WP/18/33

# IMF Working Paper

## Corporate Indebtedness and Low Productivity Growth of Italian Firms

by Gareth Anderson and Mehdi Raissi

INTERNATIONAL MONETARY FUND

WP/18/33

# IMF Working Paper

## Corporate Indebtedness and Low Productivity Growth of Italian Firms

by Gareth Anderson and Mehdi Raissi

INTERNATIONAL MONETARY FUND

 WP/18/33

**IMF Working Paper**

European Department

**Corporate Indebtedness and Low Productivity Growth of Italian Firms**[1]

**Prepared by Gareth Anderson**[2] **and Mehdi Raissi**

Authorized for distribution by Rishi Goyal

February 2018



**Abstract**

Productivity growth in Italy has been persistently anemic and has lagged that of the euro area over the period 1999-2015, while the indebtedness of its corporate sector has increased. Using the ORBIS firm-level database, this paper studies the long-term impact of persistent corporate-debt accumulation on the productivity growth of Italian firms and investigates whether total factor productivity growth varies with the level of corporate indebtedness. We employ a novel estimation technique proposed by Chudik, Mohaddes, Pesaran, and Raissi (2017) to account for dynamics, bi-directional feedback effects, cross-firm heterogeneity, and cross-sectional dependence arising from unobserved common factors (for example, oil price shocks, labor and product market frictions, and stance of global financial cycle). Filtering out the effects of unobserved common factors and controlling for firm-specific characteristics, we find significant negative effects of persistent corporate debt build-up on total factor productivity growth, and weak evidence of a threshold level of corporate debt, beyond which productivity growth drops off significantly. Our results have strong policy implications, for example the design of the tax system should discourage persistent corporate debt accumulation, and effective and timely frameworks to reduce corporate debt overhangs are essential.

JEL Classifications: C23, D22, D24, G3.

Keywords: Italy, corporate debt, productivity, dynamic heterogeneous panel threshold models, cross-sectional dependence.

Authors' E-Mail Addresses: gareth.anderson@nuffield.ox.ac.uk; mraissi@imf.org

---

[1] We are grateful to Steve Bond, Ehsan Ebrahimy, Sebastian Doerr, Romain Duval, Rishi Goyal, Tryggvi Gudmundsson, Sebnem Kalemli-Ozcan, Kamiar Mohaddes, Anne-Charlotte Paret Onorato, and seminar participants at the European department of the IMF, as well as the Italian authorities for helpful comments.

[2] University of Oxford.

# Contents



# List of Figures

## List of Tables

# 1 Introduction

Productivity growth in Italy has been persistently anaemic and has lagged that of the euro area over the period 1999-2015 (Figure 1a), while the indebtedness of its corporate sector has increased (Figure 1b). Following the global financial crisis, increased focus has been given to the impact of high and rising public and private debt levels on the macroeconomic performance of different countries. Examples include Reinhart and Rogoff (2010) and Chudik, Mohaddes, Pesaran, and Raissi (2017) who consider the consequences of high and rising public debt on economic growth of advanced and developing countries; Mian and Sufi (2010) who examine the implications of elevated household leverage in the build-up to the global financial crisis for subsequent output growth of the United States; and Kalemli-Ozcan, Laeven, and Moreno (2015) who explore the impact of debt overhang on corporate investment by Southern European firms.[1] However, far less attention has been paid to the impact of debt overhangs outside of crisis periods and how persistent debt accumulation by firms affects their long-term Total Factor Productivity (TFP) growth.

TFP growth is driven both by the productive improvements within firms as well as allocative efficiency across firms. A growing literature has investigated the implications of misallocation across firms on productivity growth (Restuccia and Rogerson (2008); Hsieh and Klenow (2009)) and the role of credit market frictions in driving resource misallocation (Midrigan and Xu (2014); Moll (2014); Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017)). However, research on the impact of persistent build-ups in corporate debt on TFP performance within firms is rather scarce.[2] We address this gap in the literature by investigating the long-term impact of persistent corporate debt accumulation on within-firm TFP growth in Italy, and by examining whether TFP growth varies with the level of corporate indebtedness.[3] Using annual ORBIS firm-level data over the period 1999-2015, our estimation approach uses the Cross-Sectionally augmented Auto-Regressive Distributed Lag (CS-ARDL) and the Cross-Sectionally augmented Distributed Lag (CS-DL) methodologies, which account for cross-firm heterogeneity, cross-sectional dependence arising from unobserved common factors as well as spillover effects, dynamics, and feedback effects. We find that a persistent increase in firms' indebtedness is associated with lower long-run TFP growth for corporates in our sample of 6282 firms. Moreover, there appears to be a threshold level of indebtedness, beyond which firms' productivity growth falls significantly.

Weak productivity growth across advanced economies has resulted in a number of studies

[1] Another example is Mohaddes, Raissi, and Weber (2017) who study the relationship between banks non-performing loans and economic growth in Italy.

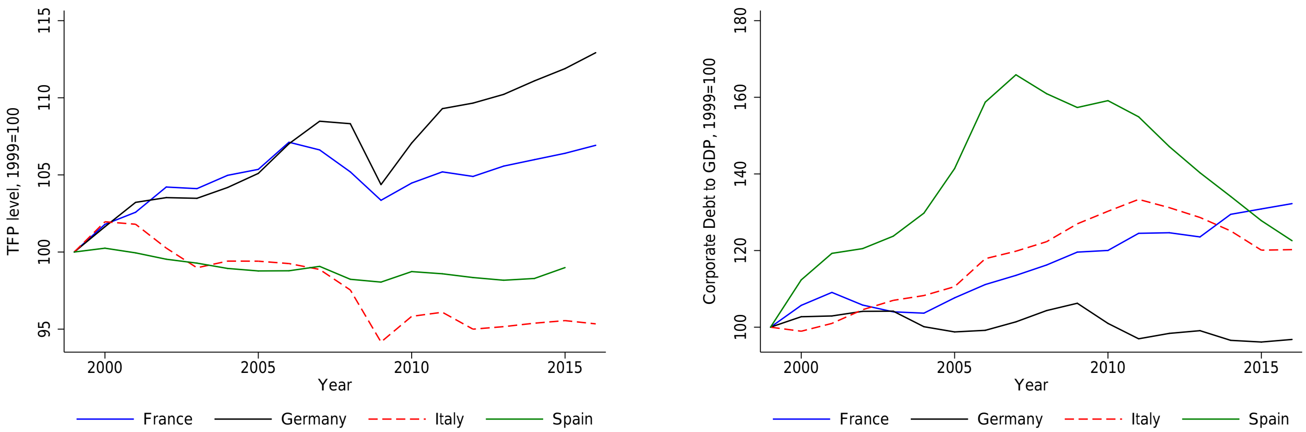
[2] Corporate debt overhangs could result in lower physical– and human–capital accumulation; and weaker-quality investment choices by firms (i.e. investing in lower-risk lower-return projects and less R&D spending), leading to slower embodied technical progress and lower TFP in the long term.

[3] Coricelli, Driffield, Pal, and Roland (2012) show that TFP growth in Central and Eastern European countries tends to increase with leverage up to a threshold, beyond which additional borrowing lowers TFP growth.

Figure 1: Total Factor Productivity and Corporate Indebtedness, Cross-Country Comparison

(a) Total Factor Productivity, 1999=100

(b) Non-Financial Corporate Debt to GDP, 1999=100




Notes: Figure 1a shows the level of total factor productivity at the aggregate level, where for each country the level has been normalised to 100 in 1999. Aggregate total factor productivity data is sourced from the OECD's "multifactor productivity" series. Figure 1b shows the ratio of total corporate debt to GDP, and is sourced from Haver Analytics.

exploring common factors weighing on within-firm productivity growth, such as reduced innovation at the technological frontier (Gordon (2012)), a slowdown in the adoption of technologies by lagging firms (Andrews, Criscuolo, and Gal (2015)), and credit-supply constraints restricting investment in research and development (e.g. Aghion, Askenazy, Berman, Cette, and Eymard (2012)).[4] In addition, a number of papers have highlighted the importance of institutional frameworks, for example product, services and labor market regulations and the prevalence of "familism" and " cronyism", as common factors weighing specifically on the productivity growth of Italian firms (e.g. Pellegrino and Zingales (2014)). Our empirical framework accounts for the impact of these common factors (which are not necessarily observed in regressions), while focusing on the long-term impact of increased corporate indebtedness on firms' productivity growth. We maintain the view that persistently fast-rising debt could negatively impact on the productivity growth of a firm in the long term, particularly if it affects its incentives or ability to undertake profitable projects or if it crowds out investment in human capital and/or research and development spending.

Our paper is also related to a large corporate finance literature highlighting how a firm's capital structure may affect its value and its productivity performance. The conventional view is that at a low level, debt can be beneficial to firm performance. Access to debt may alleviate short-lived funding constraints and allow investment opportunities to be undertaken, while also disciplining managers to ensure the projects are profitable to avoid potential bankruptcy (Grossman and Hart (1982)) and reducing the agency problems associated with managers having large cash-flows at

[4] Adler, Duval, Furceri, Celik, and Poplawski-Ribeiro (2017) argue that the processes of innovation and technological adoption which drive within firm productivity growth are facilitated by investments in human, physical and intangible capital.

their disposal (Jensen (1986); Stulz (1990)). However, excessive debt may lower productivity in the long-run, by increasing firms' vulnerabilities and limiting their flexibility. A high level of debt may lower a firm's value as highly-indebted firms may become more susceptible to adverse credit-supply shocks. For example, they may face "roll-over risk", whereby lenders are reluctant to refinance them following an adverse credit-supply shock (Diamond (1991)). They may also struggle to capitalise on new investment opportunities that arise which require them to seek additional funding (Lang, Ofek, and Stulz (1996), Marchica and Mura (2010)). Indebted firms may also be subject to a "debt overhang" problem (Myers (1977)), whereby outside investors are reluctant to provide funding for new projects because the benefits largely accrue to existing creditors.

Although the "trade-off" theory would predict that firms balance the costs and benefits associated with debt, they can often deviate from the optimal debt level for long periods of time (e.g Welch (2004); Leary and Roberts (2005)) or lack the incentive to bring the level of debt to its optimum. The tax deductibility of interest payments on debt incentivizes a bias toward debt finance and higher leverage, for example. Admati, DeMarzo, Hellwig, and Pfleiderer (2017) argue that once debt is in place, shareholders will be reluctant to reduce it, even if it is value enhancing, since the benefits would accrue to existing debt-holders. As a result, leverage may "ratchet" up over time, despite the negative consequences associated with high and rising debt levels.[5]

We contribute to the literature in a number of ways. Firstly, we allow for cross-firm slope heterogeneity as the effects of increased corporate debt on TFP growth vary across firms, depending on firm-specific factors such as governance structures, size, and their track record in meeting past debt obligations (these cannot be adequately accounted for by inclusion of fixed effects only in panel regressions). This contrasts with Coricelli, Driffield, Pal, and Roland (2012) which assumes homogeneous responses across firms to increased leverage. Secondly, we account for the impact of unobserved common factors which affect productivity growth across firms as well as spillover effects between firms. It is now widely agreed that conditioning on observed variables specific to firms alone need not ensure error cross-section independence that underlies much of the panel data literature. It is therefore also important that we allow for the possibility of cross-sectional error dependencies, which could arise due to omitted common effects (labor and product market frictions, stance of global financial cycle, oil price shocks), possibly correlated with the regressors. Neglecting such dependencies can lead to biased estimates and spurious inference.

Thirdly, by properly modelling dynamics, we are able to focus on the long-term implications of increased indebtedness on TFP growth, abstracting from short-run changes in the capital structure of firms. Fourthly, following the approach of Chudik, Mohaddes, Pesaran, and Raissi (2016), we consider the possibility of non-linearities in the relationship between indebtedness and productivity

[5] Heider and Ljungqvist (2015) provide empirical support for the "leverage ratchet" mechanism, showing that US firms respond asymmetrically to changes in corporation tax. They find that firms increase debt when tax rates increase but do not respond when tax rates are cut.

growth, allowing for a debt "threshold" effect. For example, a firm with a higher level of debt may be more susceptible to debt overhang problems and so its performance may suffer more from further increases in its debt (Cai and Zhang (2011) provide evidence of this mechanism). Finally, previous studies on corporate indebtedness have often given inadequate attention to the possibility of bi-directional feedback effects between TFP growth and indebtedness. The CS-ARDL estimation approach is robust to simultaneous determination of TFP growth and firm indebtedness.

