BACKGROUND PAPER

FINANCIAL FRICTIONS AND THE GREAT PRODUCTIVITY SLOWDOWN

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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 variation in pre-existing 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 that faced a more severe tightening of credit conditions; (iii) financially fragile firms cut back on intangible capital investment compared to more resilient firms, which is one among several plausible channels 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

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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., 2016a, 2016b). 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 such 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 on September 15th 2008. This paper argues that the interplay between tighter credit conditions and weak corporate balance sheets generated "TFP hysteresis," playing an important role in the puzzling post-crisis productivity slowdown in advanced economies.

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 on September 15th 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. This holds within narrowly defined country-industry cells—that is, controlling for any country-industry (supply or demand) shocks, and then comparing firms with strong vs. weak balance sheet vulnerabilities within each cell. We then show that pre-crisis balance sheet weakness was associated with a larger TFP slowdown for firms that faced a more severe tightening of credit conditions around Lehman—an exogenous event we measure either at the country level by the increase in the average CDS spread of domestic banks around September 15th 2008, or at the firm level by the increase in the average CDS spread of their main creditor banks. This further indicates that productivity was adversely affected by an *interaction* between a credit supply shock and pre-existing corporate financial vulnerabilities. These estimated effects are highly persistent: the TFP level 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 across our cross-country firm-level dataset between the six years before and six years after the crisis.

Our main measure of financial vulnerability captures *ex-ante* rollover-risk and is the amount of debt prior to the crisis that was scheduled to mature during the crisis, measured as the burden of current liabilities (maturing within a year) at the end of 2007. This "maturing-debt" empirical strategy is comparable to those followed in several recent papers (Almeida et al., 2012; Benmelech, Bergman and Seru, 2011; Benmelech, Frydman and Papanikolaou, 2017). 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, 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 among several possible channels. When credit markets froze after September 15th 2008, maturing debt could not be rolled over, or only at a much higher cost. The larger was the amount of maturing 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 maturing 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. Other, unexplored but related factors may also have played a role, such as the sudden inability of high-rollover-risk firms to finance their working capital and thereby to use their inputs efficiently. However, the persistence of the firm-level TFP losses even as credit conditions gradually improved after Lehman suggests to us that temporarily weaker intangible asset investment, which permanently reduced the intangible capital stock, played a significant role.

Our paper relates to the recent literature on the effects of financial frictions on productivity. The dominant strand of this literature focuses on resource misallocation across firms (Hsieh and Klenow, 2009; Restuccia and Rogerson, 2008).[2] Some studies highlight that financial frictions can increase misallocation, and thereby weaken TFP, by preventing an optimal allocation of resources toward, and the entry of, 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., 2017). Our paper does not directly relate to this literature, as our focus is not on misallocation of resources *between* firms but instead on the much-less researched impact of financial frictions for *within*-firm productivity growth.[3]

[2] See Restuccia and Rogerson (2013) for a literature review on misallocation and productivity.

[3] Although we do not explicitly study this issue, our results still highlight one potential source of misallocation of resources between firms, namely the heterogeneous impact of credit conditions on within-firm TFP growth. This leads to greater dispersion in TFP between firms which, in the presence of frictions in capital and/or labor markets, should also increase dispersion in their marginal products of capital and/or labor. In that regard, our paper also bears some connection to the literature on the cleansing effect of recessions, which has highlighted that credit frictions could undo at least some of the positive cleansing effect of recessions emphasized in Caballero and Hammour (1994) by forcing the exit of productive but constrained firms (see for example Osotimehin and Pappada, 2015).

More closely related to our work are papers by Aghion et al. (2010) and Aghion et al. (2012). Aghion et al. (2010) show theoretically that credit constraints can lead firms to cut R&D spending—and long-term illiquid investments more broadly—during recessions. Aghion et al. (2012) find supportive empirical evidence using French firm-level data. Compared with these papers, our work is novel in that we focus on productivity rather than only on R&D investment, 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.

Finally, our paper also relates to a recent literature on how the GFC affected firms. Giroud and Mueller (2017) find that U.S firms that had weaker balance sheets reduced employment more than their healthier counterparts. Chodorow-Reich (2014) show that banking frictions—having a relationship with a weak bank—also mattered, and Siemer (2016) finds that small young firms were most affected. Also focusing on the U.S, Benmelech, Bergman and Seru (2011) carry out several empirical exercises that highlight the broader role of financial frictions—including refinancing risk—for firms' labor force adjustment. Benmelech, Frydman and Papanikolaou (2017) estimate that such financial frictions contributed to sizeable job losses in large U.S firms during the Great Depression. All these studies focus on employment. De Ridder (2016) also exploits variation in firm exposure to the GFC to study the real impact of credit constraints on U.S firms, but he does not focus on TFP. Closer to our paper, Huber (2017) exploits variation in German counties' and firms' exposure to a large bank's lending cut during the GFC, and finds that more exposed German counties and firms experienced larger and persistent declines in output, capital, employment and innovative activity (patenting). Our paper provides cross-country firm-level evidence of TFP hysteresis effects from financial frictions, and highlights their contribution to the permanent productivity and output losses from the GFC in advanced economies. We also identify one channel—lower intangible asset investment—through which such adverse "TFP hysteresis" effects may have arisen.

