Gabinete de Estratégia e Estudos

GEE Paper

141

Fevereiro de 2020

Built Like a House of Cards? - Corporate Indebtedness and Productivity Growth in the Portuguese Construction Sector

José Santos | Nuno Tavares | Gabriel Osório de Barros

Gabinete de Estratégia e Estudos do Ministério da Economia
Office for Strategy and Studies of the Ministry of Economy
Rua da Prata, n.º 8 – 1149-057 Lisboa – Portugal
www.gee.gov.pt
ISSN (online): 1647-6212

Gabinete de Estratégia e Estudos

Built Like a House of Cards? - Corporate Indebtedness and Productivity Growth in the Portuguese Construction Sector[1]

José Santos[2], Nuno Tavares[3], and Gabriel Osório de Barros[4]

Abstract:

Productivity growth in southern European countries has been slowing down at least since the early 2000s. In this regard, Portugal has been no exception to this common trend as productivity growth has been sluggish since the beginning of the century, well before the global financial crisis. At the same time, corporate levels of indebtedness of Portuguese firms have built-up quite substantially until recent years. Although with different levels of intensity across sectors, this pattern was particularly prevalent in the construction sector, rendering it to be a compelling case to study the relation between debt and productivity. Using microdata from Portuguese construction firms, in this paper, we investigate the long-term impact of persistent corporate debt accumulation on total factor productivity growth. To do so, we rely on the framework provided by the estimation of heterogeneous dynamic-panel models. This framework allows us to account for dynamics, feedback effects, firm heterogeneity, and cross-sectional dependencies arising from unobserved common factors. After taking into account the effect of unobserved common factors affecting all firms in the sector as well as firm's specific characteristics, we find a negative and significant effect of corporate debt-build up on total productivity growth in the industry. This result is robust to different measures of total factor productivity, labour productivity and firms' indebtedness. Our results suggest that timely measures aiming to reduce debt overhangs by firms may be essential tools to boost productivity growth in the construction sector.

JEL Classification: D24, C23, C22.

Keywords: Portugal, construction sector, corporate debt, productivity, heterogeneous dynamic-panel models.

Note: This article is the sole responsibility of the authors and do not necessarily reflect the positions of GEE or the Portuguese Ministry of Economy.

[1] Acknowledgements: We would like to thank Ricardo Pinheiro Alves and Rita Bessone Basto for their comments and suggestions and to Banco de Portugal for providing us with the firm-level data used. All errors and omissions are due to the authors' responsibility.

[2] Strategy and Research Office - Ministry of Economy, (jose.santos@novasbe.pt)
[3] Strategy and Research Office - Ministry of Economy, (nuno.tavares@gee.gov.pt)
[4] Strategy and Research Office - Ministry of Economy, (gabriel.barros@gee.gov.pt).

Contents

List of Figures

List of Tables

1. Introduction

Productivity is widely considered an essential determinant of economic growth and development in the long-run. The recent slowdown in productivity often described as a puzzle or even as a paradox, particularly in the case of advanced economies, has raised justifiable concern amongst economists and policymakers alike. In this regard, Portugal has been no exception to other southern European developed economies, as productivity growth has been sluggish since the beginning of the century, and well before the global financial crisis (Figure 1). Meanwhile, corporate indebtedness has expanded quite substantially from 2000 onwards, peaking in 2012, decreasing ever since, but still far from the levels witnessed in the pre-crisis period (Figure 2).

Figure 1: **Multifactor Factor Productivity, 2000=100**

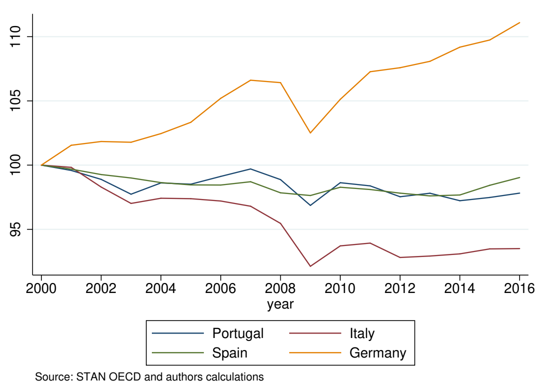
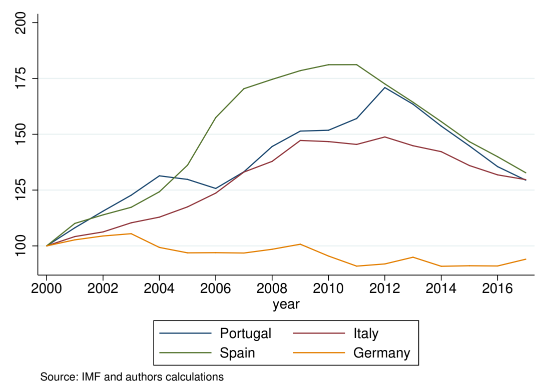


Figure 2: **Corporate Debt to GDP, 2000=100**



Notes: Figure 1 shows the level of total factor productivity at the aggregate level, where for each country the level has been normalized to 100 in 2000. TFP data has sourced from the OECD's multifactor productivity series. Figure 2 sows the ratio of total corporate debt to GDP, and was sourced from IMF's global debt database.

At the sector level, and despite different levels of intensity, productivity growth in Portugal has also shown signs of a slowdown, at least since late 2000 (Figure 3) while indebtedness levels have ratcheted up quite substantially across sectors but notably in the construction sector (Figure 4).

Having as a backdrop the performance of both productivity growth, and firms' indebtedness in the last decade, this paper contributes to the ongoing debate about productivity slowdown in developed economies by addressing the long-run impact of persistent debt accumulation in firms' total factor productivity (TFP). To highlight the sectoral features of the joint dynamics of productivity growth and indebtedness, we pay particular attention to the within-industry long-run effect rather them cross-industry effects for the whole economy. Moreover, we focus our analysis in the construction sector, which has experienced both a significant slump in productivity growth as well as a substantial increase in indebtedness levels.

Using firm-level panel data from Portuguese non-financial corporations of the construction sector, our empirical strategy relies on the estimation of dynamic heterogeneous panel data models which allow us to focus on the long-run relation between TFP growth and indebtedness while admitting heterogeneous short-run dynamics across firms. Furthermore, our empirical framework accounts for

Figure 3: **Labour Productivity, 2008=100**

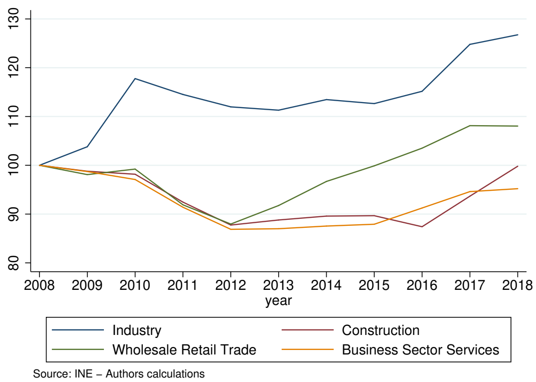
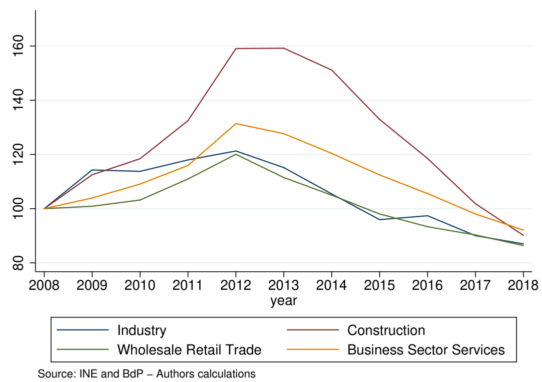


Figure 4: **Debt to GVA, 2008=100**



Notes: Figure 3 shows labour productivity for each sector, normalized to 100 in 2008. Sectoral data on labour productivity was sourced from INE (excluding sole proprietors). Figure 4 sows the debt to GVA ratio normalized to 100 in 2008. Sectoral data on debt was sourced from BdP, while GVA data was sourced from INE (both exclude sole proprietors). "Industry" figures include both sections B and C while "Business Sector Services" includes sections G to N of CAE Rev3 (Portuguese classification of economic activities).

the possible influence of unobservable common factors that might impact our estimates by allowing for cross-sectionally correlated errors.