Our results indicate that rising corporate debt burdens, measured by debt to value added, slows down TFP growth in the long-run. We find that a persistent increase in debt to value added at an annual pace of one percent is, in the long-run, associated with 0.1 percentage points lower TFP growth per year, on average. This negative impact appears to be pervasive across different firm sizes and industrial groupings. We also provide evidence of a debt threshold effect: our results suggest that productivity growth is significantly lower when a firm's debt to value added ratio is greater than 3. The proportion of firms exceeding this corporate debt threshold increased substantially from 6% in 1999 to around 12% in 2012 , and was particularly high in the wholesale and retail trade, as well as construction sectors. Our results are also robust to alternative measures of indebtedness/leverage, different model specifications, and various estimation techniques.

From a policy perspective our results suggest that initiatives which promote alternatives to corporate debt finance should be encouraged, for example fostering a capital markets union within Europe and further improving the Allowance for Corporate Equity in Italy. The proportion of firms exceeding the debt threshold has declined only slightly since 2012, implying that relief from excessive corporate debt (via timely and effective corporate debt restructuring) would have a direct long-run impact on productivity growth, whereas unconventional monetary and fiscal policies cannot directly solve the fundamental debt problem (see Kobayashi and Shirai (2017) for a theoretical justification). In addition, our results show that common factors have a large influence on productivity growth within Italian firms, suggesting sizeable benefits to reforms which seek to alleviate common headwinds, such as labor, product and services market frictions.

The remainder of the paper is organized as follows: Section 2 describes our firm-level dataset; section 3 presents summary statistics from our dataset; section 4 outlines our empirical framework; section 5 presents results; section 6 considers a number of robustness tests and section 7 concludes.

## 2 Data

Our firm-level data is sourced from the Bureau van Dijk historical financial dataset for industrial entities, which provides balance-sheet and income-statement information for both listed and unlisted companies over the period 1999-2015.[6] The dataset is compiled by merging annual disks from

[6]Banks and insurance companies are excluded from the dataset.

Bureau van Dijk's Orbis dataset, ensuring firm identification numbers are compatible and variable definitions are consistent across vintages.

Using the raw data on Italian companies extracted from the historical financial dataset, we undertake a number of cleaning steps, similar to Gal (2013), Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych, and Yesiltas (2015) and Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017). These steps are outlined in the Appendix. We focus our analysis on companies which always report having at least 3 employees.

We use a number of balance-sheet items to calculate our variables of interest. We define the debt of a firm as the sum of the loans, bonds and short-term securities reported on its balance sheet. We define our baseline measure of firm indebtedness, $DEBT$, as the ratio of a firm's debt to its nominal value added:

$$DEBT = \frac{Loans + Bonds + Short\,Term\,Securities}{Value\,added}$$

Nominal value added is given by the sum of profit before tax, depreciation, the cost of employees and interest paid. We focus on the ratio of debt to value added as our baseline measure of corporate indebtedness since it captures whether a firm is able to produce enough to repay its obligations and is similar to the concepts of debt to GDP and debt to income used to assess government and household balance-sheet vulnerabilities, respectively.

Using the ratio of debt to value added also means that we abstract from the problems inherent in widely-used measures of leverage—in particular the ratio of debt to assets or debt to equity. As discussed in Jarmuzek and Rozenov (2017), large fluctuations in asset or equity prices over the business cycle makes the leverage ratio a poor gauge of the sustainability of a firm's debt position. Furthermore, these leverage-based measures for Italy are likely to be distorted by firm behaviour associated with periodic asset revaluation laws. In Italy, asset revaluations are permitted by emergency laws. The timing of these laws and the tax conditions associated with them may distort the process of reporting assets (see Mura, Piras, and Valentincic (2016)), adding additional volatility into leverage ratio measures of firm indebtedness. For example, in 2008 a Decree Law was passed which allowed firms the opportunity to revalue their properties, resulting in a sharp jump in the value of firm equity (see Cerved 2014 SME Report). Jumps in firm equity and asset values associated with large fluctuations in asset prices or revaluation laws are unlikely to reflect changes in the indebtedness of firms and therefore, we choose to use debt to value added as our baseline measure of indebtedness. We check the robustness of our results using debt to EBITDA and debt to assets as alternative measures.

To estimate TFP growth, we require measures of firm value added, labor and capital in real terms. We compute the real cost of employees and real value added from their nominal values using

value-added deflators at the two-digit industry level, obtained from the OECD STAN database.[7] Real capital stocks are computed following the perpetual inventory method, using data on tangible fixed assets and depreciation, as well as two-digit gross fixed capital formation deflators obtained from the OECD STAN database—see the Appendix for details.

We estimate total factor productivity as the residual from a production function with labor and capital as inputs. Consider a production function for firm $i$ in industry $j$ at time $t$ given by:

$$y_{it} = a_{it} + \beta_{kj} k_{it} + \beta_{lj} l_{it} \tag{1}$$

where $y_{it}$ is the logarithm of real value added; $a_{it}$ is the logarithm of total factor productivity; $k_{it}$ is the logarithm of real capital; and $l_{it}$ is the logarithm of real labor.

As documented by Gal (2013), the most basic way of estimating unobserved total factor productivity, $a_{it}$, is to regress value added on capital and labor to obtain estimates of $\beta_{kj}$ and $\beta_{lj}$ in (1). However, labor input could be endogenous to unobserved productivity, rendering those estimates inconsistent. To address endogeneity concerns, we estimate total factor productivity using the single-equation instrumental variable approach of Wooldridge (2009), which builds on the two-step approach of Olley and Pakes (1996) and Levinsohn and Petrin (2003).

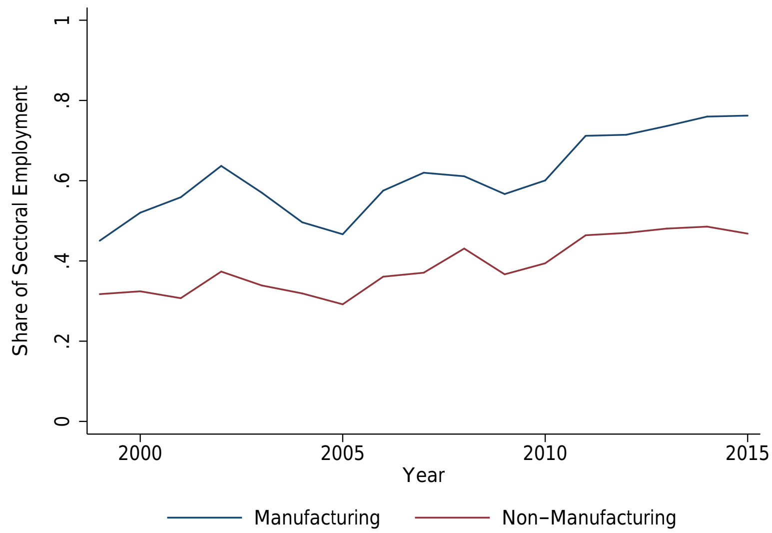
# 3 Descriptive Statistics

## 3.1 Coverage

To assess the coverage of our dataset, we compare the number of employees in the manufacturing and non-manufacturing sectors in our sample of firms to employment levels reported at the sectoral level in the OECD STAN database. Our unbalanced panel of Italian firms, constructed using the cleaning steps outlined in the Appendix, covers around 70% of employment in the manufacturing sector, as shown in Figure 2. Coverage of employment in the non-manufacturing sector is weaker at around 40% of total sectoral employment at the end of the sample period.

[7] Industry-level deflators are used as firm-level price data are not available. Dispersion in our productivity measures will therefore reflect within-industry dispersion in prices, as well as dispersion in the productive efficiency of firms (see Bartelsman and Wolf (2017) for further discussion of productivity measures which use industry-level deflators).

Figure 2: Coverage of Manufacturing and Non-Manufacturing Employment, Unbalanced Panel




Notes: The chart shows the ratio of total manufacturing employment in the unbalanced panel of firms relative to aggregate employment in the manufacturing sector in Italy and the ratio of total non-manufacturing employment in the unbalanced panel of firms relative to aggregate employment in the non-manufacturing sector in Italy. Manufacturing and non-manufacturing firms in the unbalanced panel are identified using NACE 2-digit codes. Aggregates for employment in the manufacturing and non-manufacturing sectors in Italy are sourced from the OECD STAN database.

To assess the impact of a change in indebtedness on productivity growth over time at the firm level, our empirical analysis focuses on firms which report annual financial accounts consistently over the period 1999-2015. Within this group, 490 firms report zero or very low levels of debt. We focus on firms which have a debt to value added ratio of at least 0.01 throughout the period 1999-2015.[8] This balanced panel of 6282 firms covers around 10% of manufacturing employment and 3% of services employment by the end of the sample period.[9] Our balanced panel requires firms to be active for at least 17 years. However, the average and median firms in Italy have a lower life expectancy (around 8 and 4 years, respectively). While firms in our balanced panel tend to be larger and have a greater number of employees than firms in the unbalanced panel (which are not required to be active for 17 years), Table 1 shows that the productivity growth profiles of the median firms in the balanced and unbalanced panels are broadly similar.

[8]The detail of the liabilities side of the balance sheet varies for some companies in ORBIS. In particular, for some companies a decomposition of "Non-current liabilities" into "long-term debt" and "Other non-current liabilities" is not available consistently over time. We drop companies which do not have a breakdown between "long-term debt" and "Other non-current liabilities" in any year between 1999-2015. For companies which do not have a breakdown in every year, we impute "long-term debt" by linearly interpolating the share of long-term debt in "Non-current liabilities" between years in which the company reports a breakdown.

[9]Our results in Section 6.3 are robust to the inclusion of these additional 490 firms. However, we cannot include them in our heterogeneous panel specifications owing to the firm-by-firm estimation of slope coefficients.

Table 1: Employment and TFP Growth, Balanced and Unbalanced Panels

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Employees** | | | | | | | | | | | | | | | | |
| Balanced | 33 | 38 | 41 | 43 | 38 | 39 | 40 | 41 | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| Unbalanced | 17 | 18 | 14 | 16 | 22 | 21 | 14 | 13 | 11 | 11 | 13 | 11 | 11 | 10 | 10 | 11 |
| **TFP Growth** | | | | | | | | | | | | | | | | |
| Balanced | 1.3 | 0.2 | -1.4 | -1.5 | -0.2 | -0.4 | 2.0 | 1.6 | -3.8 | -5.6 | 1.3 | 0.7 | -0.6 | -0.4 | 1.2 | 0.0 |
| Unbalanced | 1.1 | 0.1 | -1.3 | -1.4 | -0.3 | -0.2 | 2.0 | 1.1 | -2.7 | -4.1 | 0.7 | 0.3 | -0.7 | -0.3 | 0.6 | 0.3 |

Notes: The table shows the median number of employees and the median TFP growth for both the balanced and unbalanced panels of firms.

## 3.2 Evolution of Firm Indebtedness

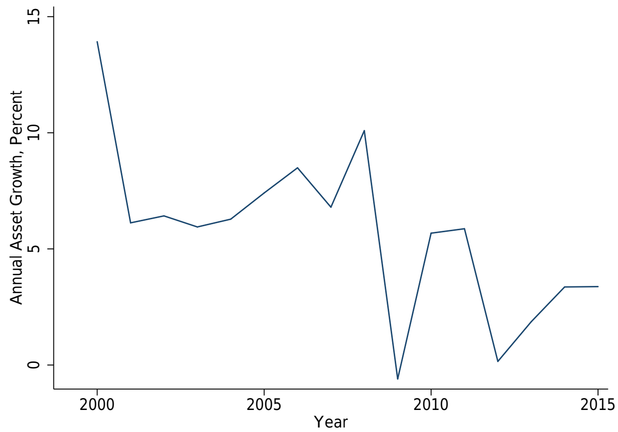
Figure 3 compares different measures of aggregate firm indebtedness for our balanced panel of firms. The profiles of debt to value added (our baseline measure) and debt to EBITDA, shown in Figures 3a and 3b, respectively, both increase up to 2012 before falling back modestly. These are similar to the debt to GDP ratio for all Italian non-financial corporations, shown in Figure 1b. In contrast, the profile of debt to assets, shown in Figure 3c, declines for much of the sample period and that of debt to equity, shown in Figure 3d, is volatile and downward sloping. Since assets and firm equity are evaluated at book value, the likelihood of large price fluctuations should be small. However, this is not corroborated by our data. Figure 4 shows that the growth of total assets for firms in our sample is very volatile over the period 1999-2015.

Figure 3: Different Measures of Firm Indebtedness


Notes: Panels (a) to (d) show different measures of aggregate firm indebtedness for the balanced panel of 6282 firms. Panel (a) shows the sum of debt for all firms as a ratio of the sum of value added for all firms. Panel (b) shows the sum of debt for all firms as a ratio of the sum of EBITDA for all firms. Panel (c) shows the sum of debt for all firms as a ratio of the sum of total assets for all firms. Panel (d) shows the sum of debt for all firms as a ratio of the sum of shareholders' funds for all firms.