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 performs various robustness checks. Section 5 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 GFC on the pre-crisis leverage ratio, their measure of firm-level credit constraint.[4] 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:

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

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 (six years after the 2008 crisis) and the pre-crisis (six 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 such as 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

[4] One advantage of comparing the six years after versus the six 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.

affect TFP growth are implicitly controlled for. Standard errors are clustered at the country-sector level.

The main variable we use to capture firm-level balance sheet vulnerabilities is the ex-ante rollover-risk, that 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. This is in similar spirit as Almeida et al. (2009) who exploit heterogeneity in pre-crisis long-term debt maturity structure.

Given that we aim to identify the effects of financial frictions on productivity growth, a threat to our identification strategy could be that our measure of vulnerability does not only reflect financial frictions but is also correlated with other unobserved factors associated with the post-GFC slowdown—such as, for example, the quality of the firm's managers, or the sensitivity of demand for its products to overall cyclical conditions. For instance, if, within a given industry, product demand was more sensitive to a decline in aggregate demand for a more vulnerable firm than for its less vulnerable counterpart, we could overestimate the negative effect of vulnerabilities on productivity growth. However, because the September 2008 shock to credit conditions was unforeseen, it is plausible to assume that firms did not systematically schedule their debt to mature just before the crisis to avoid rollover risk.[5] Therefore, 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 TFP growth post-crisis.

In addition, and crucially, 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 therefore exhibit higher leverage ratios (Rajan and Zingales, 1998). It could also be that firms' productivity in trade-intensive sectors in export-oriented countries may have suffered

[5] Cheng et al. (2014) show that even managers in the securitized finance industry failed to identify the housing bubble.

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 be affected by such factors.

To further identify the impact of tighter credit conditions on the post-crisis decline in TFP growth in firms with pre-existing balance sheet vulnerabilities, we then exploit the fact that the magnitude of the credit supply shock that followed the collapse of Lehman Brothers on September 15th 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:

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

here ΔCDS_c is the change in the average CDS spread of domestic banks in country c between the 7 days before and after the Lehman bankruptcy. In the week after Lehman's bankruptcy, CDS spreads rose as banks tried to protect themselves against defaults of other banks (Brunnermeier, 2009). All else equal, banks whose CDS spreads rose more around the collapse of Lehman Brothers experienced a larger increase in perceived vulnerabilities. These banks typically suffered a sudden erosion of bank capital and difficulties in obtaining funding on the interbank market (Brunnermeier, 2009; Afonso et al., 2011). These balance sheet constraints may have in turn induced them to restrict credit supply, with adverse effects on real outcomes (Ivashina and Scharfstein, 2009; Chodorow-Reich, 2013).

By exploiting the change in CDS spreads over a narrow window around the Lehman bankruptcy, we can plausibly consider it as a shock to credit supply and rule out that it was driven by other factors. For instance, the increase in the CDS spread is unlikely to be the consequence of a real shock that affected firms and, through them, banks' riskiness, since in the week just after the bankruptcy, the consequences for the economy had not yet materialized.

Therefore, we argue that a greater exposure to the Lehman bankruptcy, as reflected in a larger increase in domestic bank CDS spreads around September 15th 2008, captures an exogenous tightening of aggregate credit conditions for domestic firms in the country considered.

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; we see this as 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.

In a final extension, we further sharpen our identification strategy by making use of matched firm-bank credit relationship data. These allow us to exploit variation in the degree of tightening in credit conditions across firms within countries. An important source of firm-level variation in the tightening of credit conditions is that domestic firms relied on different creditor banks, which in turn were hit differentially by the Lehman shock. We exploit this heterogeneity by estimating:

$$\Delta TFP_{isc}^{growth} = \beta_1 Vulnerabilities_i^{pre} + \beta_2 Vulnerabilities_i^{pre} * \Delta CDS_i + \alpha_{sc} + \gamma' X_i + \varepsilon_{isc} \qquad (3)$$

where ΔCDS_i is now the change in the average CDS spread across firm i's main creditor banks.

2.2. Data and stylized facts

Our firm-level variables are drawn from ORBIS, a 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).[6]

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

(continued…)

We focus on 11 advanced economies for which we also have information on aggregate financial and credit conditions over this period, namely Belgium, Germany, Spain, France, Italy, Japan, Korea, the Netherlands, Portugal, Sweden, and the United Kingdom.[7] 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 service sectors including for example real estate and profession/scientific/technical activities.[8]

To ensure consistency and comparability of monetary variables across countries and over time, we adopt the methodology suggested by Gal and Hijzen (2016), which is also close to that in Gopinath et al. (2017). 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.

The main dependent variable used in the analysis is revenue TFP growth, which we obtain by estimating a production function on firm-level data for each industry separately, following the approach of Wooldridge (2009). OLS regressions would yield biased and inconsistent estimates of the production function coefficients, due to a simultaneity problem that has been known since at least Marschak and Andrews (1944). For example, more productive firms may employ more labor, which, because productivity is unobserved and enters the error term, will create a positive correlation between the error term and labor input. A remedy to this problem

[7] Our empirical specification contains only firms that exist continuously during the 6 years before and after the GFC. This reduces the estimation sample significantly relative to the raw ORBIS dataset. Furthermore, the coverage of firms varies substantially across countries—a well-known feature of ORBIS, see e.g. Kalemli Ozcan et al. (2015) or Gopinath et al. (2017). In the sample we use for the specifications that interact firm-level vulnerability with country-level CDS spreads, some countries have less than 500 firms (Germany, Portugal, the Netherlands for instance) while others have more than 10,000 firms (France, Spain, Sweden, Italy for instance).

