP growth between the pre- and post-2000 recession periods. This is indeed what comes out of Table 2, where none of coefficients reported in columns (1) – (3) show any statistical significance.

Table 4. Placebo Test: Early 2000s Recession

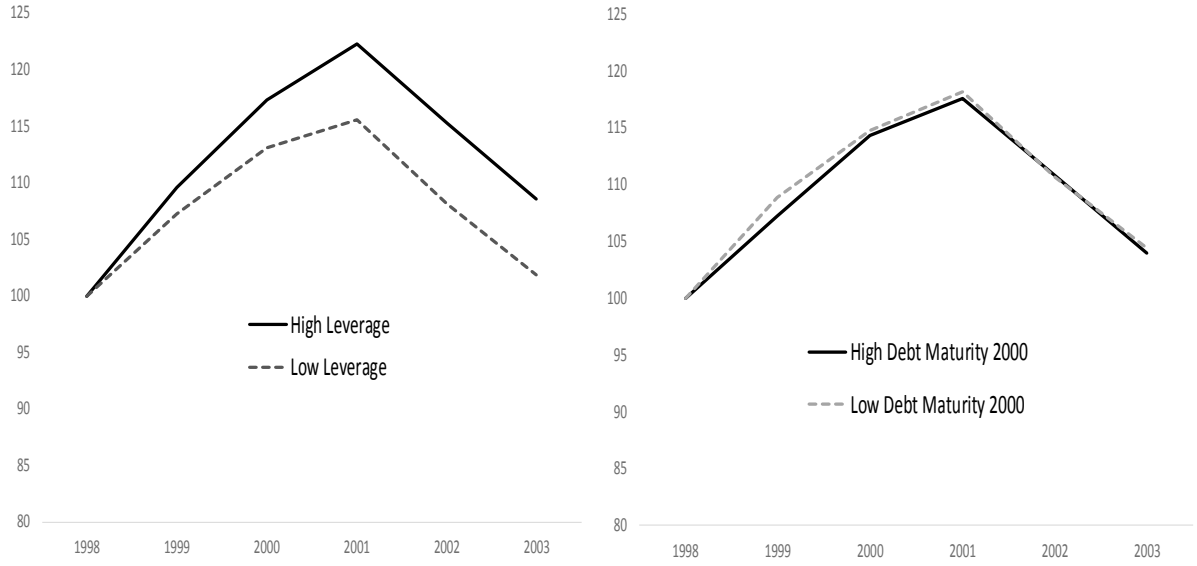
	(1)	(2)	(3)
		ΔTFP Growth	
Leverage Pre-Crisis	-0.00383		0.00620
	(0.015)		(0.017)
Debt Maturing 2000		-0.0657	-0.0690
		(0.046)	(0.050)
Controls	Yes	Yes	Yes
R-squared	0.157	0.157	0.157
N	53,200	53,200	53,200
Country*Sector FE	Yes	Yes	Yes

Note: The placebo post-crisis period runs from 2000 until 2005, with 2000 assumed to be the crisis year. The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `Debt Maturing 2000' is the amount of debt maturing in 2000 divided by average total sales pre-crisis. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors are in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

These results are presented graphically in Figure 4. Unlike Figure 1 which showed starkly different post-crisis TFP growth paths for firms with different levels of pre-crisis financial vulnerabilities, Figure 4 shows no such difference around the 2000 recession. This is consistent

with previous studies which show that banking-crisis-driven recessions tend to have a prolonged negative effect on investment and real GDP while regular recessions do not (Cerra and Saxena, 2008; Rioja et al., forthcoming). Our findings suggest that the role of financial frictions for TFP may be one channel through which financial crises have such a puzzling, permanent adverse effect on real GDP.

Figure 4: Estimated TFP Growth Rate Path for Firms with Different Leverage Ratios and Rollover Risks: 2000 Recession (Index 100 = 1998)



Note: The TFP level path is shown as an index taking value 100 in 1998. `High (Low) Leverage' corresponds to the 75th (25$^{th}$) percentile of the cross-firm distribution of `Leverage Pre-2000'. 'Leverage Pre-2000' is the average pre-2000 debt-to-assets ratio. 'High (Low) Debt Maturing 2000' corresponds to the 75th (25th) percentile of the cross-firm distribution of `Debt Maturing 2000'. `Debt Maturing 2000' is the amount of debt maturing in 2000 divided by average total sales pre-2000.