The profile of the ratio of debt to value added observed in Figure 3a is common across size categories, and for manufacturing and non-manufacturing firms, with the exception of small firms (3-19 employees) for which the median value of debt to value added did not decrease following the financial crisis (Table 2). Table 3 provides a more detailed breakdown of the evolution of debt to value added and productivity within industries over the sample period. Within manufacturing sector, debt to value added was particularly high for food and beverages manufacturers, while in non-manufacturing sector, debt to value added was high in the wholesale and retail sector and increased sharply in the construction sector over the sample period. Average productivity performance over the period was also poor for the wholesale and retail and construction sectors.

Figure 4: Total Asset Growth, Balanced Panel




Notes: Figure 4 shows the growth of total assets for all firms in the balanced panel.

Table 2: Debt to Value Added, by Firm Size and Sector, Balanced Panel.

| | **1999** | **2001** | **2003** | **2005** | **2007** | **2009** | **2011** | **2013** | **2015** |
|---|---|---|---|---|---|---|---|---|---|
| **Number of employees** | | | | | | | | | |
| 3-19 | 48 | 77 | 94 | 122 | 129 | 127 | 135 | 133 | 121 |
| 20-249 | 64 | 70 | 83 | 85 | 90 | 94 | 97 | 92 | 88 |
| >250 | 51 | 68 | 69 | 62 | 62 | 71 | 70 | 66 | 68 |
| **Sector** | | | | | | | | | |
| Manufacturing | 58 | 69 | 80 | 83 | 88 | 94 | 95 | 89 | 82 |
| Non-manufacturing | 63 | 76 | 90 | 100 | 106 | 110 | 116 | 114 | 105 |

Notes: The table shows the median value of debt to value added in the balanced panel of firms for different firm size and sector categories. Firm size is determined by the number of employees in a given year. Firm sector is identified using NACE 2-digit codes.

Table 3: Debt to Value Added, by Industry, Balanced Panel.

| | Debt to value added | | | | Productivity | % of firms |
|---|---|---|---|---|---|---|
| | 2004 | 2009 | 2014 | Average growth 1999-2015 | Average growth 1999-2015 | |
| **Manufacturing** | | | | | | |
| Manufacturing: Food and beverages | 137 | 155 | 158 | 1.9% | 0.0% | 7.5% |
| Manufacturing: Textiles, apparel, leather products | 104 | 123 | 102 | 1.2% | -0.6% | 6.4% |
| Manufacturing: Wood, paper, printing | 81 | 91 | 92 | 2.0% | -0.3% | 4.5% |
| Manufacturing: Chemicals, pharmaceuticals | 97 | 118 | 92 | 1.2% | 0.1% | 3.7% |
| Manufacturing: Rubber, plastics and non-metallic products | 79 | 102 | 98 | 2.6% | -0.6% | 7.6% |
| Manufacturing: Basic metals and fabricated metal products | 63 | 78 | 74 | 2.3% | -0.6% | 11.8% |
| Manufacturing: Computers, electronics and electrical equipment | 62 | 80 | 73 | 2.0% | -0.4% | 3.7% |
| Manufacturing: Machinery | 61 | 64 | 50 | 1.5% | -0.4% | 8.1% |
| Manufacturing: Other | 77 | 97 | 94 | 2.5% | -0.5% | 4.7% |
| **Non-Manufacturing** | | | | | | |
| Agriculture, forestry and fishing | 168 | 177 | 194 | 0.9% | -0.1% | 2.0% |
| Construction | 67 | 88 | 113 | 5.2% | -0.7% | 5.2% |
| Wholesale and retail trade | 112 | 138 | 128 | 1.9% | -0.4% | 23.0% |
| Other non-manufacturing | 50 | 62 | 69 | 3.4% | -0.6% | 11.7% |

Notes: Columns 1-3 show the median value of debt to value added for different industries in the balanced panel of 6282 firms in 2004, 2009 and 2014. Column 4 shows the geometric average growth in debt to value added over 1999-2015. Column 5 shows the geometric average growth in total factor productivity over 1999-2015. Firm industry is identified using NACE 2-digit codes.

## 3.3 Firm Productivity

Figure 5a compares mean TFP growth in our balanced panel sample with Italy's aggregate TFP growth, reported by the OECD. The broad profile of mean TFP growth in our sample of 6282 firms is similar to the profile for aggregate TFP growth. Relative to aggregate TFP growth, mean TFP growth in our balanced panel was stronger in the immediate pre-crisis period, but declined more sharply following the crisis. The proportion of firms with negative TFP growth increased sharply in the immediate aftermath of the financial crisis in 2009 (Figure 5b).

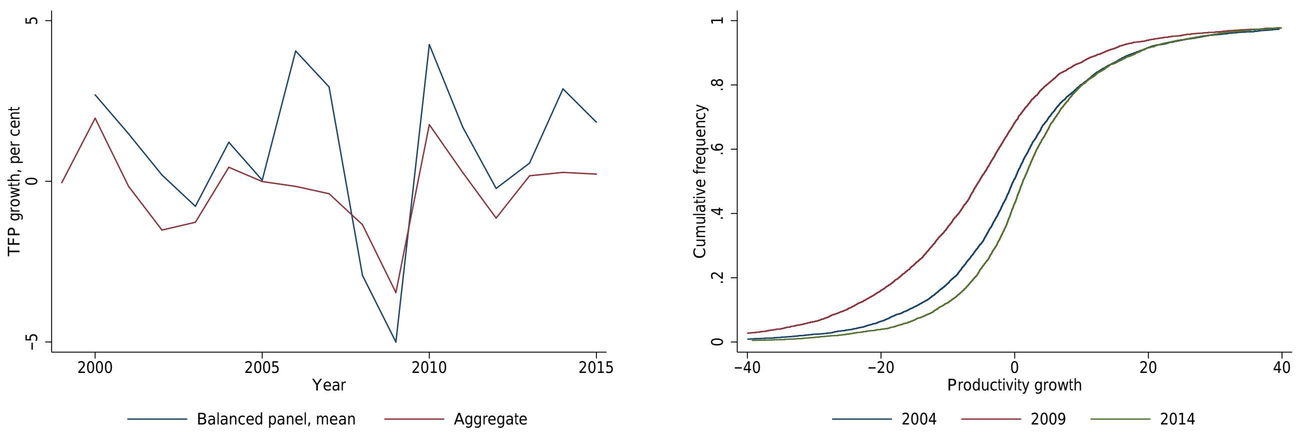
# 4 Empirical Framework

We use heterogeneous dynamic panel-threshold models with cross-sectionally correlated errors, à la Chudik, Mohaddes, Pesaran, and Raissi (2017), to analyse the long-run impact of increased corporate indebtedness on productivity growth, and investigate whether the corporate debt-productivity growth relationship varies with the level of indebtedness.

Figure 5: Total Factor Productivity Growth

(a) Evolution of TFP Growth, 1999-2015

(b) Distribution of TFP Growth




Notes: Figure 5a shows the mean annual TFP growth in our balanced panel of 6282 firms and the aggregate annual growth in total factor productivity in Italy. Aggregate TFP data is sourced from the OECD's "multifactor productivity" series. Figure 5b shows the cumulative distribution function of total factor productivity growth for the balanced panel of firms for the years 2004, 2009 and 2014.

## 4.1 Auto-Regressive Distributed Lag (ARDL) Approach

We begin our econometric analysis with a two-equation framework, where the joint dynamics of productivity growth and indebtedness for firm $i$ at time $t$ are given by:

$$\triangle tfp_{it} = \alpha_{i,y} + \delta_i \triangle tfp_{it-1} + \eta_i \triangle d_{it-1} + e_{it} \tag{2}$$

$$\triangle d_{it} = \alpha_{i,d} + \chi_i \triangle d_{it-1} + \psi_i \triangle tfp_{it-1} + \varepsilon_{it} \tag{3}$$

where $tfp_{it}$ is the estimated logarithm of TFP, $\hat{a}_{it}$, and $d_{it}$ is the logarithm of firm indebtedness.

Both specifications include fixed effects ($\alpha_{i,y}$ and $\alpha_{i,d}$) and heterogeneous slopes ($\delta_i$, $\eta_i$, $\chi_i$, and $\psi_i$), but to simplify the exposition, we initially assume cross-sectionally independent idiosyncratic errors (this assumption will be relaxed in Section 4.3). In contrast to most papers in the literature, the slope coefficients in (2) and (3) are specific to each individual firm, allowing for heterogeneity across firms in how they respond to changes in indebtedness and productivity growth. Equations 2 and 3 also allow for the possibility of feedback effects from productivity growth to indebtedness ($\psi_i \neq 0$). It is important to account for feedback effects since the productivity performance of a firm may affect the choices it makes about its capital structure. For example, a firm with weak productivity growth may be forced to take on more debt than a firm with strong productivity growth which can finance investment opportunities through retained earnings. Conversely, firms with strong productivity growth may feel more confident in their ability to take on more debt.

To address possible simultaneity bias, we assume a linear dependence between the contemporaneous error terms in (2) and (3):

$$e_{it} = \kappa_i \varepsilon_{it} + u_{it} \tag{4}$$

Where $u_{it} = e_{it} - E(e_{it} \mid \varepsilon_{it})$ such that $u_{it}$ and $\varepsilon_{it}$ are uncorrelated. $\kappa_i$ measures the extent of the simultaneity between the productivity growth errors, $e_{it}$, and the firm indebtedness errors, $\varepsilon_{it}$. We allow $\kappa_i$ to differ over $i$, considering the wide differences observed in debt financing across firms and their access to capital markets, among others. Substituting (4) into (2) and using (3), we obtain an ARDL(1,1) representation of productivity growth:

$$\triangle tfp_{it} = c_i + \lambda_i \triangle tfp_{it-1} + \beta_{i0} \triangle d_{it} + \beta_{i1} \triangle d_{it-1} + u_{it} \tag{5}$$

where $c_i = \alpha_{i,y} - \kappa_i \alpha_{i,d}$; $\lambda_i = \delta_i - \kappa_i \psi_i$; $\beta_{i0} = \kappa_i$; and $\beta_{i1} = \eta_i - \kappa_i \chi_i$.

The predominant focus of our study is on the long-run impact of a persistent build-up in debt on productivity growth.[10] From equation 5, the firm-level long-run impact of a persistent change in $\triangle d_{it}$ on $\triangle tfp_{it}$ can be recovered from the short-run coefficients and is given by $\theta_i = (\beta_{i0} + \beta_{i1})/(1 - \lambda_i)$. In the results Section, we report the mean group estimate of these long-run coefficients and the associated standard errors. We also check the robustness of our ARDL framework to a range of lag lengths.

More importantly, we extend our baseline ARDL framework in Equation 5 to allow for the possibility of a nonlinear relationship between corporate debt and average productivity growth in a cross-firm panel, characterized by a threshold effect:

$$\triangle tfp_{it} = c_i + \varphi I[d_{it} > ln(\tau)] + \lambda_i \triangle tfp_{it-1} + \beta_{i0} \triangle d_{it} + \beta_{i1} \triangle d_{it-1} + u_{it} \tag{6}$$

where $\tau$ is the threshold level of debt to value added, and $I(d_{it} > ln(\tau))$ is an indicator variable equal to 1 if $d_{it} > ln(\tau)$ and 0 otherwise. The hypothesis that the average productivity growth declines significantly once the corporate debt threshold is exceeded corresponds to $\varphi < 0$, and $\varphi$ measures the extent to which exceeding the threshold, $\tau$, further reduces productivity growth. Given that $u_{it}$ is uncorrelated with $\varepsilon_{it}$, then conditional on $(\triangle tfp_{it-1}, \triangle d_{it}, \triangle d_{it-1})$, $u_{it}$ and $d_{it}$ will also be uncorrelated. From this and under our identification condition, given by equation (4), $u_{it}$

[10] For a discussion of the short-run impact of high debt levels on productivity, see Adler, Duval, Furceri, Celik, and Poplawski-Ribeiro (2017).

and $I[d_{it} > ln(\tau)]$ will be uncorrelated and hence, for a given threshold level $\tau$, $\varphi$ can be estimated consistently using pooled least squares once the fixed effects and dynamics have been filtered out. The threshold coefficient, $\tau$, can then be estimated by the procedure which is outlined in Section 4.1.1. Although our specification allows for slope heterogeneity in the underlying productivity and indebtedness equations, it assumes that $\tau$ and $\varphi$ are homogeneous across firms.[11]

#### 4.1.1 Estimation and Panel Tests of Threshold Effects

The null hypothesis of no corporate-debt threshold effect on productivity growth, $H_0 : \varphi = 0$, can be tested against the alternative hypothesis that average productivity growth falls significantly when corporate indebtedness exceeds the threshold, $H_1 : \varphi < 0$. We treat the threshold, $\tau$, as an unknown parameter, and in developing a test of $H_0 : \varphi = 0$, we rigorously deal with the non-standard testing problem that arises, since $\tau$ is unidentified under the null hypothesis of no threshold effect. A satisfactory resolution of the testing problem is important since estimates of $\varphi$ are statistically meaningful only if $H_0$ is rejected. We closely follow the grid search procedure of Chudik, Mohaddes, Pesaran, and Raissi (2017) to estimate $\tau$ and test for statistical significant of $\varphi$. Firstly, for a given value of the threshold, $\tau$, we estimate $\varphi$. Secondly, using this estimate, we use the maximum likelihood and a grid search procedure to estimate the threshold. Finally, we test the null hypothesis that $\varphi = 0$ using the "*SupT*" and "*AveT*" test statistics. More details of our estimation procedure are provided in the Appendix.