[8] 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).

is the semi-parametric approach of Olley and Pakes (1996), which uses investment as a proxy variable for unobserved TFP to estimate the labor coefficient in the first stage of a GMM estimation procedure, and then the capital coefficient in a second stage. However, because investment is "lumpy", it may be a poor proxy for productivity. At a more practical level, because many firms do not invest every year, this approach discards a non-trivial share of available observations and reduces sample size. These issues are addressed by Levinsohn and Petrin (2003), who take a similar approach but use intermediate inputs, rather than investment, as proxies. However, Ackerberg et al. (2015) stress that the control function used in the (first stage of the) semi-parametric approach and the coefficient on labor input are collinear, because both labor and intermediate inputs are decided in similar ways, simultaneously with unobserved productivity shocks. Wooldridge's (2009) approach builds upon the Levinsohn and Petrin (2003) method but addresses the critique of Ackerberg et al. (2015), and also provides a more efficient one-step—rather than two-step—GMM estimation procedure. Therefore, this is the approach we adopt in the present paper.

The use of revenue productivity—as in Gopinath et al. (2017), for example—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 resilient 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.[9]

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. The rollover risk variable, our main measure of pre-crisis financial vulnerability, is computed as the ratio of current liabilities (i.e. debt maturing within a year) in 2007 to total sales pre-crisis.

[9] See also Syverson (2011) for a discussion of these pros and cons of using revenue-based productivity.

Finally, we collect available daily CDS spread data for all individual banks and, for each of them, measure exposure to the September 15th 2008 Lehman collapse as the change in the average CDS spread between the week after and the week before September 15th. We derive from these bank-level data two indicators of tightening in credit conditions for firms, which enter equations (2) and (3) above, respectively. The first is a country-level indicator, which we compute as the simple average of changes in bank CDS spreads around the Lehman collapse across all domestic banks within a given country.[10] The second is a firm-level indicator, which is the simple average of changes in the CDS spreads of the firm's bank creditors. We compute it using the "BANKER" variable featured in AMADEUS, which lists for each firm up to five banks that are its most important credit providers. This variable has been used to identify firm-level financial shocks (originating from the matched banks) in several previous studies, including Gianneti and Ongena (2012), Kalemli-Özcan et al. (2015) and Barbiero et al. (2016).[11] We use the matched firm-bank data from the 2015 vintage, relying on the assumption put forward by Kalemli-Özcan et al. (2015) and Barbiero et al. (2016) that bank-firm relationships are sticky and do not vary much over time. This analysis entails a severe reduction in sample size, due to the unavailability of the BANKER variable for non-European countries, and the inexistence of CDS spreads for many of the matched banks. For these reasons, we treat specification (3) as an extension rather than as the core of our analysis, which instead consists of specifications (1) and (2).

Summary statistics for the dataset are provided in Table 1. It shows that the average firm experienced a large drop in TFP growth after the GFC, from 2.14 percent to -6.73 percent.[12] Our financial vulnerability variable shows substantial variation across firms. The amount of debt maturing in 2008 as a ratio of 2007 sales is 24.98% for the median firm, with a standard deviation of 21.52%.

[10] Results are robust to considering the principal component of these spreads instead.

[11] The original source of this variable is Kompass. Kompass provides information on banks and firms over 70 countries, particularly establishing bank-firm relationships. See Giannetti and Ongena (2012) for further details.

[12] Since we only focus on within-firm TFP growth and smaller firms experienced a larger post-crisis drop in TFP growth than larger firms, these unweighted numbers are much larger than their weighted counterparts.

Figure 1 shows the TFP level path for firms with different degrees of rollover risk at the onset of the crisis. Before the crisis, the figure shows that "weak" firms (solid lines) experienced just as strong productivity growth as "strong" firms (dotted lines). However, after 2008, trajectories diverged, as "weak" firms experienced a much sharper drop in productivity growth. It is worth noting that the large gap between weak and resilient firms that opens in 2009 is not closed by 2013 (the last available year in our sample), and indeed appears to keep on widening.

3. Empirical Results

This section first presents our productivity growth regression results, and then investigates the impact of financial frictions on 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) in Section 3.1. Section 3.2 turns to our extended specifications (2) and (3), which exploit the cross-country and cross-firm heterogeneity in the degree of tightening of credit conditions around the collapse of Lehman Brothers. In Section 3.3, we re-run our specifications replacing TFP growth by intangible investment, to test whether the latter was also affected by financial frictions. This enables us to establish a connection between the productivity slowdown and weaker intangible investment. Section 3.4 runs a placebo test that checks whether the effects of financial frictions vanish when focusing instead on the recession of the early 2000s—a recession that was not accompanied by a banking crisis.