The remainder of this paper is organised as follows: Section 2 briefly discusses the relevant literature on the topic; Section 3 describes our database as well as the underlying variables of interest; Section 4 presents a set of summary statistics; Section 5 outlines our empirical framework; Section 6 presents the results; In section 7 we perform several robustness checks. Finally, in section 8, we briefly discuss our results and present our chieftain conclusions.

2. Literature Review

Productivity has been slowing down in many advanced economies, even before the global financial crisis. Despite some arguments that attribute this phenomenon to mismeasurement issues specifically those related with the increasing importance of information and communication technology (ICT) products and services[5], productivity slowdown in advanced economies is generally considered a rather undisputed fact.

As productivity is widely considered a determinant factor for long-run economic prosperity and well being, the concerning growth path of productivity during the last decade has set the stage for an extensive research agenda on this topic. Most research has been focusing on the driving forces behind productivity growth, some of which may be influenced by long-term trends. Surprisingly, though, one of such trends identified in the literature has been the diminishing pace of technological innovation. This notion has been conveyed, for instance, by Fernald (2015) who notes that after boosting productivity growth in the U.S. and some other advanced economies from the mid-1990s to the early 2000s, ICT related gains appear to be fading away[6]. Despite this, recent research highlights, instead, the role of slowing technological diffusion, pointing out to the growing productivity gap amongst leading and lagging firms across many advanced economies and industries, as well as declining business dynamism, since the early 2000s (Haltiwanger (2012); Haltiwanger et al. (2014); Andrews et al. (2015); Decker et al. (2016)).

Beyond structural aspects, researchers have been exploring the effect of other factors such as increased resource misallocation. Following the seminal contribution of Hsieh and Klenow (2009), particular attention has been given to role market frictions on the allocation of inputs and productivity growth[7]. Financial frictions, in particular, have been the focus of extensive study, examples including Moll (2014), who studies the effects of such frictions on the accumulation of capital and wealth and Midrigan and Xu (2014), who explore the role of credit constraints in generating aggregate TFP losses. More recently, Gopinath et al. (2017) focus their attention on the role played by real interest rates in the misallocation of capital in southern European countries, while Schivardi et al. (2017) explore the effect of *"zombie"* lending misallocation of credit on Italy's TFP dispersion. Moreover, there are reasons to believe that the forces driving productivity growth down may be different pre- and post-crisis (Adler et al., 2017), the latter being influenced by lack of investment exacerbated by credit constraints (Ollivaud et al., 2016)[8]. Additionally, a series of papers have highlighted the role of institutional factors weighing on productivity growth (see, for instance, Kim and Loayza (2017)). Such factors include product, services and labour market regulation (Nicoletti

[5]This argument highlights the fact that official statistics on productivity may not be able to capture the impact of technological innovations fully and has been put forward, for instance, by Feldstein (2017) and Varian (see Aeppel (2015)). Byrne et al. (2016) are dismissive of such argument has they find little evidence that the slowdown in productivity in the U.S. arises from growing mismeasurement of the gains from innovation in ICT-related goods and services.

[6]The ongoing debate on this topic is focusing into whether the slowdown in innovations is permanent (Gordon, 2017) or temporary (Brynjolfsson and McAfee, 2014) as significant advances such as artificial intelligence and other technologies offer a positive outlook into productivity improvements.

[7]Another example can be found in Restuccia and Rogerson (2008) who argue that differences in the allocation of resources across establishments that differ in productivity may be an important factor in accounting for cross-country differences in output *per capita*.

[8]For French firms, Aghion et al. (2012) show that in more credit-constrained firms, R&D investment plummets during recessions but does not increase proportionally during upturns.

and Scarpetta, 2003), as well as firms' practices of selection and rewarding of managers (Pellegrino and Zingales, 2017).

Meanwhile, in the aftermath of the global financial crisis and the sovereign debt crisis that followed, extensive research has been addressing the nexus between debt and economic growth. Particular attention has been given to the impact of high and rising levels of public debt on economic performance[9], examples including Reinhart and Rogoff (2010)[10] as well as Chudik et al. (2017). On the other hand, Mian and Sufi (2010) examine the influence of household leverage in the built-up to the global financial crisis and the economic crisis that ensued in the U.S. while Kalemli-Ozcan et al. (2015) explore the impact of corporate debt overhangs in investment by Southern European firms. Despite the growing interest given to the role of debt and debt accumulation on economic performance, its role in productivity growth has received far less attention. Exceptions include Nucci et al. (2005), who find a negative relationship between debt and TFP for Italian firms, Ghosh (2009), who finds, for Indian manufacturing firms, a negative association between firm leverage and productivity and Coricelli et al. (2012), who find a non-monotonic relationship between leverage and productivity growth in Central and Eastern European Countries[11]. More recently, Anderson and Raissi (2018) find significant negative effects of persistent corporate debt accumulation on TFP growth of Italian firms.

In this paper, we which to contribute to the ongoing debate on productivity growth slowdown by expanding on Anderson and Raisi's (2018) results and methodological framework, which we apply to the Portuguese case. We do so while focusing solely on the specific case of the construction sector. Studying the effect of debt accumulation on productivity growth in Portugal is particularly appealing for firms from the construction sector, where the relationship between both variables seems to have been particularly intense. Moreover, since the 1990s, this sector also recorded higher weight of global value-added (GVA) as well as credit granted by the financial system when compared to other European countries (Reis, 2013), rendering it to be an all-around compelling sector to study within the scope of this paper.

[9] Although the lack of consensus prevents it to be considered a stylized fact, the predominant view on the subject is that higher levels of public debt constrain economic growth. Panizza and Presbitero (2014), disagree with this view arguing that even though there is a negative correlation between economic growth and public debt, in advanced economies, there is no causality in the relation.

[10] The conclusions presented in this paper have been subject to extensive scrutiny and critique. Examples include, for instance, Herndon et al. (2014) as well as others such as Kumar and Woo (2010).

[11] TFP growth increases with leverage until the latter reaches a critical threshold beyond which leverage lowers TFP growth.

3. Data

3.1. Database

Our empirical strategy relies on firm-level data sourced from Banco de Portugal's Microdata Research Laboratory (BPlim), which provides annual information on non-financial corporations located in Portugal[12]. The data set relies on information reported through IES - *Informação Empresarial Simplicada* (Simplified Business Information). Moreover, IES is a mandatory and exhaustive repository of information on the balance sheet of firms legally registered in Portugal, as well as other variables collected by the Ministry of Justice through the Central Registry of Companies. Specifically, BPlim data set contains information on the sector of activity (at a five-digit level), legal form, location (at the district level), size category, founding year along with information on the firm's situation at the end of the fiscal year. The data set also includes detailed balance sheet information as well as employment data. Data covers firms over the period 2006-2017, which entails the use of two different accounting standards. Until 2009, the data was reported according to the POC - *Plano Oficial de Contabilidade* (National Plan of Accounts) standard, while from 2010 onwards, the SNC - *Sistema de Normalização Contabilística* (Accounting Standards System)standard has been used. The reason behind this change is the fact that this new standard is closer to the International Accounting Standards (IAS) and International Financial Reporting Standards (IFRS). Although this fact could pose difficulties in terms of comparability of figures across both accounting standards, we relied on BPlim's harmonized version of the data set, which allows a consistent definition of variables throughout the accounting vintages[13]. Despite using BPlim's data set severely limited the likelihood of encountering misreporting problems in our data, we undertook a series of cleaning steps to ensure consistency based on those performed by Anderson and Raissi (2018), and Gopinath et al. (2017). These cleaning steps are thoroughly outlined in the Appendix. Moreover, we restrain our analysis to construction firms that consistently report at least three employees in the period.