### 4.2 Distributed Lag (DL) Approach

An alternative to estimating long-run effects from the short-run coefficients in the ARDL specification in (6), is to use the Distributed-Lag (DL) representation of the model and estimate the long-run effects directly (see Chudik, Mohaddes, Pesaran, and Raissi (2013)). The DL representation of our specification is given by:

$$\triangle tfp_{it} = \tilde{c}_i + \varphi I[d_{it} > ln(\tau)] + \theta_i \triangle d_{it} + \sum_{l=0}^{p} \psi_{il} \triangle_{il}^2 d_{it} + \tilde{v}_{it} \qquad (7)$$

where p is the order of the truncation lag and $\theta_i$ is the long-run effect. In the results section, we also report the estimates of the long-run effects using the DL approach, allowing for a range of truncation lag lengths.

[11]Allowing the debt threshold to vary across firms would require a significantly longer time horizon for our firm panel than is currently available.

## 4.3 Cross-Sectionally augmented ARDL and DL Approaches

The above ARDL and DL models can be readily generalized to deal with possible correlation across $u_{it}$. Such error cross-sectional dependencies could arise due to: (i) global factors affecting the pace of technological innovation and spillover effects from one firm to another, (ii) financial crises and recessions, (iii) commodity price shocks, (iv) labor and product/service market frictions, (v) general environment for doing business and other institutional factors, (vi) the stance of global financial cycle, (vii) health of the banking system, or other omitted common factors. We allow for this possibility by assuming that the errors in (6) have a multi-factor error structure given by:

$$u_{it} = \gamma_{\mathbf{i}}'\mathbf{f_t} + v_{it}$$

where $\gamma_{\mathbf{i}}$ is a $m \times 1$ vector of factor loadings; $\mathbf{f_t}$ is a $m \times 1$ vector of unobserved common factors which could themselves be serially correlated; and $v_{it}$ are idiosyncratic errors uncorrelated with $\mathbf{f_t}$, although they could be weakly cross-correlated. We follow the approach of Chudik and Pesaran (2015) in approximating the unobserved common factors using cross-sectional averages of productivity growth and indebtedness changes and their lags. We augment the ARDL and DL specifications with these cross-sectional averages, to obtain "CS-ARDL" and "CS-DL" specifications.

Chudik, Mohaddes, Pesaran, and Raissi (2013) provide a discussion of the relative merits and drawbacks of the CS-ARDL and CS-DL estimation approaches. The main advantage of the CS-DL approach relative to the CS-ARDL approach is its superior small sample performance when the time series dimension of the panel is moderate. Specifically, for the consistency of the ARDL estimates, sufficiently long lags are necessary, whereas specifying longer lags than necessary can lead to estimates with poor small sample properties. The CS-DL method is more generally applicable and requires only that a truncation lag order be selected. A drawback of the CS-DL technique relative to the CS-ARDL approach is that the CS-DL estimates of long-run effects are not consistent when there is significant feedback from productivity growth to indebtedness. However, Chudik, Mohaddes, Pesaran, and Raissi (2016) argue that even with this bias, the performance of CS-DL in terms of RMSE is much better than that of the CS-ARDL approach when T is moderate (which is the case in our empirical application). Furthermore, the CS-DL approach is robust to a number of departures from the baseline specification, such as residual serial correlation, and possible breaks in the error processes. We, therefore, present results from estimating the long-run effects of indebtedness on productivity growth using both approaches.

# 5 Results

The estimation results from the ARDL, DL, CS-ARDL and CS-DL specifications are reported in Table 4. The top panel reports the results without the threshold variable. The bottom panel reports the results for models which allow for non-linearities in the corporate debt–productivity growth relationship, by including the threshold variable. Both panels report the mean group estimates of the long-run effect of increased indebtedness, $\triangle d_{it}$, on total factor productivity growth, $\triangle prod_{it}$. We use the same lag order, p, for all firms but consider different values of p in the range of 1 to 2 for the ARDL and CS-ARDL approaches and 0 to 2 for the DL and CS-DL methods to investigate the sensitivity of the results to the choice of the lag order. Given that we are working with productivity-growth rates that are only moderately persistent, a maximum lag order of 2 should be sufficient to fully account for the short-run dynamics. Furthermore, using the same lag order across all firms helps reduce the possible adverse effects of data mining that could accompany the use of firm-specific lag order selection procedures such as the Akaike or Schwarz criteria. Note also that our primary focus is on the long-run estimates rather than the specific dynamics that might be relevant to a particular firm. To analyse the degree of cross-sectional dependence (CD), we also report the results of the Pesaran (2004, 2015) CD test. The bottom panel reports the estimate of the threshold $\tau$ and the $SupT$ and $AveT$ test results for its significance.

## 5.1 Estimates of Long-Run Effects

The results from the ARDL and DL specifications suggest a negative long-run relationship between persistent corporate-debt accumulation and productivity growth for all lag orders, both for specifications with and without the threshold variable.[12] For the ARDL and DL specifications, the estimated mean-group value of the long-run coefficient, $\theta$, is negative and statistically significant in all specifications, ranging from $-0.193$ to$-0.103$. As expected, there is no statistical difference in the estimated long-run coefficients between specifications with or without the threshold variable. Although the ARDL and DL specifications deal with heterogeneity, endogeneity, and dynamics, we need to be cautious when interpreting their results as both methods assume that errors in the corporate debt–productivity growth relationships are cross-sectionally independent, which is unlikely because a number of factors, such as institutional quality, the euro area monetary stance, and exposures to common shocks (i.e., oil price disturbances), could invalidate such an assumption. These global factors are mostly unobserved and can simultaneously affect both productivity growth and corporate-debt build-ups and can lead to biased estimates if the unobserved common factors are indeed correlated with the regressors.

[12]Note that long-run relationships do not provide any indication about direction of causality, but merely provide a statistical association between the variables in the long run. In fact, the causality can run both ways.

To investigate the extent of error cross-sectional dependence, in Table 4 we report the cross-section dependence (CD) test of Pesaran (2004, 2015), which is based on the average of pair-wise correlations of the residuals from the underlying ARDL and DL regressions. For all lag orders, we observe that these residuals display a significant degree of cross-sectional dependence. Under the null of weak error cross-sectional dependence, the CD statistics are asymptotically distributed as N(0, 1) and are highly statistically significant.

To address this problem, we employ the CS-ARDL and CSDL approaches, which augment the ARDL and DL specifications with cross-sectional averages of the regressors, the dependent variable, and their lags as proxies for unobserved common factors. The CD test statistics for CS-ARDL and CS-DL models confirm a substantial decline in the average pair-wise correlation of residuals after the cross-section augmentation of the ARDL and DL models. The long-run coefficient remains negative and statistically significant in all of the CS-ARDL and CS-DL specifications, but somewhat lower: ranging from $-0.171$ to $-0.089$. Inclusion of the threshold variable does not change the estimated long-run coefficients significantly. Overall, our empirical results are indicative of a negative long-run effect of increased firm indebtedness on total factor productivity growth, regardless of whether there are non-linearities in the form of a corporate debt threshold.

## 5.2 Tests of Corporate Debt-Threshold Effects

The test statistics for the significance of the threshold variable suggest that there are non-linearities in the relationship between corporate debt build-up and productivity growth. The $SupT$ and $AveT$ test statistics reported in the bottom panel of Table 4 are significant for all specifications other than $DL(1)$. The estimates of the level of the threshold, $\tau$, differ somewhat depending on whether or not the ARDL and DL specifications are augmented with cross-section averages of the regressors, the dependent variable, and their lags. For ARDL and DL specifications, there appears to be support for corporate-debt threshold effects of $\frac{debt}{value\,added}$ in the range from 2 to 3. However, accounting for unobserved common factors, using the CS-ARDL and CS-DL methods, results in somewhat higher threshold estimates with an average $\frac{debt}{value\,added}$ threshold estimate of around 3. These results indicate that tolerance for corporate debt increases once unobserved common factors are filtered out (for example, under a favourable ease of doing business environment). The estimated coefficients on the threshold variable are negative and statistically significant in 9 specifications. For these specifications, the average productivity growth in firms with debt to value-added below the estimated threshold of 3 is about 0.1 percentage points higher than highly-indebted firms. The rest are either not statistically significant or positive (only at p=0 in the DL and CS-DL models).

Table 4: Mean Group Estimates of Long-Run Effects of Corporate Indebtedness on TFP Growth

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| | | | | | **Regressions without Threshold Variable** | | | | | | | |
| $\hat{\theta}$ | -0.124*** | -0.119*** | -0.114*** | -0.124*** | -0.114*** | -0.115*** | -0.108*** | -0.103*** | -0.193*** | -0.121*** | -0.112*** | -0.118*** |
| | (0.003) | (0.008) | (0.008) | (0.002) | (0.003) | (0.004) | (0.011) | (0.019) | (0.057) | (0.003) | (0.004) | (0.006) |
| CD | 612.20*** | 554.63*** | 511.64*** | 542.88*** | 502.97*** | 448.94*** | 7.18*** | 2.47** | 3.75*** | 5.07*** | 3.81*** | 6.88*** |
| | | | | | **Regressions with Threshold Variable** | | | | | | | |
| $\hat{\theta}$ | -0.121*** | -0.115*** | -0.106*** | -0.138*** | -0.118*** | -0.111*** | -0.104*** | -0.089*** | -0.171*** | -0.143*** | -0.119*** | -0.108*** |
| | (.0025) | (.0079) | (.009) | (.0021) | (.0024) | (.003) | (.0112) | (.0172) | (.0568) | (.0022) | (.0027) | (.0037) |
| $\hat{\tau}$ | 3.3 | 3.3 | 2.5 | 2.0 | 2.0 | 2.0 | 3.3 | 3.3 | 3.0 | 1.0 | 3.3 | 3.3 |
| $\hat{\varphi}$ | -0.017 | -0.019 | -0.013 | 0.007 | 0.000 | -0.009 | -0.015 | -0.021 | -0.027 | 0.004 | -0.018 | -0.020 |
| SupT | 6.63*** | 7.53*** | 8.71*** | 5.07*** | 1.16 | 3.67** | 6.54*** | 7.86*** | 11.52*** | 3.43* | 6.12*** | 6.58*** |
| AveT | 4.93*** | 5.89*** | 6.28*** | 3.34*** | .65 | 2.8*** | 3.68*** | 4.77*** | 7.08*** | 2.15*** | 4.72*** | 5.34*** |
| CD | 611.34*** | 555.58*** | 510.00*** | 609.80*** | 544.12*** | 504.39*** | 7.45*** | 2.78*** | 4.25*** | 5.01*** | 6.69*** | 5.74*** |

Notes: The ARDL and DL specifications are described by equations (6) and (7). For all specifications, indebtedness is measured by the ratio of debt to value added. The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables. The top panel reports the estimated long-run effect from specifications which do not include the threshold variable, $\tau$. The bottom panel reports results from specifications which include the threshold variable, $\tau$. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. CD refers to the Pesaran (2004) test statistic for cross-sectional dependence. $\hat{\tau}$ is the estimated threshold of the debt to value added ratio. SupT and AveT test for the significance of $\varphi$.