3.1. Baseline regression results

Table 2 shows our baseline regression (equation 1) results for different sets of (country-, sector- and country-sector) fixed effects and with and without firm-level controls. Firms with more vulnerable balance sheets, as measured by a higher share of debt maturing in 2008, experienced a stronger decline in TFP growth. The estimated impact using our preferred specification including both country-sector fixed effects and firm-level controls (column 4) is quantitatively

large: a 10 percentage points higher share of debt maturing in 2008 was associated with a 0.94 percentage point drop in annual TFP growth in the post-crisis period.[13]

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 indicator of financial vulnerability (more and less vulnerable 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).

How much of the total (firm-level) TFP growth slowdown do these findings account for? A rough back-of the-envelope calculation can provide an illustrative estimate. Let us assume conservatively 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 (4) of Table 2 (-0.094) 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. Extended specifications

[13] 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.

Our baseline specification highlights the interplay between balance sheet vulnerabilities and the 2008 shock to credit conditions in driving down TFP growth post-crisis, but it does not recognize that the shock to credit conditions was in fact heterogenous across countries and firms. To remedy this and sharpen our identification strategy, this section provides estimates of our extended specifications (2) and (3).

Our main extended specification is (2), which tests for interactions between our measure of pre-crisis firm-level vulnerability and the change in the average CDS spread of domestic banks between the weeks before and after September 15th 2008. We standardize the CDS spread by first subtracting the sample mean and then dividing by the standard deviation. Hence, this variable takes value one when the CDS spread increase after the Lehman bankruptcy is one-standard-deviation (about 20 basis points) larger than in the average country in our sample. Standardizing the change in CDS 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.[14]

The results, which are reported in Table 3, confirm the role played by tighter credit conditions in the post-crisis TFP slowdown. Firms with pre-existing balance sheet vulnerabilities experienced a larger drop in TFP growth (vis-à-vis their less vulnerable counterparts) in countries where credit conditions tightened more; interaction terms between both firm-level vulnerability measure 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 (4), in a country that experienced an average increase in bank CDS spreads, a 10 percentage points increase in the share of debt maturing in 2008 was associated with a 0.96 percentage point drop in annual TFP growth. In a country where the increase in CDS spreads was one standard deviation larger than the average country, the corresponding decline in TFP growth was 0.9 percentage points larger (0.9~10*0.0897*1).

[14] The difference in coefficients on the direct effects of vulnerabilities between Tables 2 and 3 can be explained partly by 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.

This cross-country heterogeneity is illustrated graphically in Figure 3, also using the estimates from column (4) in Table 3. The two bars compare the post-crisis decline in TFP growth for firms that lie on the 25th (low rollover risk) and 75th (high rollover risk) percentiles of the pre-crisis distribution of the share of debt maturing in 2008 for two hypothetical countries. These two hypothetical countries differ from one another by the degree of credit conditions tightening, namely, an average country is compared to a country with tighter credit conditions which experienced one standard deviation larger CDS spread around the Lehman bankruptcy. The difference is sizeable—a higher share of debt maturing in 2008 was associated with a substantially larger decline in post-crisis TFP growth in the country where CDS spreads increased more (right bar).

To further sharpen our identification strategy, we now estimate an extended specification (3) that interacts our measure of pre-crisis firm-level vulnerability with the change in the average CDS spread of the main creditor bank(s) of the firm considered between the weeks before and after September 15th 2008. As noted above, this comes at the cost of a severe reduction in sample size as not all firms report their creditors (see Kalemli-Özcan et al. (2015) for further details on the limitations of creditor information in certain countries). Nonetheless, the results, which are shown in Table 4, strengthen our key finding: firms with greater debt maturing in 2008 suffers a larger drop in TFP growth post-Lehman, and that drop was greater for firms that faced a more severe tightening of credit conditions (from their matched banks). The interaction of debt maturing in 2008 and the increase in the matched firm-bank CDS spread is negative and statistically significant at the 5% confidence level. It is also economically significant: a 10 percentage point larger ratio of debt maturing in 2008 was associated with a 1.63 percentage point larger decline in average annual TFP growth post-crisis for a firm whose main creditor bank(s) had an average exposure to Lehman, but with a 1.86 percentage points (1.63+0.23=1.86) larger decline in TFP growth for a firm's whose main creditor bank(s) faced an increase in CDS spreads that was one-standard-deviation larger than the average. While smaller than the implied impact from the specification with the country-wide CDS spread (equation (2)), this still amounts to a large cumulative impact of pre-crisis vulnerabilities on the TFP level over the 6 years after the GFC—keeping in mind that a 10 percentage point larger ratio is equivalent to just half a standard deviation of the cross-firm distribution of debt maturing in 2008. Finally, an increase in the CDS spread of the firm's main creditor bank(s),

in and of itself, does not appear to affect TFP growth, as suggested by its statistically insignificant coefficient. This further confirms that it is the *interplay* between pre-existing firm-level vulnerability and tighter credit conditions, rather than tighter credit conditions *per se*, that mattered for the post-GFC TFP slowdown.

3.3. Financial Frictions and 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; de Ridder, 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 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. Our baseline regression is as follows:

$$\Delta Inv\_Intan_{isc} = \alpha_{sc} + \beta_1 Vulnerabilities_i^{pre} + \gamma' \mathrm{X}_i + \varepsilon_{isc} \quad (4)$$

Furthermore, we assess if firms cut investment in intangibles more than investment in physical capital by estimating the following regression:

$$\Delta\text{Share\_}Int_{isc} = \alpha_{sc} + \beta_1 Vulnerabilities_i^{pre} + \gamma' \text{X}_i + \varepsilon_{isc} \quad (5)$$

which is analogous 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 (physical) and intangible fixed assets. Table 5 shows these results. First two columns use the investment in intangible assets as the dependent variable, while the latter two columns use the share of intangible investments as the dependent variable.