3.2. Variables of Interest

We use firms' balance-sheet figures to build our variables of interest. Firstly, we define total debt as the sum of current[14] and non-current obtained funding as reported by firms in their balance-sheet. As in Anderson and Raissi (2018), we define our baseline measure of indebtedness, DEBT, as the ratio of firms' debt to its nominal value-added. Moreover, we compute the nominal value-added as the difference between total output (which includes total turnover, variation in production, capitalised production, supplementary income and operating subsidies) and intermediate consumption (which comprises costs of goods sold and material consumed as well as external supplies and services).

Although alternative measures of firm indebtedness could be used, such as measures based on

[12] This data set only provides information on corporations. For that reason, sole proprietors were excluded from this study.

[13] The harmonization procedure performed by Banco de Portugal tried to ensure the compatibility of the variables over time as much as possible. However, the procedure heavily relies on the harmonization methodology adopted. Moreover, the transition between the old and the new accounting rules and concepts may take some time. For this reason, some harmonized variables may show a clear discontinuity in 2010.

[14] Current obtained funding was not directly available in our data set. As such current obtained funding was computed as the difference between total current liabilities and other current liabilities accounts namely, suppliers and remaining current liabilities which include state and other public sector institutions, other current liabilities and deferred income.

leverage ratios, this formulation is relatively unresponsive to asset price volatility or revaluation, which could contaminate our estimates. Despite this fact, we check the robustness of our results to alternative measures of indebtedness such as debt, as defined earlier, to assets.

To estimate TFP, we require figures for labour and capital inputs. As for labour, we use the cost of employees as a proxy, whereas capital stock was computed using the perpetual inventory method outlined in the Appendix. We estimate TFP as the fitted residuals of a standard log-linearized Cobb-Douglas production function. Formally, the production function for the firm i at time t operating in a given sector is the following:

$$y_{i,t} = \beta_k k_{i,t} + \alpha_l l_{i,t} + u_{i,t} \tag{1}$$

where $y_{(i,t)}$ is the logarithm of value-added; $k_{(i,t)}$ is the logarithm of capital; $l_{(i,t)}$ is the logarithm of labour and $u_{(i,t)}$ is the logarithm of TFP. Related literature on the subject has often pointed to the positive correlation between the observable input levels and unobservable productivity, rendering ordinary least squares (OLS) to be inconsistent. To address this simultaneity issue, we estimate TFP using Wooldridge's single-step approach[15] (Wooldridge, 2009), which builds upon Olley and Pakes (1996) and Levinsohn and Petrin (2003) two steps procedures.

4. Descriptive Statistics

4.1. Sample

Our initial data set comprises an extensive collection of information about the population of non-financial corporations in Portugal from 2006 to 2017, which includes firms from the construction sector. To obtain our initial sample, we started by eliminating irrelevant sectors. We followed by applying a series of cleaning steps outlined in the Appendix section. Although the limitations imposed on the initial data set by our cleaning procedures severely limited the number of observations and firms available [16], our unbalanced panel covers over 60% of yearly value-added as well as over 55% of yearly employment in the sector (Figure 5).

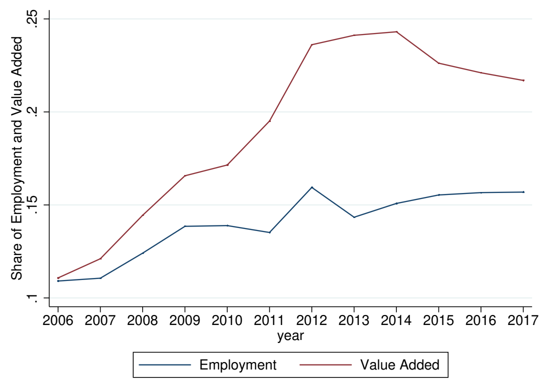
To assess the long-run impact of indebtedness build-up on productivity growth in the construction sector, we focus on firms that consistently reported their annual financial accounts statements over the 2006-2017 period. This requires firms to be active for the full 12 years of available data. However, the average and the median number of active years of construction firms in our initial sample is 6.3 and 6 years, respectively. Additionally, we follow Anderson and Raissi (2018), as we focus our analysis on firms that report a debt to value-added ratio of at least 1% during the period. As a result, our balanced panel ended up with observations for firms covering approximately 15% of employment and 20% of value added by the end of the sample period (Figure 6).

[15] This procedure was implemented in Stata using Mollisi and Rovigatti's prodest command (Rovigatti and Mollisi, 2018).

[16] After performing our cleaning procedures our unbalanced panel covered approximately 18% of the initial observations and 20% of the initial firms.

Figure 5: **Coverage Unbalanced Panel**

Figure 6: **Coverage Balanced Panel**



Notes: Figures 5 and 6 show the yearly share of employment and value-added for the unbalanced and balanced panels of construction firms respectively.

Although firms in our balanced panel tend to be larger and have a higher number of employees than firms in our unbalanced panel, median productivity growth profiles of firms in the unbalanced and balanced panel are remarkably close (Table 1).

Table 1. **Employment and TFP Growth - Balanced and Unbalanced Panels**

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
TFP Growth											
Balanced	2,9	1,2	-0,4	-1,5	-2,3	-3,8	-0,1	-0,2	1	0,8	2,8
Unbalanced	2,2	0,3	-1,2	-1,9	-2,2	-3,1	-0,07	0,6	1,7	0,9	2,5
Employment											
Balanced	12	12	12	13	12	12	11	11	12	12	12
Unbalanced	9	10	9	9	9	8	8	8	8	8	8

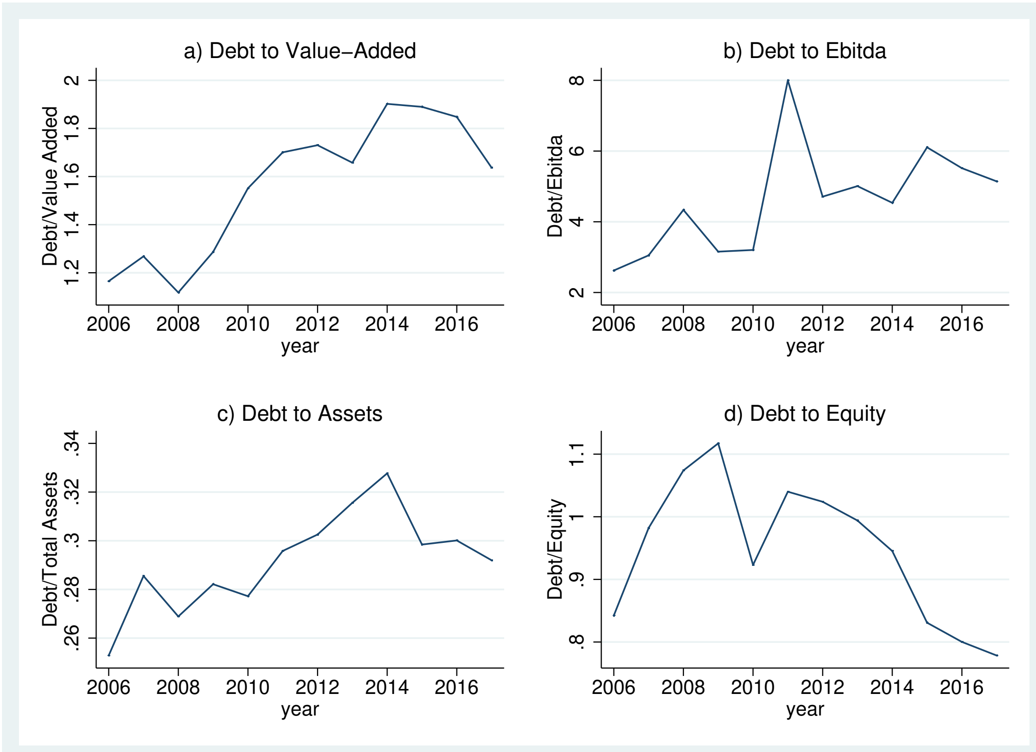
Notes: The table shows the median number of employees and TFP growth for both the balanced and unbalanced panels of firms.