Table 5: Mean Group Estimates of Short-Run Effects of Corporate Indebtedness on TFP Growth

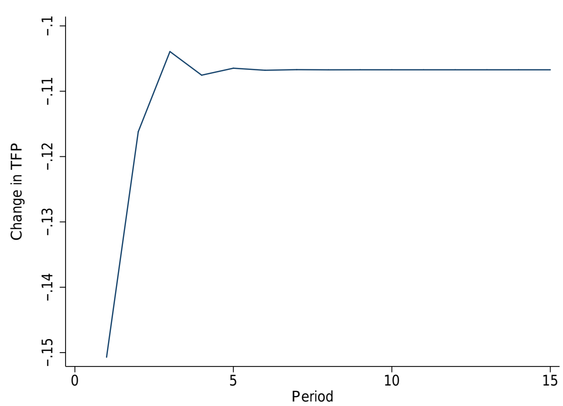
| | CS-ARDL (1,2,1,2) |
|---|---|
| $\hat{\lambda}$ | -0.294*** |
| | (0.006) |
| $\hat{\beta}_0$ | -0.151*** |
| | (0.003) |
| $\hat{\beta}_1$ | -0.010*** |
| | (0.003) |
| $\hat{\beta}_2$ | 0.022*** |
| | (0.002) |

Notes: The Table reports the estimated short-run coefficients from the CS-ARDL(1,2,1,2) specification which does not include the threshold variable, $\tau$. The CS-ARDL specification augments the ARDL specification described by equation (6) with cross sectional averages and lags of the dependent and independent variables. Indebtedness is measured by the ratio of debt to value added. $\hat{\lambda}$ corresponds to the mean group estimate of the coefficient on lagged TFP growth, $\triangle tfp_{it-1}$ . $\hat{\beta}_0$ corresponds to the mean group estimate of the coefficient on changes in indebtedness, $\triangle d_{it}$ . $\hat{\beta}_1$ corresponds to the mean group estimate of the coefficient on changes in indebtedness in the previous period, $\triangle d_{it-1}$ . $\hat{\beta}_2$ corresponds to the mean group estimate of the coefficient on changes in indebtedness two periods ago, $\triangle d_{it-2}$ . Standard errors are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

## 5.3 Estimates of Short-Run Effects

To illustrate how productivity responds over time to increased indebtedness, Table 5 reports the mean group estimates of the short-run coefficients for the CS-ARDL (1, 2, 1, 2) specification. Figure 6 shows the dynamic response of TFP over time to a change in debt which takes place in period one, using the mean group estimates of the short run coefficients from this specification. Productivity falls significantly in period one and partially recovers afterwards before reaching its long-term value in year 5. The speed of adjustment to the long-term in our sample of firms is, therefore, consistent with the life expectancy of the median firm in Italy.

Figure 6: Dynamic Response of TFP to a Change in Debt



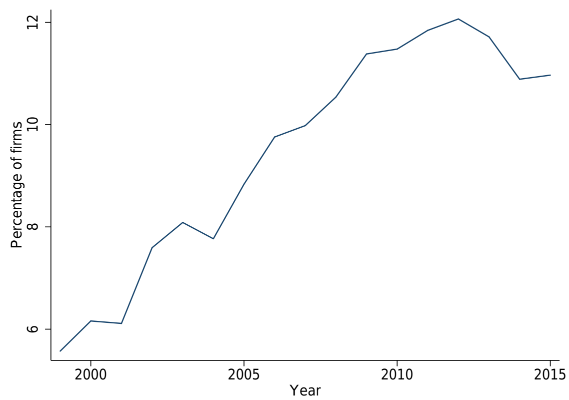
## 5.4 Economic Significance

Our results show that persistent debt build-ups within Italian firms over the period 1999-2015 reduced firm productivity growth. The coefficient estimates in our CS-ARDL and CS-DL specifications imply that a persistent increase in debt to value added at an annual pace of one percent is, in the long-run, associated with 0.1 percentage points lower TFP growth per year, on average. Debt to value added in our balanced sample of 6282 firms increased by around 1.4% per year between 1999-2015, on average, implying a reduction in long-run TFP growth of around 0.14pp.

Our results also provide evidence that average productivity growth within Italian firms declines significantly when corporate indebtedness exceeds a threshold. Our preferred specifications (i.e. CS-ARDL and CS-DL as they account for the impact of global factors and their spillover effects) suggest that this threshold is reached when a firm's level of debt is around three times its nominal value added. Figure 7 shows the percentage of firms in our sample in each year with a ratio of debt to value added in excess of three. Between 1999-2012, the proportion of firms exceeding the estimated corporate-debt threshold more than doubled, from below 6% in 1999 to around 12% in 2012. The proportion of vulnerable firms only fell back modestly subsequently, to around 11% in 2015. Figure 8a shows that these vulnerable firms are mostly small (with employment levels of less than 19) and their numbers grew rapidly over time relative to medium and large corporations. Figure 8b shows that the proportion of non-manufacturing firms exceeding the threshold increased by more over the sample period relative to manufacturing firms. Figures 10a and 10b in the Appendix show the proportion of vulnerable firms within different manufacturing and non-manufacturing industries.

Finally, while our results highlight that persistent debt build-ups can weigh down on productivity growth, the CD test statistics in our ARDL and DL specifications suggest that there are important unobserved common factors impacting on productivity growth within Italian firms. Such factors are likely to include the quality of institutional framework in Italy, as highlighted, for example, by Pellegrino and Zingales (2014), the general macroeconomic climate, such as the credit conditions facing Italian firms, as well as global headwinds such as a slowdown in technological innovation (Gordon (2012)). To this extent, reforms which aim to alleviate the common headwinds affecting the productivity prospects of Italian companies should be pursued.

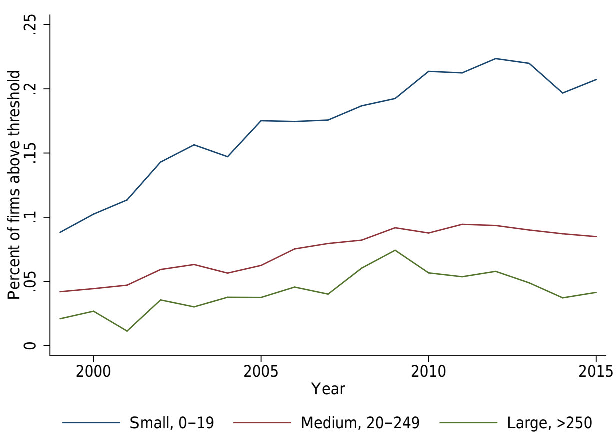
Figure 7: Percentage of Firms Exceeding the Threshold Level of Indebtedness



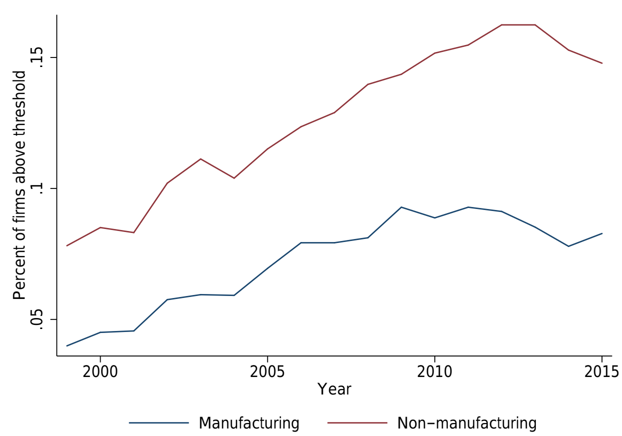

Notes: Figure 7 shows the percentage of firms in the balanced panel exceeding a debt to value added threshold of 3 in each year.

Figure 8: Percentage of Firms Exceeding the Threshold Level of Indebtedness, by Size and Sector

(a) Percentage Exceeding Threshold, by Size




(b) Percentage Exceeding Threshold, by Sector




Notes: Figure 8a shows the percentage of firms within different size categories exceeding a debt to value added threshold of 3 in each year. The size categories are small ($employees < 20$), medium ($20 \leq employees < 250$) and large ($250 \leq employees$) . Figure 8b shows the percentage of firms within manufacturing and non-manufacturing sectors exceeding a debt to value added threshold of 3 in each year. Industries are identified using 2-digit NACE codes.

# 6 Extensions and Robustness

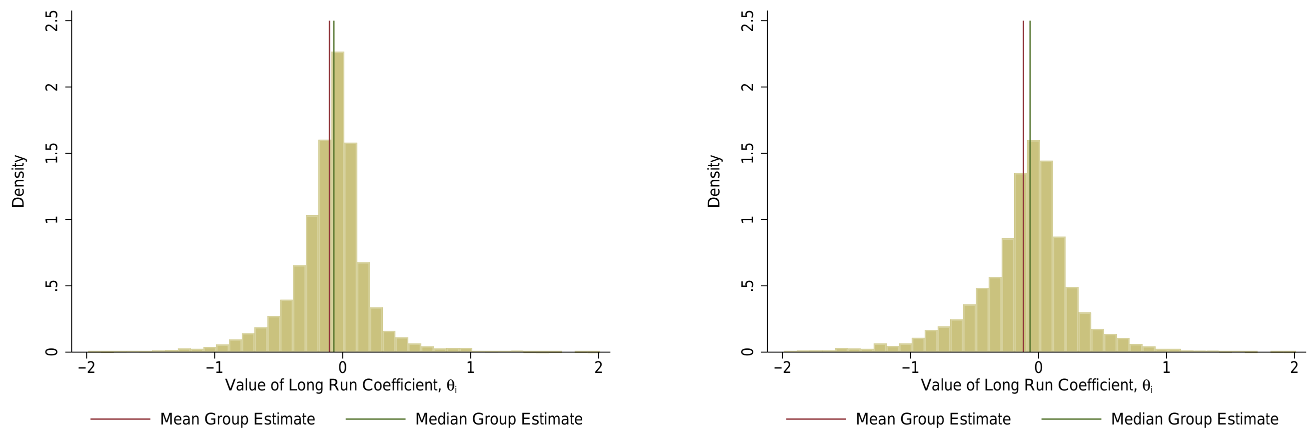
## 6.1 Long-Run Effects by Firm Size and Sector

More granularly, Figures 9a and 9b show the distribution of estimates of the long-run coefficients $\theta_i$ in our CS-ARDL (1, 2, 1, 2) and CS-DL (2) specifications, respectively. We also show the mean group and median group estimates of the long-run coefficients in our sample of 6282 firms. The mean group estimates match those reported in Table 4 ( -0.103 and -0.118 for the CS-ARDL (1, 2, 1, 2) and CS-DL (2) specifications without the threshold variable, respectively). As shown in

Figure 9: Distribution of Long Run Coefficient Estimates

(a) Specification: CS-ARDL(1, 2, 1, 2)

(b) Specification: CS-DL (2)




Pesaran and Smith (1995), while the individual coefficients may be imprecisely estimated for some firms in small samples (like ours), the mean group estimates of the average of the parameters are consistent. Nonetheless, the histogram of the estimated individual coefficients has valuable information content, including that the long-term mean group coefficient estimates are not driven by outliers; the distributions are somewhat skewed to the left (i.e. larger number of firms are adversely affected by persistent debt accumulation) and the median group estimates are close to the mean group estimates of $\theta$. The median group estimates are slightly lower in absolute terms, indicating the presence of some outliers, though limited in impact, in the estimated long-term coefficients.[13] It is, therefore, preferable to focus on mean group estimates for groups of firms (according to size or sector) rather than on individual firm estimates.

We consider whether the impact of increased corporate indebtedness on productivity growth varies by firm size and sector by calculating the mean group estimates of the long-run effects for respective groups. The results are reported in Table 6. The estimated average value of the long-run coefficient, $\theta$, is negative and statistically significant across firm size and sectors no matter what is the lag order or estimation method. While the results suggest that the negative impact of persistent debt accumulation on productivity growth may be slightly higher for manufacturing firms than for firms in non-manufacturing sector, such variations are less pronounced within different size groupings.

[13]Similar histograms can be produced for the estimated short-term coefficients $\lambda_i$, $\beta_i$, and $\psi_i$. For brevity, these results are not reported here but they are available upon request.