3.3. The Role of Intangible Investment

Having established that financial frictions mattered for the post-GFC TFP slowdown, we now turn to the question of why they did so. While we do not attempt to provide a comprehensive answer to this question, we explore the role of weaker intangible investment as one possible channel. A wide range of recent studies have linked investments in intangible assets with productivity since the influential work of Corrado, Hulten and Sichel (2005, 2009). When hit by a financial shock, firms may adjust various types of investment differently depending on expected returns, risks and gestation periods (Holstrom and Tirole, 1997; Matsuyama, 2007; Garcia-Macia, 2016). While most forms of physical capital can be pledged as collateral to get

a loan, intangible assets such as R&D or workforce training cannot. Furthermore, investments in intangible assets tend to translate more slowly into sales and also to be riskier. Therefore, our hypothesis is that credit-constrained firms cut their investment in intangible assets, contributing in part to a sharper productivity slowdown after the crisis.

To explore this question, we follow the same difference-in-differences strategy used earlier, only that now the change in the investment rate in intangible assets replaces the change in TFP growth as our dependent variable. We define the investment rate in intangibles as the change in the stock of intangible assets divided by value added available in ORBIS. This is comparable in spirit to the investment rate expressed as a share of GDP in national accounts.[11] The estimated specification is as follows:

$$\Delta Inv\_Intan_{isc} = \alpha_{sc} + \beta_1 Vulnerabilities_i^{pre} + \beta_2 Vulnerabilities_i^{pre} * \Delta CDS_c + \gamma' \mathrm{X}_i + \varepsilon_{isc} \quad (3)$$

Table 5 shows the results. We find that firms with more vulnerable balance sheets indeed decreased their investment in intangible assets significantly more than their less vulnerable counterparts. This difference in investment behavior across firms was also statistically stronger in countries whose banking sectors were more exposed to the collapse of Lehman Brothers. Given that investment rates are typically much lower for intangible assets than for tangible ones, the estimates are also economically significant. In column (3), a 10 percentage point higher leverage ratio in the pre-crisis period is associated with a 0.23 percentage points larger drop in the intangible investment rate post-crisis in a country whose banking sector had an average exposure to the Lehman bankruptcy. This number rises to 0.66 percentage point in a country whose banking sector experienced a 100 basis point larger increase in CDS spreads than the average country. Likewise, a 10 percentage point higher share of debt maturing in 2008 is associated with a 0.19 larger decline in TFP growth in the average country, and with a 0.33 larger decline in a country where CDS spreads rose 100 basis points more than in the average country.

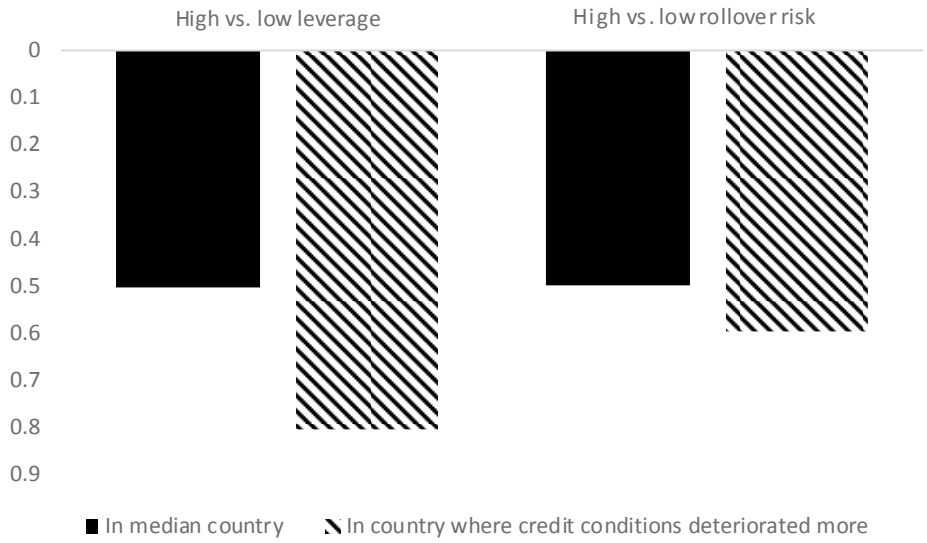
Table 5: Intangible Investment Regression Results