4.2. Evolution of Firm Indebtedness

In figure 7, we compare different measures of firm indebtedness for our balanced panel of construction firms. Debt to value-added, our baseline measure of firm indebtedness, raised rapidly and steadily from 2008 onward, peaking in 2015 before falling back modestly. However, firms debt to value-added in 2017 was still well above pre-crisis levels. Debt to assets displayed a similar pattern, particularly between 2010 and 2014. By contrast, both debt to EBITDA[17], as well as debt to equity, displayed a more volatile behaviour during the period. Debt to EBTIDA was particularly volatile from 2010 to 2012, stabilizing, by the of the period, at approximately two times its 2006 value. Debt to equity, that had been raising consistently since 2006 fell abruptly in 2010, picked-up again in 2012 but has been decreasing ever since. More remarkably, though, is the fact that this is the only measure of firm's indebtedness that, by 2017, had reached pre-crisis levels.

[17]EBITDA is computed as the difference between operating income (which includes turnover and remaining income, excepting obtained interest and similar income) and total operating costs (that include costs of goods sold and material consumed, supplies and external services, employee expenses and remaining expenses).

Figure 7: **Different Measures of Firm Indebtedness**



Notes: Panels (a) to (d) show different measures of aggregate firm indebtedness for the balanced panel of x 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 equity funds for all firms.

Furthermore, the detailed breakdown of the median value of debt to value-added by size class[18], presented in Table 2, shows that this measure of firm indebtedness displayed a certain degree of heterogeneity across size categories [19]. After a rapid increase in indebtedness levels, particularly after 2008, Micro and Small firms began scaling down debt from 2012 onwards, reaching 2017 with median values of indebtedness comparable to the ones observed in 2006. Medium firms indebtedness levels displayed a similar pattern to the one seen in smaller firms, although the reduction of debt in the period after the crisis was far more modest. Notably, in 2017, the median value of debt to value-added of Medium firms was 20 p.p. above its 2006 level. More interesting though was the behaviour displayed by the median value of debt to value-added in larger firms. Following 2009, median indebtedness levels rose sharply, more than doubling in three years. After peaking in 2013, a short period of adjustment followed. In 2017, though, larger firms indebtedness levels ratchet-up once more nearing the level of 2013.

[18]Firms are grouped according to the Commission Recommendation of 6 of May of 2003 concerning the definition of micro, small, and medium-sized enterprises.

[19]For further detail, in the Annex, we present a size class breakdown of other measures of median firm indebtedness such as debt to EBITDA, debt to Assets and debt to Equity.

Despite this, our empirical approach is not likely to be influenced by size class heterogeneity of indebtedness levels, as the analysis focuses on the rate of change of debt rather than on a level effect. Besides that, larger firms account only for a small fraction of the total number of firms in our balanced panel (see Table 10 in the Annex for further detail on the distribution of firms by size class) rendering results likely to be rather irresponsive to robustness checks based on the exclusion of larger firms from our empirical analysis.

Table 2. **Debt to Value Added, by Size Class (%)**

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Size Class												
Micro	60.4	58.4	65.4	69.0	71.7	70.0	72.2	70.0	71.0	62.5	63.1	58.7
Small	53.3	52.3	49.2	56.2	66.2	65.7	63.7	61.9	62.5	54.5	55.0	49.6
Medium	30.8	32.4	37.5	40.2	65.8	59.0	75.8	77.8	73.7	66.3	65.8	57.4
Large	45.9	50.5	59.0	49.6	80.6	90.1	106.5	112.8	94.5	93.4	93.5	111.7

Notes: The table shows the median value of debt to added value for the balanced panel of construction firms in the period.

4.3. Evolution of Firm Productivity

In figure 8, we present mean and median TFP growth in our balanced panel of construction firms. Both median and mean TFP growth rates fell sharply from 2007 to 2012, entering negative terrain as soon as 2009 and 2010 respectively. After bottoming in 2012, average TFP growth picked-up and became positive as late as 2013, while median TFP growth remained negative until 2014. Contrary to what happened in the previous period, where TFP growth fell almost continuously, the recovery that ensued the 2012 bottom was far bumpier and characterized by stop-and-go moments, particularly when it comes to the average construction firm.

Alternatively to TFP, figure 9 depicts mean and median labour productivity[20] growth for our balanced panel of construction firms. Albeit with different scales, mean and median labour productivity growth show similar trends to mean and median TFP growth during the period. As for differences between the two measures of productivity, they arise primarily from the behaviour of median growth rates. Whereas median TFP growth had been negative since 2010, only in 2012 did median labour productivity reached negative figures. Another striking difference between both measures of productivity steams from the fact that until 2012, the gap between median and mean TFP growth rates narrowed down more intensively than in the case of labour productivity. This suggests that once capital is taken into account, productivity slowdown seems to have been equally felt across all firms. More interestingly, though, is the fact that during the recovery period, there seems to be a decoupling between the median and mean growth rates, hinting towards greater dispersion among firms both in TFP and labour productivity growth.

[20]Here on after we refer to labour productivity as the ratio between value-added and the number of employees.

Notwithstanding the different dynamics, both parametric and empirical measures of productivity growth are in line with the Portuguese business cycle pattern of the last decade. As such and in order to strengthen our results, we assess their robustness to different measures of productivity, namely labour productivity. Similarly, we check whether our results are influenced by the chosen method of TFP computation by using alternative parametric methods.

Figure 8: **Total Factor Productivity Growth**

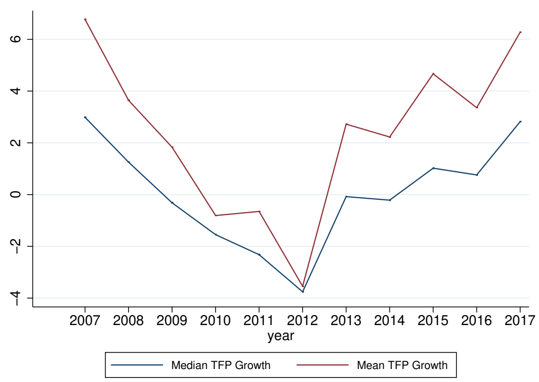


Figure 9: **Labour Productivity Growth**

Notes: Figure 8 shows median and mean TFP growth for the balanced panel of construction firms. TFP is estimated using Wooldridge's single-step approach and corresponds to the fitted residuals of a standard log-linearized Cobb Douglas production function described in equation (1). Figure 9 shows median and mean labour productivity growth. Labor productivity is calculated as the ratio between value-added and the number of employees.

Moreover, in Figures 10 and 11, we breakdown mean and median TFP growth by firm size. In this sense, both average firms, as well as median firms of different size categories, experienced a similar growth path during the period, maybe except for medium firms, for which the behaviour of TFP growth was far more volatile. Once again, these results highlight the fact that size may not have been the prominent factor when it comes to productivity growth during the period.

Figure 10: **Mean TFP Growth, by Size Class**

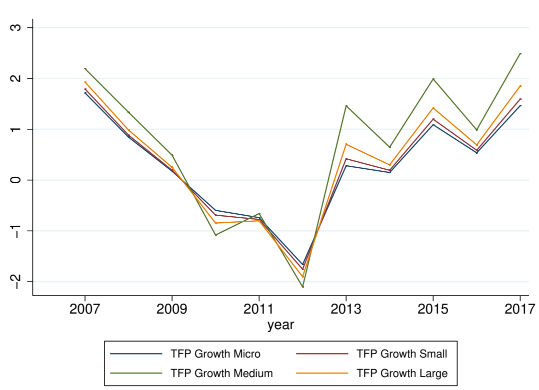
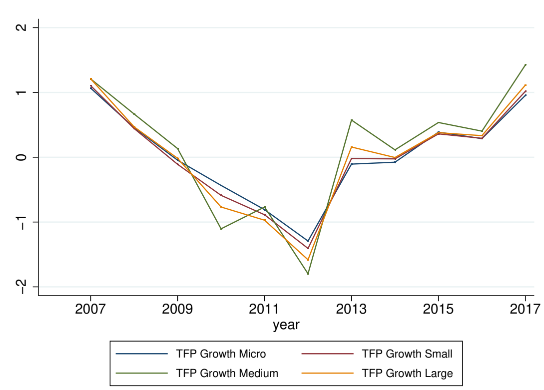


Figure 11: **Median TFP Growth, by Size Class**



Notes: Figure 10 shows mean TFP growth of all size classes of our balanced panel of construction firms during the period. Figure 11 shows the median TFP growth for the same firms.