Table 6: Mean Group Estimates of Long-Run Effects of Corporate Indebtedness on TFP Growth, by Firm Size and Sector

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| **Small** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.107*** | -0.117*** | -0.101*** | -0.108*** | -0.097*** | -0.090*** | -0.069*** | -0.033 | -0.361 | -0.108*** | -0.099*** | -0.094*** |
| | (0.005) | (0.024) | (0.006) | (0.005) | (0.005) | (0.007) | (0.033) | (0.047) | (0.171) | (0.005) | (0.006) | (0.010) |
| **Medium** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.133*** | -0.121*** | -0.120*** | -0.133*** | -0.123*** | -0.128*** | -0.126*** | -0.137*** | -0.113*** | -0.128*** | -0.118*** | -0.129*** |
| | (0.003) | (0.004) | (0.012) | (0.003) | (0.004) | (0.005) | (0.005) | (0.018) | (0.031) | (0.003) | (0.004) | (0.007) |
| **Large** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.111*** | -0.098*** | -0.117*** | -0.107*** | -0.095*** | -0.104*** | -0.119*** | -0.107*** | -0.169*** | -0.113*** | -0.107*** | -0.141*** |
| | (0.011) | (0.014) | (0.013) | (0.011) | (0.014) | (0.019) | (0.013) | (0.023) | (0.082) | (0.013) | (0.016) | (0.032) |
| **Manufacturing** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.134*** | -0.119*** | -0.116*** | -0.134*** | -0.121*** | -0.124*** | -0.113*** | -0.158*** | -0.163*** | -0.131*** | -0.120*** | -0.131*** |
| | (0.003) | (0.004) | (0.011) | (0.003) | (0.004) | (0.005) | (0.018) | (0.019) | (0.026) | (0.003) | (0.005) | (0.007) |
| **Non-Manufacturing** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.109*** | -0.119*** | -0.110*** | -0.109*** | -0.104*** | -0.103*** | -0.100*** | -0.026*** | -0.236 | -0.107*** | -0.101*** | -0.100*** |
| | (0.004) | (0.018) | (0.011) | (0.004) | (0.005) | (0.006) | (0.007) | (0.037) | (0.134) | (0.004) | (0.006) | (0.009) |

Notes: The ARDL and DL specifications are described by equations (6) and (7). For all specifications, indebtedness is measured by the ratio of debt to value added. The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. All specifications considered here do not include the threshold variable, $\tau$. The top three panels report estimated long-run effects for small ($employees < 20$), medium ($20 \leq employees < 250$) and large ($250 \leq employees$) companies, and the bottom two panels report estimated long-run effects for manufacturing and non-manufacturing companies, identified using NACE 2 digit codes.

## 6.2 Alternative Measures of Corporate Indebtedness

### 6.2.1 Debt to EBITDA

As an alternative measure of corporate indebtedness, we consider the ratio of debt to earnings before interest, tax, depreciation and amortization (EBITDA). Relative to value added, EBITDA does not include financial profits, extraordinary profits or the cost of employees. For some firm-year observations in our sample, EBITDA is zero or negative. For these cases, we set the ratio of debt to EBITDA equal to its maximum value over the sample period for that firm.

The results using this alternative specification are reported in Table 7. Consistent with the results from our baseline specification, reported in Section 5, we confirm a negative long-run relationship between persistent increase in debt to EBITDA and productivity growth. The estimate of the long-run effect is statistically significant in all specifications other than CS-ARDL (1,2,1,2). As before, the CD test statistics for the ARDL and DL specifications suggest substantial cross-sectional dependence. Finally, the panel threshold tests based on the ARDL and DL specifications provide evidence for a corporate debt threshold effect (in the range of 6.5 to 10 times earnings) in the relationship between corporate debt build-up and productivity growth. However, once we account for the possible effects of common unobserved factors and their spillovers, we are able to find a higher corporate debt threshold effect (in the range of 8.5 to 10 times earnings) based on the $AveT$ test statistics. This fits nicely with the results in Section 5 showing that in the absence of unobserved common factors firms are able to tolerate higher levels of corporate debt. The estimated coefficients on the threshold variable are negative and statistically significant in 7 specifications. For these specifications, average productivity growth in firms with debt to EBITDA below the estimated thresholds is about 0.05 percentage points higher than highly-indebted firms. The rest are either not statistically significant (2 cases) or positive in DL (2 cases) and CS-DL models (1 specification).

### 6.2.2 Debt to Assets

We also check whether our results are robust to using an asset based measure of leverage. Specifically, we consider the ratio of a firm's debt to total assets in all regression in lieu of debt to value added. The results are reported in Table 8. Using this measure, we do not find evidence of an indebtedness threshold beyond which productivity growth declines significantly and, so for brevity we only display the results from specifications without the threshold variable. Our main finding of a negative long-run relationship between increased leverage and productivity growth is supported by these results. In every specification considered other than ARDL(2,1) and CS-ARDL (1,2,1,2), the estimated long-run effect is negative and statistically significant.

Table 7: Mean Group Estimates of Long-Run Effects Using Debt to EBITDA

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| **Regressions without Threshold Variable** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.120*** | -0.114*** | -0.115*** | -0.119*** | -0.114*** | -0.109*** | -0.112*** | -0.118*** | -0.294 | -0.114*** | -0.110*** | -0.106*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.004) | (0.010) | (0.155) | (0.002) | (0.002) | (0.003) |
| CD | 539.09*** | 483.56*** | 456.70*** | 474.97*** | 436.79*** | 398.73*** | 13.22*** | 8.20*** | 6.51*** | 9.80*** | 9.16*** | 2.95*** |
| **Regressions with Threshold Variable** | | | | | | | | | | | | |
| $\hat{\theta}$ | -0.119*** | -0.112*** | -0.111*** | -0.113*** | -0.112*** | -0.106*** | -0.112*** | -0.118*** | -0.128*** | -0.115*** | -0.113*** | -0.111*** |
| | (.0016) | (.0021) | (.0022) | (.0013) | (.0016) | (.0019) | (.0038) | (.009) | (.0158) | (.0013) | (.0018) | (.0024) |
| $\hat{\tau}$ | 10.0 | 8.0 | 8.0 | 8.0 | 6.5 | 6.5 | 10.0 | 9.0 | 8.5 | 9.5 | 10.0 | 10.0 |
| $\hat{\varphi}$ | -0.010 | -0.008 | -0.011 | 0.002 | 0.005 | 0.005 | -0.003 | 0.001 | -0.003 | -0.005 | -0.001 | 0.001 |
| SupT | 8.28*** | 7.51*** | 10.91*** | 1.29 | 3.61** | 3.8** | 3.3 | 1.83 | 3.9 | 5.02*** | 2.84 | 3.36 |
| AveT | 7.39*** | 6.29*** | 9.68*** | .61 | 3.14*** | 2.98*** | 2.45*** | .86 | 2.8*** | 3.65*** | 1.94*** | 1.65* |
| CD | 534.51*** | 482.21*** | 452.32*** | 523.99*** | 471.15*** | 434.35*** | 13.69*** | 8.06*** | 7.08*** | 10.93*** | 10.63*** | 11.78*** |

Notes: The ARDL and DL specifications are described by equations (6) and (7). For all specifications, indebtedness is measured by the ratio of debt to EBITDA. The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables. The top panel reports the estimated long-run effect from specifications which do not include the threshold variable, $\tau$. The bottom panel reports results from specifications which include the threshold variable, $\tau$. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. CD refers to the Pesaran (2004) test statistic for cross-sectional dependence. $\hat{\tau}$ is the estimated threshold of the debt to EBITDA ratio. SupT and AveT test for the significance of $\varphi$.

Table 8: Mean Group Estimates of Long-Run Effects Using Debt to Assets

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| $\hat{\theta}$ | -0.044*** | -0.027*** | -1.576 | -0.040*** | -0.032*** | -0.025*** | -0.057*** | 0.090 | -0.115*** | -0.045*** | -0.026*** | -0.005 |
| | (0.004) | (0.006) | (1.521) | (0.004) | (0.005) | (0.006) | (0.006) | (0.174) | (0.047) | (0.004) | (0.006) | (0.010) |
| CD | 603.75*** | 558.20*** | 508.67*** | 528.85*** | 495.57*** | 440.76*** | 5.19*** | 3.29*** | 3.43*** | 4.13*** | 3.26*** | 5.70*** |

Notes: The ARDL and DL specifications are described by equations (6) and (7). For all specifications, indebtedness is measured by the ratio of debt to total assets. The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. CD refers to the Pesaran (2004) test statistic for cross-sectional dependence. All specifications considered here do not include the threshold variable, $\tau$.

### 6.2.3 Long-Term Debt to Value Added

In our baseline specification, debt includes short-term loans and securities, as well as long-term loans and bonds. We consider whether our results are robust to using the ratio of long-term debt to value added, defined as the sum of long-term loans and bonds. Focusing on firms which have a long-run debt to value added ratio of at least 0.01 throughout the period 1999-2015, we end up with a balanced panel of 5543 firms. The findings are reported in Table 9. Consistent with our baseline analysis, the results suggest a negative impact of increased corporate indebtedness on productivity growth. Nonetheless, the estimates are smaller than in our baseline analysis, suggesting that a persistent increase in long-term debt to value added at an annual pace of one percent is associated, in the long-run, with lower TFP growth of around 0.07 percentage points per year.

### 6.2.4 Economic Significance of Alternative Measures of Corporate Indebtedness

Table 10 compares the impact of a persistent increase in corporate debt on long-term TFP growth using four alternative measures of indebtedness. For comparability, the results show the response of a one standard deviation increase in the relevant measure of indebtedness, where standard deviations are calculated using annual changes of aggregate firm indebtedness for our balanced panel of firms.[14] The results imply that a persistent increase in debt to value added, debt to EBITDA, debt to assets, and long-term debt to value added is, in the long-run, associated with 0.01 to 0.08 percentage points lower TFP growth per year, on average.

## 6.3 Alternative Measures of Productivity

We also consider the robustness of our results to alternative measures of TFP as well as a measure of labor productivity. The measure of TFP used in our baseline analysis is calculated using the single-equation instrumental variable approach of Wooldridge (2009). We assess the robustness of our results to using a simple ordinary least squares (OLS) measure of TFP and a "Solow residual" measure of TFP (Gal (2013) provides a detailed description and comparison of these approaches). The OLS approach estimates the production function for each industry, given by equation 1, using OLS. The Solow residual approach calculates the labor share in industry $j$ in year $t$, given by $\beta_{ljt}$ , as the average share of labor in value added in industry $j$ in year $t$ while assuming that the factor shares sum to one. TFP for firm $i$ is then given by:

[14]Note that a one standard deviation increase in corporate indebtedness corresponds to a 4, 6, 4, and 6 percent increase in indebtedness using debt to value added, debt to EBITDA, debt to assets, and long-term debt to value added, respectively.

Table 9: Mean Group Estimates of Long-Run Effects Using Long-Term Debt to Value Added

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| $\hat{\theta}$ | -0.070*** | -0.062*** | -0.064*** | -0.071*** | -0.064*** | -0.063*** | -0.066*** | -0.040*** | -0.094*** | -0.065*** | -0.062*** | -0.064*** |
| | (0.002) | (0.003) | (0.003) | (0.002) | (0.002) | (0.003) | (0.004) | (0.021) | (0.048) | (0.002) | (0.003) | (0.005) |
| CD | 413.51*** | 367.42*** | 342.92*** | 362.72*** | 326.96*** | 284.80*** | 1.83* | 2.59*** | 1.77* | 2.48** | 2.55** | 1.58 |

Notes: The ARDL and DL specifications are described by equations (6) and (7). For all specifications, indebtedness is measured by the ratio of long-run debt to value added. The balanced panel using this alternative debt measure consists of 5543 firms. The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. CD refers to the Pesaran (2004) test statistic for cross-sectional dependence.All specifications considered here do not include the threshold variable, $\tau$.

Table 10: Long-Run Effects of Alternative Measures of Corporate Indebtedness on TFP Growth

| CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|
| (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| **Debt to Value Added** | | | | | |
| -0.005*** | -0.004*** | -0.008*** | -0.005*** | -0.005*** | -0.005*** |
| **Debt to EBITDA** | | | | | |
| -0.007*** | -0.007*** | -0.018 | -0.007*** | -0.007*** | -0.007*** |
| **Debt to Assets** | | | | | |
| -0.002*** | 0.003 | -0.004*** | -0.002*** | -0.001*** | 0.000 |
| **Long-Term Debt to Value Added** | | | | | |
| -0.004*** | -0.003*** | -0.006*** | -0.004*** | -0.004*** | -0.004*** |

Notes: The results show the response of a one standard deviation increase in the relevant measure of indebtedness, where standard deviations are calculated using annual changes of aggregate firm indebtedness for our balanced panel of firms. The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications, equations (6) and (7), with cross sectional averages and lags of the dependent and independent variables. All panels report the estimated long-run effect from specifications which do not include the threshold variable, $\tau$. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

$$tfp_{it}^{SOLOW} = y_{it} - (1 - \beta_{ljt})k_{it} - \beta_{ljt}l_{it} \tag{8}$$

The results using these two alternative measures of TFP are reported in Table 11. For this analysis, we use our standard measure of indebtedness, given by total debt to value added. Both measures of TFP suggest a negative long-run relationship between persistent build-ups in debt and TFP growth. The results using the OLS approach are similar in magnitude to our baseline results, suggesting that an increase in debt to value added at an annual pace of one percent is associated with around 0.1 percentage points lower TFP growth per year, on average. The results using the Solow residual approach imply a larger drag on TFP growth from increased indebtedness.[15]

We also consider whether our results hold when we use labor productivity growth as the dependent variable instead of TFP growth. We use the change in the logarithm of labor productivity, measured as value added divided by the number of employees, as our dependent variable and we use our standard measure of indebtedness, given by total debt to value added. The results, reported in Table 12, suggest that persistent corporate debt build-ups have a negative impact on labor productivity in the long-run. The estimated coefficients are similar in magnitude to our baseline analysis which considers the impact of debt build-ups on TFP growth.