Columns (1) and (2) show that firms with more vulnerable balance sheets indeed cut their investment in intangible assets significantly more than their less vulnerable counterparts. Considering that investment rates are typically much lower for intangible assets than for tangible ones, the estimates are also economically significant. Based on the estimates in column (2), a 10 percentage points increase in the share of debt maturing in 2008 was associated with a 0.18 percentage point drop in the investment rate in intangibles.

In addition, as the results in columns (3) and (4) show, 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 (4) of Table 5, a 10 percentage point larger share of debt maturing in 2008 was associated with a 0.58 percentage point decline in the share of intangible assets.

3.4. Placebo Test

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 recession was not associated with a banking 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 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 6, where none of coefficients reported in columns (1) – (4) show any statistical significance.

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—which, although much milder than the post-GFC recession, was still associated with a large TFP decline after 2001 in our sample of firms. This is consistent with previous studies which show that recessions associated with banking crises tend to have a prolonged negative effect on investment and real GDP while regular recessions do not (Cerra and Saxena, 2008; Rioja et al., 2014). 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.

4. Robustness Checks

4.1. Labor Productivity

Given the methodological and data issues involved in measuring TFP, we confirm that our main result holds when using labor productivity instead. To this end, we re-run our baseline regression replacing the dependent variable with the change in labor productivity, measured as the ratio of real value-added output to the number of employees. Table 7 reports the results, which largely confirm those in Table 2 —firms with greater financial vulnerabilities prior to the crisis experienced a sharper decline in labor productivity growth after the crisis. The magnitudes of the coefficients are also broadly in line with those in Table 2—a 10 percentage point higher share of debt maturing in 2008 was associated with a 0.5 percentage point further weaker average labor productivity growth rate in the post-crisis period.

4.2. Other Dimensions of Financial Vulnerability

We also check whether other dimensions of firms' financial vulnerability also affected post-crisis productivity growth, over and above the impact of our preferred rollover risk measure (debt maturing in 2008). To this end, we consider the following three additional variables: the ratio of cash and cash equivalents to total assets, a high value of which should reduce liquidity

risk, all else equal; leverage, measured as the ratio of total liabilities to total assets; the interest coverage ratio (ICR), measured as the ratio of earnings to interest expenses, which captures the firm's ability to meet its interest payments. All three indicators are averaged over the pre-crisis period and included in our baseline regression, either separately or jointly. Table 8 shows the results. Most importantly, the coefficients of debt maturing in 2008 are highly stable across all specifications—the role of the random distribution of debt maturing in 2008 for post-crisis TFP growth is unaffected by the presence of different other measures of financial vulnerability. This is even though other dimensions of financial vulnerability also appear to have affected post-crisis TFP growth. All coefficients have the expected signs and are statistically significant, except for the cash ratio when all indicators are entered jointly in column (4).

4.3. GIIPS vs. Non-GIIPS

Firms in GIIPS countries (Greece, Ireland, Italy, Portugal and Spain) were on average more financially vulnerable than their counterparts in non-GIIPS countries coming into the financial crisis. Furthermore, banks in GIIPS countries were hit hardest, experiencing a bigger spike in their CDS spreads. Therefore, one would expect a more severe decline in productivity growth due to financial vulnerabilities in GIIPS countries. To test for this, we re-run our baseline regression for GIIPS non-GIIPS countries separately. Table 9 shows that our baseline result holds for both samples. Furthermore, we find stronger effects of financial vulnerabilities affecting the post-crisis TFP growth in GIIPS countries compared to non-GIIPS countries—based on columns (3) and (4) in Table 9, a firm with a 10 percentage points higher share of debt maturing in 2008 experienced a 1.34 percentage point decline in TFP growth in GIIPS countries versus only 0.46 percentage point in non-GIIPS countries.

4.4. Old firms vs. Young firms

Young and old firms may differ fundamentally in that the former may be forced to take up short-term debt for lack of alternative means of funding, while the latter may have more options and may therefore set their debt maturity more freely. In this robustness check, we check for any potential endogeneity issue due to firm age by splitting our sample in two bins—older

firms and younger firms —and comparing the coefficients of each bin. Older (younger) firms are defined as those that are more (less) than 16 years old—the average firm age in our sample—in 2007. Table 10 reports the results. Our main finding appears to hold for both samples, while the coefficients of debt maturing in 2008 do not differ significantly between them when we group young and old firms together and interact a dummy for young with the share of debt maturing in 2008.

4.5. Interacting Controls with CDS spread changes

We also re-run our extended specification (2) with interactions between all the firm-level controls and the change in the average bank CDS spread around the Lehman shock. This is to further ensure the stability of our coefficients of interest to such controls. The results reported in Table 11. The estimated coefficients of debt maturing in 2008 and its interaction with the change in the average bank CDS spread are very similar to those in Table 3.