5. Empirical Framework

5.1. Auto-Regressive Distributed Lag (ARDL) Approach

Our econometric strategy relies on the framework provided by the estimation of heterogeneous dynamic-panel models which allows us to focus on the long-run effect of firm-level indebtedness build-up on productivity growth. We rely on a two-equation setting where the joint dynamics of productivity growth and indebtedness at the firm level is described as follows:

$$\Delta TFP_{it} = \alpha_{i,y} + \delta_i \Delta TFP_{it-1} + \tau_i \Delta d_{it-1} + \epsilon_{it} \tag{2}$$

$$\Delta d_{it} = \alpha_{i,d} + \rho_i \Delta d_{it-1} + \omega_i \Delta TFP_{it-1} + \varepsilon_{it} \tag{3}$$

where TFP_{it} is the estimated logarithm of TFP for firm i at time t, and d_{it} is the logarithm of firm indebtedness. This specification allows both for firm-fixed effects, ($\alpha_{i,y}$ and $\alpha_{i,d}$) as well as for feedback effects from firm productivity to indebtedness, as the former is more than likely to impact firms' choices on how to finance their assets. Despite focusing only in the construction sector, our model allows for heterogeneous short-run dynamics in productivity and indebtedness across all firms, as slope coefficients are firm-specific (δ_i, τ_i, ρ_i, and ω_1). In our baseline ARDL specification, we assume cross-sectionally independent errors, although, in our preferred version of the model, this rather strict assumption is relaxed by allowing cross-sectional dependencies. Moreover, TFP and debt levels are determined simultaneously at the end of the period for all firms. As in Anderson and Raissi (2018) we address the possibility of simultaneity bias stemming from this fact, by assuming that $\epsilon_{i,t}$ linearly depends on $\varepsilon_{i,t}$:

$$\epsilon_{it} = l_i \varepsilon_{it} + u_{it} \tag{4}$$

such that ε_{it} and u_{it} are uncorrelated. We can interpret l_i as the degree of simultaneity between ε_{it} and ϵ_{it}. We also assume that l_i differs across all i as firms have different needs as well as access to external financing.

Substituting ϵ_{it} for (4) and plugging (3) into (2), we obtain an ARDL (1,1) representation of productivity growth:

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

where $c_i = \alpha_{i,y} - l_i \alpha_{i,d}$; $\lambda_i = \delta_i - l_i \omega_i$; $\beta_{i0} = l_i$; and $\beta_{i1} = \tau_i - l_i \rho_i$.

Our primary interest is to study the long-run impact of firm-level debt build-up on TFP growth. This impact can be retrieved from (5) using short-run coefficients, such that:

$$\theta_i = \frac{\beta_{io} + \beta_{i1}}{(1 - \lambda_i)} \tag{6}$$

The literature on heterogeneous panel-data models estimation, in which both cross-sectional units and the number of times-series are large, suggests several approaches to estimate (5). For the ARDL representation, we use the pooled mean group (PMG) estimator, as proposed by Pesaran, Shin and Smith in Pesaran et al. (1997) and Pesaran et al. (1999), which allows for an intercept, heterogeneous short-run dynamics, and joint long-run debt growth elasticity of TFP. Furthermore, the traditional ARDL approach is suitable for the long-run analysis as this methodology is valid regardless of whether the regressors are exogenous, or endogenous, and irrespective of whether the underlying variables are $I(0)$ or $I(1)$[21].

5.2. Distributed Lag (DL) Approach

Alternatively, to the estimation of the long-run effects of debt on productivity through the short-run coefficients of the ARDL representation, we use a distributed lag (DL) approach to assess this effect directly. We do so to strengthen the robustness of our results as the DL can be seen as complementary to the ARDL approach (Chudik et al., 2013). Moreover, this method has a better small sample performance for moderate values of T (Chudik et al., 2013), which is the case. Furthermore, in the DL representation, we use the mean group (MG) estimator proposed by Pesaran and Smith (1995) where the intercepts, slope coefficients, and error variances are all allowed to differ across groups. Additionally, it should be noted that the PMG estimator constrains the long-run elasticities to be equal across all firms. This *"pooling"* across firms yields efficient and consistent estimates when this restriction is valid. Despite this, MG estimates are consistent whether slopes are homogeneous or heterogeneous. Formally, the DL specification is given by the following expression:

$$\Delta TFP_{it} = c_i + \theta_i \Delta d_{it} + \sum_{l=0}^{p} \delta_{il} \Delta^2 d_{it} + v_{it} \tag{7}$$

where $\theta_i$is now the long run-effect of debt on ΔTFP and p is the lag order. In the result section, we report the estimates of the long-run effect using the DL approach, allowing for various lag lengths.

5.3. Cross-Sectionally Augmented ARDL and DL Approaches

Until now, we have assumed a somewhat restrictive assumption about the nature of the cross-sectional errors. That is, we have assumed that the errors in the debt/TFP relationship are cross-sectionally independent, which is likely to be problematic as several factors could lead to cross-sectional error dependencies. This fact is particularly true as we are dealing with firms operating in

[21] For further details see Chudik et al. (2013).

the same sector that are likely to have been subject to the same kind shocks during the period. Factors that can lead to cross-sectional dependencies are most likely unobserved and include financial crises and recession, labour and product market frictions, commodity price shocks, institutional factors that condition business environment, the health of the banking system or other omitted common factors. We introduce this possibility by assuming that the errors in (5) have a multifactor error structure given by:

$$u_{it} = \gamma_i^{'} f_t + \hat{u}_{it} \tag{8}$$

where $\gamma_i^{'}$ a $m \times 1$ vector of factor loading and f_t is a $m \times 1$ vector of unobserved common factors themselves possibly correlated. As for $\hat{u}_{it}$, they are idiosyncratic errors uncorrelated with f_t or at least mildly cross-correlated.

Both ARDL and DL specifications, described in previous sections, can be readily generalized to deal with cross-sectional dependence by approximating the unobserved common factors. We do so by following a parsimonious version of the one implemented by Chudik and Pesaran (2015) as both ARDL and DL specifications are augmented with cross-sectional averages of productivity and indebtedness growth. Moreover, the DL models were also augmented with lagged values of cross-sectional averages both of the dependent and independent variables. In doing so, we obtain a CS-ARDL and CS-DL specifications of our baseline models [22].

6. Results

6.1. Baseline ARDL and DL Specifications

The results from the estimation of our baseline ARDL, DL specifications are reported in Table 1. As discussed earlier, for every ARDL specification, we report PMG estimates, of the long-run effect of increased indebtedness, Δd_{it}, on total factor productivity growth ΔTFP_{it}. For these specifications, we also report the error-correction speed of adjustment parameter $\hat{\lambda}$. Likewise, for the DL specification, we report the MG estimates for the long-run effect. Moreover, we report different ranges of lag lengths to access the sensitivity of our results to the choice of the lag order. Notably, we use the same lag order for all firms, but consider different values of lags in the range of 1 to 2 for both the ARDL method and DL. Furthermore, as noted by Chudik et al. (2013), sufficiently long lags are necessary to ensure the consistency of the ARDL approach, whereas using more lags than necessary can be conducive to estimates with poor small sample properties. The results both from our ARDL and DL approaches, reported in Table 3, suggest a negative long-run relationship between persistent debt build-up and productivity growth, regardless of the chosen lag order. In both specifications, the estimated coefficient, $\hat{\theta}\Delta_d$, is negative and statistically significant. However, the PMG estimate of debt elasticity in the ARDL specification is smaller in magnitude than the estimate from the MG used in the DL specification.

[22]The relative merits and drawbacks of both approaches are thoroughly discussed in Chudik et al. (2013).

Particularly, estimates from the ARDL models fall between -0.045 and -0.056, whereas the figures from the DL models range between -0.135. and -0.139.