## 6.4 Jackknife Fixed Effects Estimator

Our main analysis in Sections 4 and 5 allows for slope heterogeneity across firms (i.e. in how they respond to a change in indebtedness) and estimates the long-run effects of increased indebtedness on productivity growth using the mean group estimator (in which separate equations are estimated for each cross-section unit and the average of estimated coefficients across firms is examined). Pesaran and Smith (1995) show that the mean group method produces consistent estimates of the average of the parameters when the time-series dimension of the data is sufficiently large (in our sample $T = 17$). To ensure that our results are robust to alternative estimation methods (in panels of large N and small T), we consider pooling our firm-year observations and estimating the long-run effects under the assumption of homogeneous slopes, allowing for firm fixed effects only and without accounting for unobserved common factors. Note that inference based on the traditional fixed

[15] The similarity between the baseline results which use the Wooldridge TFP measure and the results using the OLS approach is consistent with the high correlation between these measures reported in Gal (2013). The correlation between the Wooldridge measure and the Solow measure is weaker and so the difference in the magnitude of the long-run estimates is not altogether surprising.

Table 11: Mean Group Estimates of Long-Run Effects Using Alternative TFP Measures

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| | | | | | | | **TFP-OLS** | | | | | |
| $\hat{\theta}$ | -0.123*** | -0.118*** | -0.124*** | -0.124*** | -0.114*** | -0.115*** | -0.122*** | -0.110*** | -0.115*** | -0.122*** | -0.111*** | -0.116*** |
| | (0.003) | (0.008) | (0.005) | (0.002) | (0.003) | (0.004) | (0.009) | (0.016) | (0.028) | (0.003) | (0.004) | (0.006) |
| CD | 534.10*** | 489.10*** | 452.16*** | 466.58*** | 436.07*** | 387.76*** | 5.98*** | 2.40** | 3.17*** | 4.39*** | 3.69*** | 7.37*** |
| | | | | | | | **TFP-Solow** | | | | | |
| $\hat{\theta}$ | -0.205*** | -0.202*** | -0.213*** | -0.195*** | -0.193*** | -0.202*** | -0.176*** | 0.222 | -0.107 | -0.194*** | -0.197*** | -0.202*** |
| | (0.015) | (0.012) | (0.023) | (0.004) | (0.005) | (0.006) | (0.022) | (0.417) | (0.104) | (0.004) | (0.006) | (0.009) |
| CD | 976.09*** | 911.96*** | 842.93*** | 925.50*** | 871.41*** | 738.48*** | 3.47*** | -1.04 | 5.07*** | 1.80* | -0.24 | 1.79* |

Notes: The ARDL and DL specifications are described by equations (6) and (7). The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables. For all specifications, indebtedness is measured by the ratio of total debt to value added. In the top panel, the dependent variable is the change in TFP, where TFP is estimated using the OLS approach. In the bottom panel, the dependent variable is the change in TFP, where TFP is measured using the Solow residual approach. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. CD refers to the Pesaran (2004) test statistic for cross-sectional dependence.All specifications considered here do not include the threshold variable, $\tau$.

Table 12: Mean Group Estimates of Long-Run Effects of Corporate Indebtedness on Labor Productivity Growth

| | ARDL | | | DL | | | CS-ARDL | | | CS-DL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lags | (1,1) | (1,2) | (2,1) | p=0 | p=1 | p=2 | (1,1,1,1) | (1,2,1,2) | (2,1,2,1) | p=0 | p=1 | p=2 |
| $\hat{\theta}$ | -0.131*** | -0.103*** | -0.120*** | -0.134*** | -0.105*** | -0.097*** | -0.130*** | -0.045 | -0.902 | -0.126*** | -0.114*** | -0.120*** |
| | (0.004) | (0.005) | (0.004) | (0.004) | (0.005) | (0.006) | (0.007) | (0.107) | (0.834) | (0.005) | (0.006) | (0.010) |
| CD | 857.42*** | 723.86*** | 772.73*** | 839.63*** | 724.79*** | 604.99*** | 25.11*** | 4.38*** | 1.16 | 28.76*** | 3.24*** | 5.48*** |

Notes: The ARDL and DL specifications are described by equations (6) and (7). The CS-ARDL and CS-DL specifications augment the ARDL and DL specifications with cross sectional averages and lags of the dependent and independent variables.. For all specifications, indebtedness is measured by the ratio of debt to value added. In these specifications labor productivity growth is used as the dependent variable. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively. CD refers to the Pesaran (2004) test statistic for cross-sectional dependence.All specifications considered here do not include the threshold variable, $\tau$.

effects (FE) estimator would result in significant size distortions, due to the inclusion of lagged dependent variable and other weakly exogenous regressors in our specifications (in which N/T is large). To overcome this distortion, we apply the jackknife bias correction to the FE estimator, discussed in Chudik, Pesaran, and Yang (2016). Our baseline ARDL(1,1) specification can be expressed as:

$$\triangle tfp_{it} = c_i + \lambda \triangle tfp_{it-1} + \beta_0 \triangle d_{i,t} + \beta_1 \triangle d_{i,t-1} + u_{it} \tag{9}$$

where apart from the intercept, all other coefficients are assumed to be homogeneous. The results using the Jackknife Fixed Effects (FE-JK) estimator are reported in Table 13. We consider a number of different lag-lengths for the ARDL model and we present results for our three different measures of indebtedness. For each of our measures of indebtedness, the FE-JK estimates provide further support of a negative long-run relationship between increased corporate indebtedness and productivity growth. Relative to the estimates of the long-run effects using the mean group ARDL and CS-ARDL specifications, the FE-JK estimates suggest a slightly smaller adverse impact on productivity growth from increased corporate indebtedness. However, the FE-JK estimator does not account for unobserved common factors impacting on productivity growth within Italian firms.

Table 13: Jackknife FE Estimates of Long-Run Effects of Corporate Indebtedness on TFP Growth

| | ARDL(1,1) | ARDL(2,1) | ARDL(1,2) | ARDL(2,2) |
|---|---|---|---|---|
| | | A: Debt/Value Added | | |
| $\hat{\theta}$ | -0.071*** | -0.062*** | -0.060*** | -0.060*** |
| | (0.002) | (0.001) | (0.002) | (0.002) |
| | | B: Debt/EBITDA | | |
| $\hat{\theta}$ | -0.093*** | -0.083*** | -0.088*** | -0.089*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| | | C: Debt/Total Assets | | |
| $\hat{\theta}$ | -0.040*** | -0.038*** | -0.028*** | -0.033*** |
| | (0.003) | (0.002) | (0.004) | (0.003) |

Notes: The ARDL specifications are described by equations (9). "FE-JK" refers to fixed effects estimation with the jackknife bias correction. Standard errors for the long-run effect are given in parentheses. Symbols ***, **, * denote statistical significance at 1%, 5%, and 10% levels, respectively.

# 7 Conclusion

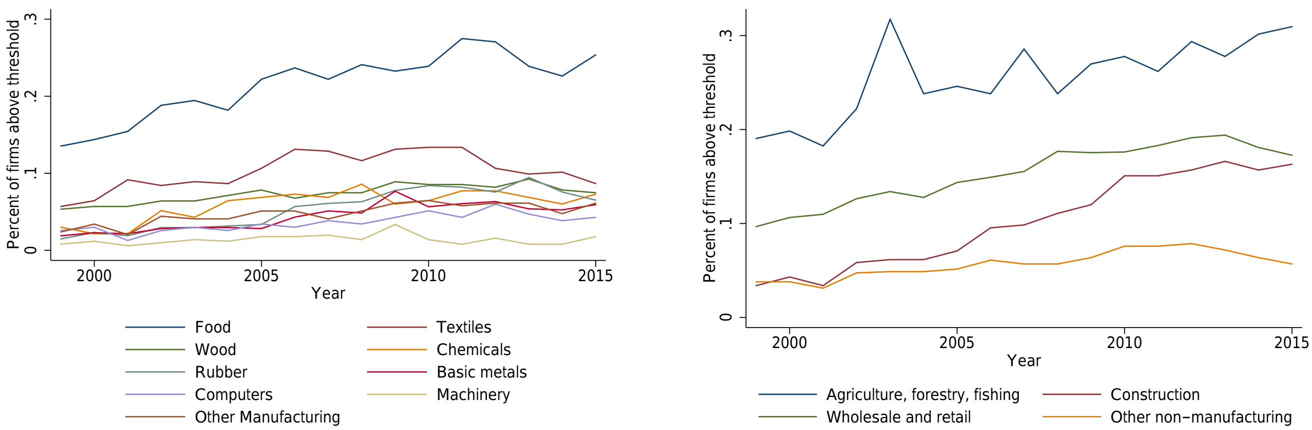
Using a novel estimation technique for dynamic heterogeneous panels with cross-sectionally correlated errors, we found significant negative effects of persistent corporate-debt accumulation on total factor productivity growth within Italian firms over the period 1999-2015. In addition, we provided evidence for the presence of a threshold level of corporate debt (estimated at about three times corporate value added), beyond which productivity growth declines significantly. The proportion of firms exceeding this corporate-debt threshold increased throughout most of the sample period and remained relatively high in 2015, highlighting the importance of timely and effective debt reduction measures. Policies should also seek to discourage persistent corporate debt accumulation and facilitate alternative forms of finance. Our results also highlighted the importance of structural reforms that can enhance firms productivity growth and increase their tolerance for debt. It is advisable to undertake these reforms while financial conditions are still accommodative.

# Appendix

## Additional Tables and Charts

Figure 10: Percentage of Firms Exceeding the Threshold Level of Indebtedness, by Industry

(a) Manufacturing (b) Non-Manufacturing




Notes: Figure 10a shows the percentage of firms within manufacturing industries exceeding a debt to value added threshold of 3 in each year. Figure 10b shows the percentage of firms within non-manufacturing industries exceeding a debt to value added threshold of 3 in each year. The industries are identified using NACE 2-digit codes.

## Data Cleaning

1. We drop observations which are missing either a Bureau van Dijk identification number, a two digit NACE Rev. 2 industry code, an accounts date, total assets, the number of employees, the cost of employees, operating revenue or sales. We also drop firms which have a consolidation code C2 (this means that we select companies which file accounts that are either i) unconsolidated, ii) consolidated but with no unconsolidated counterpart or iii) have an unknown consolidation status).

2. We define the "year" which an observation refers to based on when firms file their accounts. If the accounts are filed before June, the observation is assigned to the previous year. If the accounts are filed in June or after, the accounts are assigned to that year. For example, an account filed in August 2015 would be assigned to the year 2015, while an account filed in April 2015 would be assigned to the year 2014. In practice, the vast majority of accounts are filed in December.

3. We drop any duplicate observations which have the same identification number and year.

4. We drop all observations on a given firm if at any point that firm reports negative total assets, negative tangible fixed assets, negative number of employees, negative cost of employees or negative sales. In addition, to abstract from very small companies, we drop firms which at any point report that they have less than 3 employees.

5. We drop observations where the time between accounts is not annual.

6. We drop observations for which operating revenue or total assets in a given year are more than 50 times their value in the previous year or if operating revenue or total assets are more than 50 times smaller than their value in the previous year.

7. We compute real value added and real wages using 2-digit industry value added deflators obtained from the OECD STAN database. We compute real material costs by deflating nominal material costs using 2 digit-industry producer price deflators, again obtained from the OECD STAN database. Real capital is then computed using the perpetual inventory method, detailed below.

8. We drop observations for which we are unable to compute real wages or real capital.

9. Following Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) we drop observations for which the ratio of tangible fixed assets to the cost of employees is in the bottom 0.1% of the distribution. After this step, we then drop observations with ratios which exceed the 99.9 percentile or are below the 0.1 percentile. We also drop observations if the ratio of the cost of employees to value added is in the bottom 1% or top 1% of the distribution, or if the ratio exceeds 1.1.