	(1)	(2)	(3)
	ΔInvestment in Intangible Assets		
Leverage Pre-Crisis	-0.025***		-0.023***
	(0.004)		(0.004)
Leverage Pre-Crisis * ΔCDS	-0.047***		-0.043***
	(0.009)		(0.009)
Debt Maturing 2008		-0.02***	-0.019***
		(0.002)	(0.002)
Debt Maturing 2008 * ΔCDS		-0.018***	-0.014***
		(0.004)	(0.004)
Controls	Yes	Yes	Yes
R-squared	0.041	0.041	0.045
N	97,487	97,487	97,487
Country*Sector FE	Yes	Yes	Yes

Note: The dependent variable `ΔInvestment in Intangible Assets' is the difference in the investment in intangible assets as a ratio of value added post vs. pre-crisis. `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. The post-crisis period starts in 2008. `ΔCDS' is the difference in the average CDS spread of banks in each country between the two quarters after and the two quarters before the Lehman bankruptcy. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

A graphical summary of Table 5 is shown in Figure 5. Firms that lie at the 25th percentile of the cross-firm distribution of financial vulnerability reduced their investment in intangible assets substantially less than firms that lie at the 75th percentile. This relationship is stronger in countries that lie at the 75th percentile of the distribution of the change in CDS spreads around the Lehman Bankruptcy than in the average country.

Figure 5. Estimated Decline in Investment Rate in Intangible Assets for Firms with Different Leverage Ratios and Rollover Risks



Note: `ΔInvestment in Intangible Assets' is the difference in the investment in intangible assets as a ratio of value added post vs. pre-crisis. 'Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `High (Low) Leverage Pre-crisis' corresponds to the 75th (25th) percentile of the cross-firm distribution of `Leverage Pre-Crisis'. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. `High (Low) Debt Maturing 2008' corresponds to the 75th (25th) percentile of the cross-firm distribution of 'Debt Maturing 2008'. The `country where credit conditions deteriorated more' corresponds to the 75th percentile of the cross-country distribution of changes in the average bank CDS spreads between the two quarters after and the two quarters before the Lehman bankruptcy. The post-crisis sample starts in 2008. Estimates are obtained from Table 5 column (3).

We also confirm that firms cut investment in intangibles more than investment in physical capital by estimating the following regression:

$$\Delta\text{Share\_}Intan_{isc} = \alpha_{sc} + \beta_1 Vulnerabilities_i^{pre} + \beta_2 Vulnerabilities_i^{pre} * \Delta CDS_c + \gamma' \mathrm{X}_i + \varepsilon_{isc} \quad (4)$$

Which is similar to equation (4) but now considering as dependent variable the change in the share of intangibles in total assets. Total assets are the sum of tangible (or physical fixed) and intangible fixed assets.

Table 6 reports the results for equation (5). Firms with more vulnerable balance sheets indeed reduced the share of intangibles in total assets more than their less vulnerable counterparts. Using the estimates in column 3, a firm with a 10 percentage point higher leverage ratio reduced the share of intangible assets by 1.29 percentage points more than the average firm in

the average country, and by 3.94 percentage points more than the average firm in a country where bank CDS spreads rose by 100 basis points more than in the average country. For a 10 percentage point increase in the share of debt maturing in 2008, the corresponding effects are 0.61 and 1.36 percentage points, respectively.

Table 6: Share of Intangible Assets Regression Results

	(1)	(2)	(3)
		ΔShare of Intangible Assets	
Leverage Pre-Crisis	-0.136***		-0.129***
	(0.018)		(0.018)
Leverage Pre-Crisis * ΔCDS	-0.277***		-0.265***
	(0.043)		(0.043)
Debt Maturing 2008		-0.069***	-0.061***
		(0.009)	(0.009)
Debt Maturing 2008* ΔCDS		-0.103***	-0.075***
		(0.017)	(0.016)
Controls	Yes	Yes	Yes
R-squared	0.382	0.3795	0.3835
N	101,150	101,150	101.150
Country*Sector FE	Yes	Yes	Yes

Note: The dependent variable `ΔShare of Intangible Assets' is the difference in the share of intangible assets in total capital post vs. pre-crisis. `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. The post-crisis period starts in 2008. `ΔCDS' is the difference in the average CDS spread of banks in each country between the two quarters after and the two quarters before the Lehman bankruptcy. Standard errors in parentheses. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

4. Dynamic Responses of Productivity Growth

So far, we analyzed the role of financial frictions on the cumulative change in productivity growth from 2008 until 2013. As a result, the estimates reflect the average response over this

period. In this section, we investigate the dynamic response of productivity growth to show that our estimated effects do not just reflect transitory responses in the early phase of the crisis but instead are highly persistent.