Table 3. **Estimates of Long-Run Effects of Corporate Indebtedness on TFP Growth**

	ARDL			DL	
Lags	(1,1)	(1,2)	(2,1)	p=1	p=2
$\hat{\theta}_{\Delta d}$	-0.054***	-0.056***	-0.045***	-0.135***	-0.139***
	(0.002)	(0.002)	(0.002)	(0.007)	(0.009)
$\hat{\lambda}$	-1.152***	-1.175***	-1.394***		
	(0.011)	(0.013)	(0.019)		
Constant	-0.005***	-0.010***	-0.009	-0.005***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Observations	10,940	9,846	9,846	10,940	9,846
CD	67.667***	67.367***	68.906***	43.200***	21.470***

Notes: The ARDL and DL specifications are described in equations (5) and (7). For the ARDL we report PMG estimates while for the DL we report MG estimates. CD refers to test statistic for weak cross-sectional dependence. Standard errors are reported in parentheses. Symbols *, **, and *** denote significance at 10%, 5%, and at 1% respectively.

6.2. Cross-sectionally Augmented ARDL and DL Specifications

As noted before, in our baseline specifications for the ARDL and DL models, we deal with heterogeneity, simultaneity and dynamics in the long-run relationship between debt build-up and productivity growth. Despite this, we assumed cross-sectionally independent errors. Notwithstanding, a series of common factor are likely to have affected all firms during the period, deeming this assumption to be implausible. Furthermore, some of these factors may be unobservable as well as correlated with the regressors, leading to biased estimates. In order access, the degree of cross-sectional dependence we apply a CD test based on Pesaran (2015) under the null hypothesis of weak cross-sectional dependence. As reported in Table 1, for all lag orders, we firmly reject the null hypothesis, leading us to conclude for the presence of a significant degree of cross-sectional dependence amongst errors. To address the problem, we use the CS-ARDL and CS-DL approaches. These are modified versions of our baseline specifications that make use of cross-sectional averages of the regressors, the dependent variable, and their lags as proxies of unobserved common factors.

Results from this approach are reported in Table 4. Under these specifications, the long-run relationship between debt built-up and TFP growth remains negative and statistically significant for all specifications. On the other hand, once we control for common correlated effects, the long-run relationship between debt growth and productivity seems to become more intense in the case of our DL representation, though the same does not hold for the ARDL representation. Interestingly, for our DL representation, we now accept the null hypothesis of weak cross-sectional dependence of errors, as the CD statistic becomes insignificant.

Table 4. **Estimates of Long-Run Effects of Corporate Indebtedness on TFP Growth**

	CS-ARDL			CS-DL	
Lags	(1,1)	(1,2)	(2,1)	p=1	p=2
$\hat{\theta}_{\Delta d}$	-0.060***	-0.037***	-0.044***	-0.145***	-0.192***
	(0.002)	(0.002)	(0.001)	(0.011)	(0.037)
$\hat{\lambda}$	-1.272***	-1.345***	-1.737***		
	(0.013)	(0.018)	(0.029)		
Constant	-0.001	-0.002	0.000	-0.001	0.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
Observations	10,940	9,846	9,846	10,940	9,846
CD	66.753**	69.904***	69.089***	-1.296	-1.192

Notes: The CS-ARDL specification augmented the baseline ARDL model with cross-sectional averages of the dependent and independent variables. The CS-DL specification augmented the baseline DL model with cross-sectional averages and lags of the dependent and independent variables. For the CS-ARDL we report PMG estimates while for the CS-DL we report MG estimates. CD refers to test statistic for cross-sectional dependence. Standard errors are reported in parentheses. Symbols *, **, and *** denote significance at 10%, 5%, and at 1% respectively.

Overall, both our ARDL and DL specifications results are of economic significance as they are indicative of a negative long-run effect of increasing firm indebtedness on TFP growth in the construction sector during the period 2006-2017. Particularly for the coefficient estimates of our CS-ARDL specifications, this implies that a persistent annual increase in the debt to value-added ratio of 1%, in the long-run, is associated with a decrease in TFP growth rate of approximately 0,1 percentage points. Alternatively, if we consider the possibility of different responses in the relationship between indebtedness and productivity across firms, our CS-DL results show that the decrease in TFP growth is about the double, that is 0,2 percentage points. Moreover, these results are robust to the inclusion of multiple lag lengths of the regressors and qualitatively consistent after we control for common correlated effects that are shown to have had an impact on construction firms during the period.

7. Robustness

7.1. Alternative Measures of Firm Indebtedness

7.1.1. Debt to EBITDA

As an alternative measure of corporate indebtedness, we use the ratio of total debt, as defined in our baseline specification, to earnings before interest, taxes depreciation and amortizations, commonly known as EBITDA. From a financial standpoint, EBITDA is the amount of *"cash-flow"* generated by the firms' operational activities and distinguishes itself from value-added by not including financial profits, extraordinary profits, as well as the cost of employees. Being so, EBITDA can assume positive or negative values at the end of the period. As some firm-year observation presented zero or negative figures for EBITDA, these had to be removed from our sample in order to implement our empirical procedure.

The results from this alternative specification are reported in Table 5 and confirm the long-run negative relationship between persistent debt to EBITDA build-up and TFP growth. Moreover, we find the effect to be statistically significant for both ARDL and DL specifications. As in the case of our baseline models, figures from the CD statistic suggest the role of common correlated effects influencing the relationship. Despite this, and after controlling for these effects, in both our CS-DL representations, we are unable to reject the null hypothesis of weak cross-sectional dependence. This happens without compromising neither the proper sign for our estimates nor statistical significance.

7.1.2. Debt to Assets

As another measure of firm indebtedness, we use a leverage ratio based on assets. Particularly, we consider the ratio of total debt to total assets in all our specifications. The results for these specifications are reported in Table 6. Although more likely to be susceptible to the influence of price fluctuation and revaluation issues, the negative relationship between this leverage ratio and productivity growth is confirmed in our results. Moreover, the estimates of the long-run effect are statistically significant in all specifications other than the CS-DL of order 2. Although displaying the proper sign, the relevant coefficient for this specification is statistically non-different from zero.

Table 5. **Estimates of Long-Run Effects on TFP Using Debt to EBITDA**

	ARDL			DL		CS-ARDL			CS-DL	
Lags	(1,1)	(1,2)	(2,1)	p=1	p=2	(1,1)	(1,2)	(2,1)	p=1	p=2
$\hat{\theta}_{\Delta d}$	-0.075***	-0.078***	-0.069***	-0.097***	-0.026***	-0.076***	-0.068***	-0.044***	-0.102***	-0.021***
	(0.002)	(0.002)	(0.001)	(0.005)	(0.007)	(0.001)	(0.001)	(0.001)	(0.010)	(0.049)
$\hat{\lambda}$	-1.170***	-1.188***	-1.343***			1.296***	-1.359***	-1.734***		
	(0.013)	(0.015)	(0.021)			(0.015)	(0.020)	(0.031)		
Constant	0.001	-0.003**	-0.003*	0.000	-0.004**	-0.001	-0.004*	-0.005*	-0.002	-0.012*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.006)
Observations	8,770	7,893	7,893	8,770	7,893	8,770	7,893	7,893	8,770	7,893
CD	45.456***	44.805***	46.693***	28.403***	33.468***	45.293***	46.996***	51.776***	-1.983**	-0.560

Notes: The ARDL and DL specifications are described in equations (5) and (7). For all specifications, indebtedness is measured by the ratio of debt to EBITDA. For the ARDL we report PMG estimates while for the DL we report MG estimates. The CS-ARDL specification augmented the baseline ARDL model with cross-sectional averages of the dependent and independent variables. The CS-DL specification augmented the baseline DL model with cross-sectional averages and lags of the dependent and independent variables. CD refers to test statistic for weak cross-sectional dependence. Standard errors are reported in parentheses. Symbols *, **, and *** denote significance at 10%, 5%, and at 1% respectively.