4.6. Controlling for the level of TFP prior to the crisis

In a final robustness check, we check for the robustness of our baseline results when controlling for the average level of TFP before the crisis. This is to address the potential concern that the post-crisis change in firm's TFP growth could be somehow related to its pre-crisis TFP level, which in turn may correlate with the firm's reliance on short-term debt. For example, it could be that firms that had higher short-term debt prior to the crisis were low-TFP-level firms that were catching up fast, and were thus bound to experience a gradual slowdown in their TFP growth regardless of the GFC. In practice, however, the data show no material link between the average TFP level and short-term debt prior to crisis. The correlation is -0.09, and the average pre-crisis TFP level of firms that were above the 75^{th} percentile of the distribution of short-term debt was just 1.1 percent higher than that of firms that were below the 25^{th} percentile. Reflecting this, controlling for the level of TFP does not affect our baseline results, as shown in Table 12.

5. 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 variation in pre-existing firm-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 for firms that faced a more severe tightening of credit conditions. The resulting effect on TFP levels has been large and highly persistent. 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 could affect productivity within firms.

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Tables

Table 1. Summary Statistics

	Mean	Median	25th percentile	75th percentile	Standard Deviation
ΔTFP growth	-10.72	-8.78	-30.55	9.00	33.83
Average TFP growth pre-crisis	2.14	2.82	-8.84	14.10	18.53
Average TFP growth post-crisis	-6.73	-5.22	-17.89	4.02	17.13
Debt Maturing 2008	30.81	24.98	15.80	39.70	21.52
Observations	134,838				

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. `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.

Table 2. Baseline Regression Results

	(1)	(2)	(3)	(4)
	ΔTFP growth			
Debt Maturing 2008	-0.0693***	-0.0704***	-0.0674***	-0.0935***
	(0.007)	(0.006)	(0.006)	(0.008)
R-squared	0.127	0.131	0.142	0.151
N	134838	134838	134838	134838
Country*Sector FE	No	No	Yes	Yes
Sector FE	No	Yes	-	-
Country FE	Yes	Yes	-	-
Controls	No	No	No	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between post- and pre-crisis periods. `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.

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

	(1)	(2)	(3)	(4)
	ΔTFP growth			
Debt Maturing 2008	-0.0706***	-0.0686***	-0.0682***	-0.0960***
	(0.007)	(0.006)	(0.006)	(0.007)
Debt Maturing 2008*ΔCDS_c	-0.0823***	-0.0781***	-0.0824***	-0.0897***
	(0.024)	(0.023)	(0.020)	(0.020)
R-squared	0.143	0.148	0.156	0.167
N	104275	104275	104275	104275
Country*Sector FE	No	No	Yes	Yes
Sector FE	No	Yes	-	-
Country FE	Yes	Yes	-	-
Controls	No	No	No	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. `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_c' is the standardized change in the country-level CDS between the weeks before and after the Lehman bankruptcy, where the change in the country-level CDS is calculated as an average of the changes in domestic banks' CDS spread over the same window. 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.

Table 4. Extended Specification: Accounting for Firm-Level Heterogeneity in Exposure to the Collapse of Lehman Brothers

	(1)	(2)	(3)	(4)
	ΔTFP growth			
Debt Maturing 2008	-0.112***	-0.112***	-0.114***	-0.163***
	(0.014)	(0.015)	(0.015)	(0.015)
ΔCDS_i	-0.140	-0.179	-0.176	-0.293
	(0.214)	(0.219)	(0.217)	(0.214)
Debt Maturing 2008*ΔCDS_i	-0.023**	-0.024**	-0.024**	-0.024**
	(0.010)	(0.010)	(0.010)	(0.011)
R-squared	0.0640	0.0719	0.0793	0.109
N	20798	20798	20798	20798
Country*Sector FE	No	No	Yes	Yes
Sector FE	No	Yes	-	-
Country FE	Yes	Yes	-	-
Controls	No	No	No	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between post- and pre-crisis periods. `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. 'ΔCDS_i' refers to the standardized change in the average CDS spread of the firm's main creditor bank(s) (up to five of them, drawn from the 'BANKER' variable in AMADEUS) between the weeks before and after the collapse of Lehman Brothers. 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.

Table 5. Financial Frictions and Investment in Intangible Assets

	(1)	(2)	(3)	(4)
	Δ Investment in Intangible Assets		Δ Share of Intangible Investments	
Debt Maturing 2008	-0.0188***	-0.0184***	-0.0633***	-0.0584***
	(0.002)	(0.002)	(0.010)	(0.010)
R-squared	0.0406	0.0407	0.373	0.379
N	97487	97487	101150	101150
Country*Sector FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes

Note: The dependent variable `ΔInvestment in Intangible Assets' for Columns (1) and (2) is the difference in the investment in intangible assets as a ratio of value added post vs. pre-crisis. The dependent variable `ΔShare of Intangible Assets' for Columns (3) and (4) is the difference in the share of intangible assets in total capital post vs. pre-crisis. `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. 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.