First, we estimate the dynamic response of TFP growth to a higher pre-crisis leverage ratio as well as its interaction with the change in the average bank CDS spread for all possible horizons between 2008 and 2013. Results over each of these horizons are reported in Table 7. Column (1) shows the response on TFP growth in 2008. Both coefficients are insignificant, partly reflecting that the collapse of Lehman Brothers only took place in September 2008. Column (2) shows the response of average TFP growth over 2008-2009. Both coefficients are negative and highly significant. As we lengthen the horizon in the subsequent columns, the estimated effect first gets larger, before declining slightly and then stabilizing. There is no evidence of any decline even toward the end of our sample, which implies that the cumulative TFP level gap between more and less vulnerable firms that opened up in 2009 does not start shrinking even by 2013, that is five years after the initial shock.

A similar pattern can be observed when using instead the share of debt maturing in 2008 as the measure of financial vulnerability. In Table 8, column (1) shows that a decline in productivity growth in more vulnerable firms starting from 2008. As in Table 7, the estimated coefficients continue to grow as we lengthen the post-crisis period, and if anything get bigger over time.

Taken together, these results imply that financial frictions had long-lasting effects of TFP after the GFC. They also provide support for our hypothesis that one transmission channel was reduced investment in intangible assets, whose impact on productivity takes time to materialize. Indeed, in contrast to the estimated TFP effects of the 2008 shock, which were gradual and highly persistent, the impact on intangible asset investment was front-loaded and shorter-lived. This can be seen in the dynamic responses shown in Tables 9 and 10.

Table 7. Dynamic Response of the Change in TFP Growth to Pre-Crisis Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
	2008	2009	2010	2011	2012	2013
				ΔTFP Growth		
Leverage Pre-Crisis	0.00796	-0.0325***	-0.0523***	-0.0446***	-0.0433***	-0.0439***
	(0.009)	(0.009)	(0.010)	(0.008)	(0.008)	(0.008)
Leverage Pre-Crisis *						
ΔCDS	-0.0226	-0.0621**	-0.0899***	-0.0703***	-0.0623***	-0.0615***
	(0.030)	(0.026)	(0.024)	(0.022)	(0.021)	(0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0379	0.0790	0.225	0.185	0.165	0.150
N	115,214	115,214	115,214	115,214	115,214	115,214
Country*Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. The end date of the post-crisis period varies from 2008 in column (1) to 2013 in column (6). `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `ΔCDS' is the difference in the average CDS spread of banks in each country between the two quarters after and the two quarters before the Lehman bankruptcy. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors are in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table 8. Dynamic Response of the Change in TFP Growth to Pre-Crisis Debt Maturity