Table 6. **Estimates of Long-Run Effects on TFP Using Debt to Assets**

	ARDL			DL		CS-ARDL			CS-DL	
Lags	(1,1)	(1,2)	(2,1)	p=1	p=2	(1,1)	(1,2)	(2,1)	p=1	p=2
$\hat{\theta}_{\Delta d}$	-0.017***	-0.010***	-0.009***	-0.050**	-0.068**	-0.022***	-0.065***	-0.532***	-0.047*	-0.001
	(0.002)	(0.003)	(0.002)	(0.015)	(0.024)	(0.002)	(0.002)	(0.001)	(0.025)	(0.198)
$\hat{\lambda}$	-1.242***	-1.239***	-1.545***			-1.367***	-1.343***	-1.863***		
	(0.010)	(0.012)	(0.019)			(0.011)	(0.014)	(0.026)		
Constant	-0.004***	0.009***	0.008***	-0.003**	-0.005*	0.001	-0.002	0.003	-0.001	-0.008
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.020)
Observations	10,940	9,846	9,846	10,940	9,846	10,940	9,846	9,846	10,940	9,846
CD	72.382***	72.249***	72.227***	51.502***	28.472***	72.402***	58.875***	60.601	-1.417	-1.348

Notes: The ARDL and DL specifications are described in equations (5) and (7). For all specifications, indebtedness is measured by the ratio of debt to Assets. For the ARDL we report PMG estimates while for the DL we report MG estimates. The CS-ARDL specification augmented the baseline ARDL model with cross-sectional averages of the dependent and independent variables. The CS-DL specification augmented the baseline DL model with cross-sectional averages and lags of the dependent and independent variables. CD refers to test statistic for weak cross-sectional dependence. Standard errors are reported in parentheses. Symbols *, **, and *** denote significance at 10%, 5%, and at 1% respectively.

7.2. Alternative Measures of Productivity

7.2.1. Labour Productivity

We also consider the robustness of our results to a non-parametric measure of productivity, namely labour productivity. As stated previously, labour productivity is calculated as the ratio of value-added per worker. The results for the long-run effect of debt built-up on labour productivity growth, reported in Table 7, show a negative and significant relationship in all specifications. These results are in line with our baseline models that make use of a parametric measure of TFP, although using labour productivity renders a stronger long-run response from both ARDL and DL models. The same holds once we control for common correlated effects, as the results remain qualitatively unchanged and statistically significant.

7.2.2. Alternative Measure of TFP

In our baseline estimations, TFP was computed using the single-equation approach as proposed by Wooldridge (2009). Alternatively, we use TFP estimates computed through Levinsohn-Petrin's method (Levinsohn and Petrin, 2003). As in our baseline specification for the computation of TFP, we begin by assuming a Cobb-Douglas production function:

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_m m_t + \omega_t + \eta_t \tag{9}$$

where y_t is the logarithm of the firm's output; l_t and m_t are the logarithm of freely variable inputs of labour and the intermediate input; and k_t is the logarithm of the state variable for capital. The error term has two different components, namely ω_t, the productivity transmitted component and η_t an error term that is uncorrelated with input choices. Moreover, Levinsohn and Petrin (2003) show that the unobservable productivity term ω_t can be expressed solely as a function of two observed inputs, namely:

$$\omega_t = \omega_t(k_t, m_t) \tag{10}$$

Notably, for the computation of our alternative measure of TFP we use value-added as our measure for firm's output, labour costs as our free variable, supplies and external services as our proxy variable and capital computed through the perpetual inventory method.

The results for the long-run effect of debt in productivity using this alternative method of TFP computation are reported in table 8. Overall, they are once again indicative of a negative and significant relationship between debt growth and productivity. Despite this, the effect seems to be, on the one hand, less intense across all specifications, and on the other hand less significant, mainly once common correlated effects are accounted for in CS-DL (p=2) where the coefficient associated with this specification is statistically no longer different from zero.

Table 7. **Estimates of Long-Run Effects of Corporate Indebtedness on Labour Productivity**

	ARDL			DL		CS-ARDL			CS-DL	
Lags	(1,1)	(1,2)	(2,1)	p=1	p=2	(1,1)	(1,2)	(2,1)	p=1	p=2
$\hat{\theta}_{\Delta d}$	-0.074***	-0.083***	-0.057***	-0.152***	-0.168**	-0.074***	-0.061***	-0.025***	-0.147***	-0.178***
	(0.003)	(0.004)	(0.002)	(0.009)	(0.013)	(0.003)	(0.003)	(0.001)	(0.017)	(0.068)
$\hat{\lambda}$	-1.201***	-1.219***	-1.488***			-1.309***	-1.336***	-1.838***		
	(0.010)	(0.012)	(0.018)			(0.012)	(0.015)	(0.007)		
Constant	0.013***	0.005**	0.009***	0.011***	0.010***	0.000	-0.002	0.002	0.004	0.018*
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.008)
Observations	10,940	9,846	9,846	10,940	9,846	10,940	9,846	9,846	10,940	9,846
CD	64.531***	62.944***	67.298***	40.587***	15.894***	64.407***	66.622***	70.921***	-0.912	2.381**

Notes: The ARDL and DL specifications are described in equations (5) and (7). For all specifications, indebtedness is measured by the ratio of debt to value-added and productivity by labour productivity. For the ARDL we report PMG estimates while for the DL we report MG estimates. The CS-ARDL specification augmented the baseline ARDL model with cross-sectional averages of the dependent and independent variables. The CS-DL specification augmented the baseline DL model with cross-sectional averages and lags of the dependent and independent variables. CD refers to test statistic for weak cross-sectional dependence. Standard errors are reported in parentheses. Symbols *, **, and *** denote significance at 10%, 5%, and at 1% respectively.

Table 8. **Estimates of Long-Run Effects of Corporate Indebtedness on TFP Growth - Levinsohn-Petrin**

	ARDL			DL		CS-ARDL			CS-DL	
Lags	(1,1)	(1,2)	(2,1)	p=1	p=2	(1,1)	(1,2)	(2,1)	p=1	p=2
$\hat{\theta}_{\Delta d}$	-0.007***	-0.017***	-0.007***	-0.018***	-0.028***	-0.007***	-0.009***	-0.012***	-0.021***	-0.029
	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)	(0.001)	(0.000)	(0.005)	(0.019)
$\hat{\lambda}$	-1.143***	-1.145***	-1.389***			-1.282***	-1.321***	-1.293***		
	(0.010)	(0.012)	(0.018)			(0.011)	(0.016)	(0.016)		
Constant	0.005***	0.003***	0.004***	0.004***	0.003***	0.000	0.000	0.000	0.000	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
Observations	10,940	9,846	9,846	10,940	9,846	10,940	9,846	9,846	10,940	9,846
CD	71.781***	71.437***	71.772***	105.046***	60,747***	71.780***	71.724***	71.623***	-1.683*	-0.393

Notes: The ARDL and DL specifications are described in equations (5) and (7). For all specifications, indebtedness is measured by the ratio of debt to value-added. For the ARDL we report PMG estimates while for the DL we report MG estimates. The CS-ARDL specification augmented the baseline ARDL model with cross-sectional averages of the dependent and independent variables. The CS-DL specification augmented the baseline DL model with cross-sectional averages and lags of the dependent and independent variables. CD refers to test statistic for weak cross-sectional dependence. Standard errors are reported in parentheses. Symbols *, **, and *** denote significance at 10%, 5%, and at 1% respectively.

8. Conclusions

Productivity growth slowdown in developed countries has been at the forefront of the economic research agenda for the past years. This paper aims to contribute to the ongoing debate on the topic by addressing the relationship between firms' debt build-up and productivity growth, particularly for the construction sector. To do so, we rely on the framework provided by the estimation of heterogeneous dynamic-panel models with cross-sectionally correlated errors. Using firm-level data from the Portuguese construction sector from 2006 to 2017, our empirical approach suggests a significant and negative relationship, during the period, between debt accumulation and TFP growth. This result is consistent with what Anderson and Raissi (2018) found for the Italian economy. We also find this result to be robust to different measures of firm indebtedness as well as to various measures TFP and labour productivity. These results highlight the importance of structural reforms as well as policy measures that enable alternative forms of firms' financing. In this regard, the Portuguese flagship program *Capitalizar* is a good example of one of such policies, as it aims not only at the strengthening traditional financial intermediaries but also at stimulating the use of financing alternatives based on equity solutions. Moreover, our empirical approach suggests a significant influence of common factors over productivity growth during the period. Despite this, our empirical framework accounts for those factors, particularly throughout our CS-DL specifications, without compromising our chieftain conclusion.