Table 6. Placebo Test: Early 2000s Recession

	(1)	(2)	(3)	(4)
	ΔTFP growth (post-2000 minus pre-2000)		Δ Investment in Intangible Assets (post-2000 minus pre-2000)	
Debt Maturing 2000	-0.0719	-0.0152	0.00483	0.00496
	(0.046)	(0.031)	(0.033)	(0.028)
R-squared	0.170	0.204	0.104	0.105
N	53139	53139	3295	3295
Country*Sector FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	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. `Debt Maturing 2000' is the amount of debt maturing in 2000 divided by average total sales pre-2000. 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 7. Baseline Regression: Labor Productivity

	(1)	(2)	(3)	(4)
	Δ Labor Productivity			
Debt Maturing 2008	-0.0515***	-0.0556***	-0.0428***	-0.0501***
	(0.006)	(0.006)	(0.005)	(0.005)
R-squared	0.0130	0.0192	0.0349	0.0383
N	106424	106424	106395	106395
Country*Sector FE	No	No	Yes	Yes
Sector FE	No	No	-	-
Country FE	Yes	Yes	-	-
Controls	No	No	No	Yes

Note: The dependent variable `ΔLabor Productivity' is the difference in the labor productivity growth rate post vs. pre-crisis. `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.

Table 8. Baseline Regression: Incorporating Other Measures of Financial Vulnerability

	(1)	(2)	(3)	(4)
	ΔTFP growth			
Debt Maturing 2008	-0.0900***	-0.0907***	-0.0917***	-0.0907***
	(0.007)	(0.007)	(0.007)	(0.007)
Cash Pre-Crisis	0.0284***			0.000564
	(0.007)			(0.008)
Leverage Pre-Crisis		-0.0363***		-0.0229***
		(0.008)		(0.009)
ICR Pre-Crisis			-0.0236***	-0.0193***
			(0.005)	(0.005)
R-squared	0.151	0.151	0.158	0.158
N	133272	134838	117882	116441
Country*Sector FE	Yes	Yes	Yes	Yes
Controls	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. 'Cash Pre-Crisis' is the ratio of average cash and cash equivalents to total assets before the crisis. 'Leverage Pre-Crisis' is average leverage, measured as the debt-to-asset ratio, before the crisis. 'ICR Pre-Crisis' is the average ratio of interest expenses to earnings (EBITDA), that is, the inverse of the interest coverage ratio, before the 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.

Table 9. Baseline Regression: GIIPS countries vs. Non-GIIPS

	(1)	(2)	(3)	(4)
	ΔTFP growth			
	GIIPS	Non-GIIPS	GIIPS	Non-GIIPS
Debt Maturing 2008	-0.131***	-0.0521***	-0.134***	-0.0456***
	(0.009)	(0.009)	(0.009)	(0.008)
R-squared	0.0955	0.0384	0.106	0.0543
N	56223	78615	56223	78615
Country*Sector FE	Yes	Yes	Yes	Yes
Controls	No	No	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. `Debt Maturing 2008' is the amount of debt maturing in 2008 divided by average total sales pre-crisis. Post-crisis starts in 2008. 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. Baseline Regression: Old firms vs. Young firms

	(1)	(2)	(3)	(4)
	ΔTFP growth			
	Old Firms	Young Firms	Old Firms	Young Firms
Debt Maturing 2008	-0.0647***	-0.0725***	-0.0823***	-0.105***
	(0.009)	(0.008)	(0.010)	(0.009)
R-squared	0.183	0.127	0.193	0.138
N	48827	85859	48827	85859
Country*Sector FE	Yes	Yes	Yes	Yes
Controls	No	No	Yes	Yes

Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. Old (young) firms are firms with the age older (less) than 16 years in 2007. 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 11. Productivity Growth and Controls Interacted with CDS changes

	(1)	(2)	(3)
	Δ TFP growth		
Debt Maturing 2008	-0.0900***	-0.0956***	-0.0951***
	(0.008)	(0.007)	(0.007)
Debt Maturing 2008*ΔCDS_c	-0.115***	-0.105***	-0.113***
	(0.025)	(0.024)	(0.021)
R-squared	0.156	0.161	0.169
N	104275	104275	104275
Country*Sector FE	No	No	Yes
Sector FE	No	Yes	-
Country FE	Yes	Yes	-
Controls	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. 'ΔCDS_c' is the standardized change in the country-level CDS between the weeks before and after the Lehman bankruptcy, where the change in the country-level CDS is calculated as an average of the changes in domestic banks' CDS spread over the same window. Firm-specific controls include firm age, size of assets, employment and earnings (EBITDA). Each specification also includes interactions between each of these controls and `ΔCDS'. 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 12. Controlling for the pre-crisis TFP level

	(1)	(2)	(3)	(4)
	ΔTFP growth			
Debt Maturing 2008	-0.0698***	-0.0670***	-0.0629***	-0.0899***
	(0.006)	(0.005)	(0.005)	(0.006)
Average TFP level pre-crisis	-0.0641	0.637	0.860	0.595
	(0.419)	(0.655)	(0.673)	(0.609)
R-squared	0.127	0.131	0.142	0.151
N	134838	134838	134838	134838
Country*Sector FE	No	No	Yes	Yes
Sector FE	No	Yes	-	-
Country FE	Yes	Yes	-	-
Controls	No	No	No	Yes