	(1)	(2)	(3)	(4)	(5)	(6)
	2008	2009	2010	2011	2012	2013
				ΔTFP Growth		
Debt Maturity 2008	-0.0525***	-0.0760***	-0.0683***	-0.0730***	-0.0737***	-0.0779***
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Debt Maturity 2008 *						
ΔCDS	-0.0308**	-0.0681***	-0.0562***	-0.0653***	-0.0634***	-0.0727***
	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0388	0.0810	0.226	0.187	0.167	0.153
N	115,214	115,214	115,214	115,214	115,214	115,214
Country*Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between post- and pre-crisis periods. The end date of the post-crisis period varies from 2008 in column (1) to 2013 in column (6). `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. `ΔCDS' is the difference in the average CDS spread of banks in each country two quarters before and two quarters after the Lehman bankruptcy. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors are in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table 9. Dynamic Response of the Change in Investment in Intangible Assets to Pre-Crisis Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
	2008	2009	2010	2011	2012	2013
			ΔInvestment in Intangible Assets			
Leverage Pre-Crisis	-0.182***	-0.112***	-0.0915***	-0.0777***	-0.0727***	-0.0696***
	(0.030)	(0.019)	(0.016)	(0.015)	(0.014)	(0.014)
Leverage Pre-Crisis * ΔCDS	-0.321***	-0.187***	-0.154***	-0.132***	-0.121***	-0.115***
	(0.057)	(0.036)	(0.030)	(0.028)	(0.026)	(0.026)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0852	0.0922	0.0926	0.0793	0.0828	0.0850
N	114,680	114,680	114,680	114,680	114,680	114,680
Country*Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable `ΔInvestment in Intangible Assets' is the difference in the investment in intangible assets as a ratio of value added post vs. pre-crisis. The end date of the post-crisis period varies from 2008 in column (1) to 2013 in column (6). `Leverage Pre-Crisis' is the average pre-crisis debt-to-assets ratio. `ΔCDS' is the difference in the average CDS spread of banks in each country between the two quarters after and the two quarters before the Lehman bankruptcy. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors are in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table 10. Dynamic Response of the Change in Investment in Intangible Assets to Pre-Crisis Debt Maturity

	(1)	(2)	(3)	(4)	(5)	(6)
	2008	2009	2010	2011	2012	2013
			ΔInvestment in Intangible Assets			
Debt Maturity 2008	-0.0868***	-0.0592***	-0.0517***	-0.0534***	-0.0490***	-0.0465***
	(0.012)	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)
Debt Maturity 2008 * ΔCDS	-0.122***	-0.0804***	-0.0666***	-0.0661***	-0.0645***	-0.0607***
	(0.022)	(0.019)	(0.018)	(0.018)	(0.018)	(0.018)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.0731	0.106	0.0908	0.0748	0.0773	0.0789
N	116,843	116,843	116,843	116,843	116,843	116,843
Country*Sector FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable `ΔInvestment in Intangible Assets' is the difference in the investment in intangible assets as a ratio of value added post vs. pre-crisis. The end date of the post-crisis period varies from 2008 in column (1) to 2013 in column (6). `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. `ΔCDS' is the difference in the average CDS spread of banks in each country between the two quarters after and the two quarters before the Lehman bankruptcy. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors are in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

5. Robustness Check: labor productivity versus TFP

Given the methodological and data issues involved in measuring TFP, we check that our main results hold when using labor productivity instead. To this end, we re-run our baseline regressions using as dependent variable the change in labor productivity, measured as the ratio of real value-added output to the number of employees. Table 11 reports results that largely confirm those in Table 2—firms with greater financial vulnerabilities prior to the crisis experienced a sharper decline in productivity growth afterward.[12]

Table 11: Baseline Regression: Labor Productivity

	(1)	(2)	(3)
		ΔLabor Productivity Growth	
Leverage Pre-Crisis	-0.027***		-0.022***
	(0.006)		(0.006)
Debt Maturing 2008		-0.050***	-0.048***
		(0.005)	(0.005)
Controls	Yes	Yes	Yes
R-squared	0.037	0.038	0.038
N	106,395	106,395	106,395
Country*Sector FE	Yes	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the labor productivity growth rate post vs. pre-crisis. `Leverage Pre-Crisis' is the average pre-crisis debt over assets ratio. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. Post-crisis starts in 200. Firm-specific controls include firm age, size of assets and earnings (EBITDA). Standard errors in parentheses. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

6. Conclusion

In this paper we have studied the impact of financial frictions on firm-level productivity. Using a rich cross-country, firm-level data set and exploiting quasi-experimental variation in firm-

[12] The results are also robust along several other dimensions. For instance, the results hold with other measures of financial vulnerabilities (i.e. interest coverage ratio), with different windows of pre-crisis period and with other measures of credit conditions at the country level (based on national survey of senior loan officers on credit supply conditions). The results are not reported here, but are available upon request.

level exposure to the 2008 global financial crisis, we have shown that the interplay between pre-existing financial fragilities and tightening credit conditions weakened within-firm productivity growth after the crisis, and disproportionately so in countries where credit conditions tightened more. We have also provided evidence that more restrictive access to credit led more vulnerable firms to cut back on intangible investment expenditure. Future research should delve deeper into this and other channels through which credit conditions can affect productivity within firms.

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