## Computing the Real Capital Stock

To compute a measure of the real capital stock, we use the perpetual inventory method detailed in Gal (2013). The book value of the capital stock, $K_{it}^{BV}$, is defined as book value of fixed tangible assets. $Depr_{it}^{BV}$ is the book value of depreciation reported in a company's accounts. The evolution of the real capital stock, $K_{it}$, is calculated by:

$$K_{it} = K_{it-1}(1 - \delta_{it}) + I_{it}$$

where real investment, $I_{it}$, is given by the change in the book value of capital plus depreciation, deflated by an industry specific investment price deflator, $PI_{jt}$:

$$I_{it} = (K_{it}^{BV} - K_{i,t-1}^{BV} + Depr_{it}^{BV})/PI_{jt}$$

and the depreciation rate is equal to the book value of depreciation divided by the sum of the book value of depreciation and the lagged book value of capital:

$$\delta_{it} = \frac{Depr_{it}^{BV}}{Depr_{it}^{BV} + K_{it-1}^{BV}}$$

The initial value of the real capital stock is given by the initial book value of capital, $K_{i0}^{BV}$, deflated using the investment price deflator:

$$K_{i0} = \frac{K_{i0}^{BV}}{PI_{j0}}$$

In our baseline analysis, we abstract from firm entry and firm exit and focus on a balanced panel of firms which report accounts annually between 1999-2015.

## Threshold Estimation and Testing

Following Chudik, Mohaddes, Pesaran, and Raissi (2017), we can consistently estimate $\varphi$ for a given value of $\tau$. The threshold parameter can then be estimated by maximizing a concentrated normalized likelihood function using a grid search method with the grid $\tau = \{\tau_{min}, \tau_{min} + \epsilon, ..., \tau_{max}\}$. Finally, we are able to test the null hypothesis that $\varphi = 0$ for the estimated $\tau$ using the "$SupF$" and "$AveF$" test statistics.

### i) Estimating $\varphi$ for a Given Value of the Threshold, $\tau$

The ARDL specification above can be expressed in matrix notation:

$$\triangle \mathbf{tfp}_i = \mathbf{Q}_i \boldsymbol{\theta}_i + \boldsymbol{\varphi}' \mathbf{g}_i(\tau) + \mathbf{u}_i \;\; for \, i = 1, 2, ..., N \tag{10}$$

where $\triangle \mathbf{tfp}_i$ is a $T \times 1$ vector of observations on $\triangle tfp_{it}$; $\mathbf{Q}_i$ is a $T \times h$ observation matrix of regressors $\mathbf{q}_{it} = (1, \triangle tfp_{it-1}, \triangle d_{it}, \triangle d_{it-1})$, $h = 4$; and $\mathbf{g}_i(\tau)$ is a $T \times 1$ vector of observations on the threshold variable. The filtered pooled estimator of $\varphi$ for a given value of the threshold $\tau$ is given by:

$$\hat{\boldsymbol{\varphi}}(\tau) = \left[ \sum_{i=1}^{N} \mathbf{g}_i^{'}(\tau) \mathbf{M}_i \mathbf{g}_i(\tau) \right]^{-1} \sum_{i=1}^{N} \mathbf{g}_i^{'}(\tau) \mathbf{M}_i \triangle \mathbf{tfp}_i \tag{11}$$

where $\mathbf{Q}_i$ contains the filtering variables and $\mathbf{M}_i = \mathbf{I}_T - \mathbf{Q}_i(\mathbf{Q}_i^{'}\mathbf{Q}_i)^{-1}\mathbf{Q}_i$.

**ii) Estimating the Threshold, $\tau$**

For a given $\tau$ and $\hat{\varphi}(\tau)$, the variance of the individual errors, $\sigma_{ui}^2$ , can be consistently estimated by:

$$\hat{\sigma}_{ui}^2(\tau) = T_i^{-1} \sum_{t=1}^{T_i} \hat{u}_{it}^2(\tau) \tag{12}$$

where $\hat{u}_{it}$ are the estimated residuals.

Given $\hat{\sigma}_{ui}^2$, the threshold parameter $\tau$ can be estimated by maximizing a concentrated normalized likelihood function given by:

$l(\tau) = N^{-1} \sum_{i=1}^{N} T_i^{-1} l_i(\tau)$

where $l_i(\tau) = -\frac{T_i}{2} log(2\pi) - \frac{T_i}{2} log(\hat{\sigma}_{ui}^2(\tau)) - \frac{T_i}{2}$.

We solve for the maximum of the function $l(\tau)$ numerically by a grid search method with the grid $\tau = \{\tau_{min}, \tau_{min} + \epsilon, ..., \tau_{max}\}$.

**iii) Testing the Null Hypothesis, $\varphi = 0$**

The $SupF$ and $AveF$ test statistics can be used to test the null hypothesis that $\varphi = 0$. They are given by:

$SupF = sup_{\tau \in H}[F_{NT}(\tau)]$

$AveF = \frac{1}{\#H} \sum_{\tau \in H} F_{NT}(\tau)$

where $F_{NT}(\tau) = \frac{(RSS_r - RSS_u)/r}{RSS_u/(n-s)}$; $RSS_u$ is the residual sum of squares in the unrestricted model; $RSS_r$ is the residual sum of squares in the restricted model under the null $\varphi = 0$; $n = NT$ is the number of observations; $s = Nh + r$ is the estimated number of coefficients in the unrestricted model; $H$ is the admissible set of values for $\tau$, and $\#H$ is the number of elements of $H$.

# References

Adler, G., R. Duval, D. Furceri, S. Celik, and M. Poplawski-Ribeiro (2017): "Gone with the Headwinds: Global Productivity," IMF Staff Discussion Notes 17/04, International Monetary Fund.

Admati, A. R., P. M. DeMarzo, M. F. Hellwig, and P. Pfleiderer (2017): "The Leverage Ratchet Effect," *Forthcoming in the Journal of Finance*.

Aghion, P., P. Askenazy, N. Berman, G. Cette, and L. Eymard (2012): "Credit Constraints And The Cyclicality Of R&D Investment: Evidence From France," *Journal of the European Economic Association*, 10(5), 1001–1024.

Andrews, D., C. Criscuolo, and P. N. Gal (2015): "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries," OECD Productivity Working Papers 2, OECD Publishing.

Bartelsman, E. J., and Z. Wolf (2017): "Measuring Productivity Dispersion," Tinbergen Institute Discussion Papers 17-033/VI, Tinbergen Institute.

Cai, J., and Z. Zhang (2011): "Leverage Change, Debt Overhang, and Stock Prices," *Journal of Corporate Finance*, 17(3), 391–402.

Chudik, A., K. Mohaddes, M. H. Pesaran, and M. Raissi (2013): "Debt, Inflation and Growth Robust Estimation of Long-Run Effects in Dynamic Panel Data Models," Globalization and Monetary Policy Institute Working Paper 162, Federal Reserve Bank of Dallas.

——— (2016): "Long-Run Effects in Large Heterogeneous Panel Data Models with Cross-Sectionally Correlated Errors," in *Essays in Honor of Aman Ullah*, vol. 36 of *Advances in Econometrics*, pp. 85–135. Emerald Publishing Ltd.

——— (2017): "Is There a Debt-Threshold Effect on Output Growth?," *The Review of Economics and Statistics*, 99(1), 135–150.

Chudik, A., and M. H. Pesaran (2015): "Common Correlated Effects Estimation of Heterogeneous Dynamic Panel Data Models with Weakly Exogenous Regressors," *Journal of Econometrics*, 188(2), 393–420.

Chudik, A., M. H. Pesaran, and J.-C. Yang (2016): "Half-Panel Jackknife Fixed Effects Estimation of Panels with Weakly Exogenous Regressors," Globalization and Monetary Policy Institute Working Paper 281, Federal Reserve Bank of Dallas.

Coricelli, F., N. Driffield, S. Pal, and I. Roland (2012): "When Does Leverage Hurt Productivity Growth? A Firm-Level Analysis," *Journal of International Money and Finance*, 31(6), 1674–1694.

Diamond, D. W. (1991): "Debt Maturity Structure and Liquidity Risk," *The Quarterly Journal of Economics*, 106(3), 709–737.

Gal, P. (2013): "Measuring Total Factor Productivity at the Firm Level using OECD-ORBIS," OECD Economics Department Working Papers 1049, OECD Publishing.

Gopinath, G., S. Kalemli-Ozcan, L. Karabarbounis, and C. Villegas-Sanchez (2017): "Capital Allocation and Productivity in South Europe," *The Quarterly Journal of Economics*, p. qjx024.

Gordon, R. J. (2012): "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," NBER Working Papers 18315, National Bureau of Economic Research, Inc.

Grossman, S., and O. Hart (1982): "Corporate Financial Structure and Managerial Incentives," in *The Economics of Information and Uncertainty*, pp. 107–140. National Bureau of Economic Research, Inc.

Heider, F., and A. Ljungqvist (2015): "As Certain as Debt and Taxes: Estimating the Tax Sensitivity of Leverage from State Tax Changes," *Journal of Financial Economics*, 118(3), 684–712.

Hsieh, C.-T., and P. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 124(4), 1403–1448.

Jarmuzek, M., and R. Rozenov (2017): "Excessive Private Sector Leverage and Its Drivers; Evidence from Advanced Economies," IMF Working Papers 17/72, International Monetary Fund.

Jensen, M. C. (1986): "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers," *American Economic Review*, 76(2), 323–329.

Kalemli-Ozcan, S., L. Laeven, and D. Moreno (2015): "Debt Overhang in Europe: Evidence from Firm-Bank-Sovereign Linkages," *University of Maryland*.

Kalemli-Ozcan, S., B. Sorensen, C. Villegas-Sanchez, V. Volosovych, and S. Yesiltas (2015): "How to Construct Nationally Representative Firm Level Data from the ORBIS Global Database," NBER Working Papers 21558, National Bureau of Economic Research, Inc.

Kobayashi, K., and D. Shirai (2017): “Debt-Ridden Borrowers and Economic Slowdown,” CIGS Working Paper Series 17-002E, The Canon Institute for Global Studies.

Lang, L., E. Ofek, and R. M. Stulz (1996): “Leverage, Investment, and Firm Growth,” *Journal of Financial Economics*, 40(1), 3–29.

Leary, M. T., and M. Roberts (2005): “Do Firms Rebalance Their Capital Structures?,” *The Journal of Finance*, 60(6), 2575–2619.

Levinsohn, J., and A. Petrin (2003): “Estimating Production Functions Using Inputs to Control for Unobservables,” *Review of Economic Studies*, 70(2), 317–341.

Marchica, M., and R. Mura (2010): “Financial Flexibility, Investment Ability, and Firm Value: Evidence from Firms with Spare Debt Capacity,” *Financial Management*, 39(4), 1339–1365.

Mian, A., and A. Sufi (2010): “Household Leverage and the Recession of 2007 09,” *IMF Economic Review*, 58(1), 74–117.

Midrigan, V., and D. Y. Xu (2014): “Finance and Misallocation: Evidence from Plant-Level Data,” *American Economic Review*, 104(2), 422–458.

Mohaddes, K., M. Raissi, and A. Weber (2017): “Can Italy Grow Out of its NPL Overhang? A Panel Threshold Analysis,” *Economics Letters*, 159(Supplement C), 185 – 189.

Moll, B. (2014): “Productivity Losses from Financial Frictions: Can Self-Financing Undo Capital Misallocation?,” *American Economic Review*, 104(10), 3186–3221.

Mura, A., F. Piras, and A. Valentincic (2016): “Do Asset Revaluations Signal Future Performance of Private Firms?,” *Unpublished Manuscript*.

Myers, S. C. (1977): “Determinants of Corporate Borrowing,” *Journal of Financial Economics*, 5(2), 147–175.

Olley, G. S., and A. Pakes (1996): “The Dynamics of Productivity in the Telecommunications Equipment Industry,” *Econometrica*, 64(6), 1263–1297.

Pellegrino, B., and L. Zingales (2014): “Diagnosing the Italian Disease,” *Unpublished Manuscript*.

Pesaran, M. (2004): “General Diagnostic Tests for Cross Section Dependence in Panels,” Cambridge Working Papers in Economics 0435, Faculty of Economics, University of Cambridge.

Pesaran, M., and R. Smith (1995): "Estimating Long-Run Relationships from Dynamic Heterogeneous Panels," *Journal of Econometrics*, 68(1), 79–113.

Pesaran, M. H. (2015): "Testing Weak Cross-Sectional Dependence in Large Panels," *Econometric Reviews*, 34(6-10), 1089–1117.

Reinhart, C. M., and K. S. Rogoff (2010): "Growth in a Time of Debt," Working Paper 15639, National Bureau of Economic Research.

Restuccia, D., and R. Rogerson (2008): "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics*, 11(4), 707–720.

Stulz, R. (1990): "Managerial Discretion and Optimal Financing Policies," *Journal of Financial Economics*, 26(1), 3–27.

Welch, I. (2004): "Capital Structure and Stock Returns," *Journal of Political Economy*, 112(1), 106–131.

Wooldridge, J. M. (2009): "On Estimating Firm-Level Production Functions using Proxy Variables to Control for Unobservables," *Economics Letters*, 104(3), 112–114.