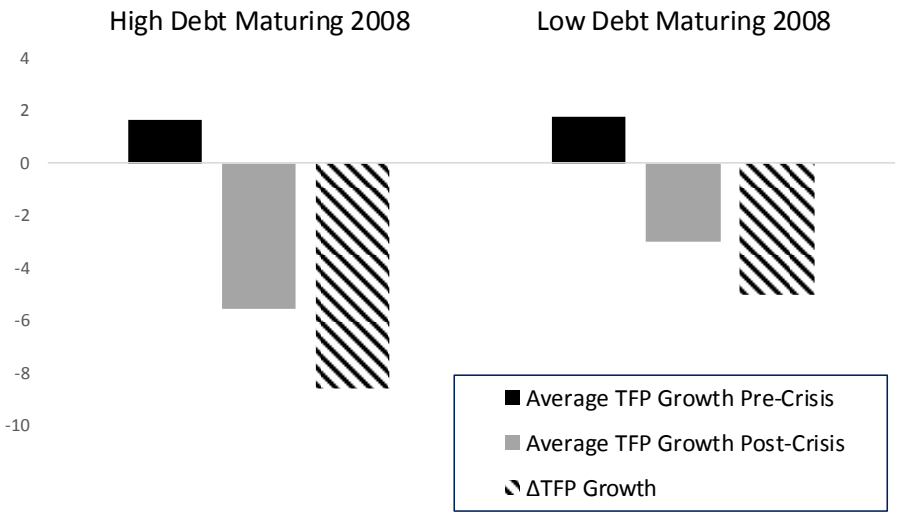
Note: The dependent variable `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. 'Average TFP level pre-crisis' is the average firm-level TFP level (measured by the Wooldridge method) before the crisis. Firm-specific controls include firm age, size of assets, employment and earnings (EBITDA). Each specification also includes interactions between each of these l. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Figures

Figure 1. TFP Level Path for Firms with Different Rollover Risks (Index 100 = 2005)

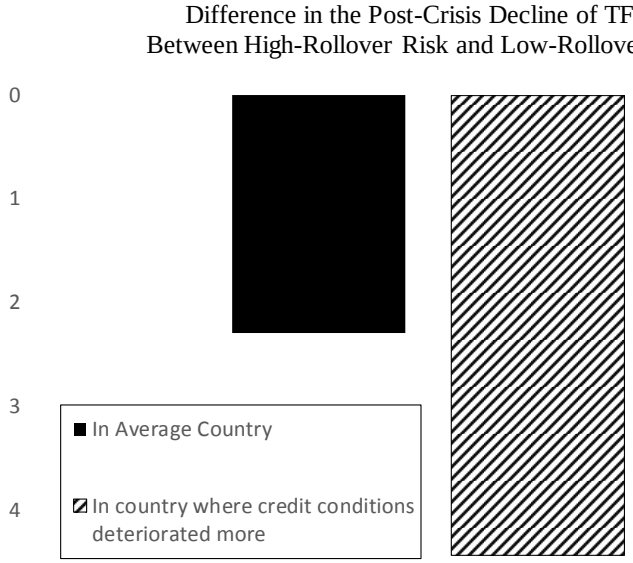
Note: The TFP level path is shown as an index taking value 100 in 2005. `High Debt Maturing in 2008' corresponds to the 75th percentile of the distribution of `Debt Maturing in 2008'. `Low Debt Maturing in 2008' corresponds to the 25th percentile of the distribution of `Debt Maturing in 2008'. `Debt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

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



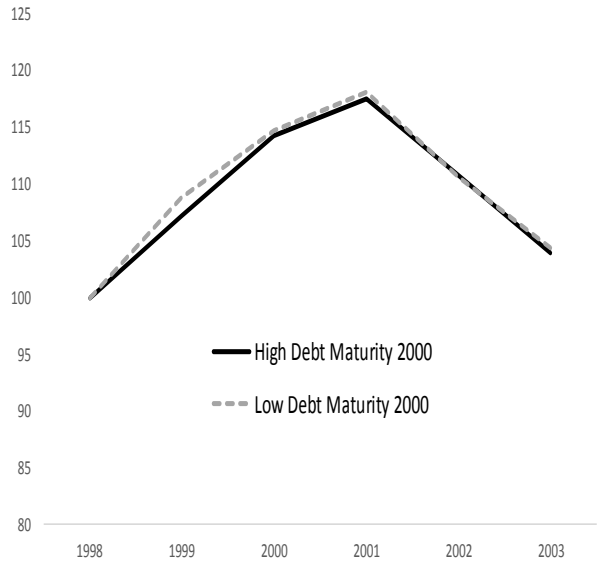
Note: `ΔTFP Growth' is the difference in the average TFP growth rate between the post- and pre-crisis periods. `Average TFP Growth Pre (Post) -Crisis' is the average TFP growth rate pre-crisis (post-crisis). `Debt Maturing in 2008' is the amount of debt maturing in 2008 divided by average total sales 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. The underlying regression estimates are those in column 4 of Table 2.

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



Note: `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 75th (25th) percentile of the cross-firm distribution of `Debt Maturing in 2008'. The 'average country' corresponds to a no change in CDS spread after standardizing the variable. The `country where credit conditions deteriorated more' corresponds to one standard deviation larger change in standardized CDS spread compared to the average country CDS spreads. The post-crisis sample starts in 2008. The underlying regression estimates are those in column 4 of Table 3.

Figure 4: TFP Level Path for Firms with Different Rollover Risks:
2000 Recession (Index 100 = 1998)



Note: The TFP level path is shown as an index taking value 100 in 1998. 'High (Low) Debt Maturing 2000' corresponds to the 75th (25^{th}) 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.