A. Appendix

Data Cleaning Steps

After discarding irrelevant sectors, our data set comprised 552.960 observations for 84.020 firms from the construction sector. We followed by imposing a series of cleaning steps, namely:

1. Only companies employing at least three employees were considered, since those who do not are more likely to misreport their financial situation.

2. We dropped firms that presented gaps between their annual financial accounts.

3. Firms reporting an activity status other them "Active" were dropped. Further, we dropped firms that in any given year reported negative equity (solvency requirement).

4. Observations with no information about BdP's identification number, year, as well as figures for assets, number or cost of employees and sales were discarded.

5. To ensure consistency of reporting, we demanded that some fundamental accounting identities were satisfied. Despite this, and to abstract from potential rounding errors, observations are kept if the absolute value of the difference between both sides of the identity is bounded to one euro. To put into place the described procedure, we used the following accounting identities:

   (a) Total Assets = Total liabilities + Total equity

   (b) Total Assets = Non-current Assets + Current Assets

   (c) Total Liabilities = Non-current Liabilities + Current Liabilities

6. We dropped observations from the sample if at any given time, during the 12-years, firms reported negative figures for total assets, tangible assets, number or cost of employees, and sales.

7. We dropped observation for any given year whenever the figures reported for total assets, sales, Equity and EBITDA exceeded 50 times the figure reported in the previous year.

8. As in Gopinath et al. (2017), we abstain from the effect of other possible outliers, by computing the ratio of tangible fixed assets to cost of employees and the ratio of cost of employees to value-added, and dropping observations belonging to the top and bottom 0.1%. Moreover, in the case of cost of employees to value-added, we also drop observation whenever the ratio exceeds 1.1.

9. Finally, observations for which there were missing values in the variables used to compute productivity were dropped.

Table 9 outlines the number of observations and firms lost after imposing all the restrictions described above.

Table 9. **Number of Lost Observations and Firms**

Procedure	Observations	Firms
Less than 3 employees	409.686	61.973
Gap between accounts	1.364	205
No activity or insolvent	15.395	2.069
Missing essential information	664	602
Fundamental Accounting Equalities	1.174	17
Negative Figures	18	3
Consistency in Assets and Sales	599	0
Consistency in Equity and EBITDA	664	0
Based on Gopinath et al. (2017)	10.325	320
Computation of Productivity	12.478	2.414
Total	**452.178**	**67.603**

Table 10. **Number of Firms by Firm Size - Balanced Panel**

Firm Size	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Micro	474	442	424	402	383	408	445	474	450	443	443	434
Small	541	561	577	600	611	592	560	530	551	559	550	559
Medium	61	72	72	69	77	71	68	70	71	69	79	78
Large	18	19	21	23	23	23	21	20	22	23	22	23
Total	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094	1.094

Computing the Capital Stock

To compute a measure of capital stock, we follow a modified version of the perpetual inventory method as laid out in Anderson and Raissi (2018). Particularly, the evolution of capital stock, K_{it}, follows a law of motion given by:

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

where, I_{it} is investment of firm i in year t and δ_{it} is the depreciation rate of capital for firm i in year t.

The initial balance-sheet value of the capital stock, $K^{\mathrm{BS}}_{\mathrm{i0}}$, corresponds to the value of fixed tangible assets and intangible assets in 2006. Furthermore, the depreciation rate is equal to the value of depreciations and amortizations, $D^{\mathrm{BS}}_{\mathrm{it}}$, divided by the sum of the value of depreciations and the lagged value of the balance-sheet value of the capital stock, $K^{\mathrm{BS}}_{\mathrm{it-1}}$, such that:

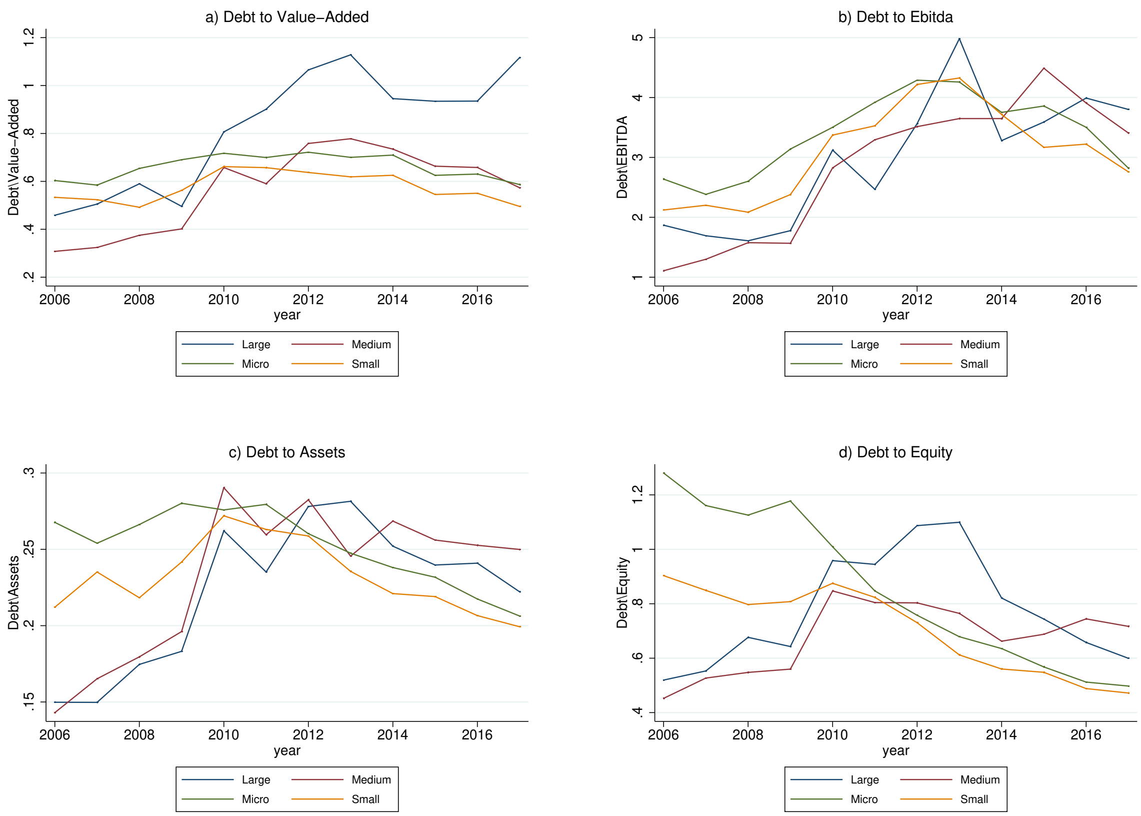
$$\delta_{it} = 1 + \frac{D^{\mathrm{BS}}_{\mathrm{it}}}{K^{\mathrm{BS}}_{\mathrm{it-1}}}$$

Finally, I_{it} is computed as the sum of the change in the balance-sheet value of the capital stock and depreciations:

$$I_{it} = \Delta K^{\mathrm{BS}}_{\mathrm{it}} + D^{\mathrm{BS}}_{\mathrm{it}}$$

Median Indebtedness by Size Class

Figure 12: **Median Firm Indebtedness, by Firm Size Class**



Notes: Panels (a) to (d) show different measures of firm indebtedness for the balanced panel of x firms. Panel (a) shows the median value debt to value-added for all size classes. Panel (b) shows the median debt to EBITDA for all size classes. Panel (c) the median value of debt to assets for all size classes. Panel (d) shows the median value of debt to Equity for all size classes.

References

Adler, G., R. Duval, D. Furceri, S. K. Çelik, K. Koloskova, and M. Poplawski-Ribeiro (2017). *Gone with the Headwinds: Global Productivity*. International Monetary Fund.

Aeppel, T. (2015). Silicon valley doesn't believe us productivity is down. *Wall Street Journal 16*.

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.

Anderson, G. and M. M. Raissi (2018). *Corporate indebtedness and low productivity growth of Italian firms*. International Monetary Fund.

Andrews, D., C. Criscuolo, and P. N. Gal (2015). Frontier firms, technology diffusion and public policy.

Brynjolfsson, E. and A. McAfee (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.

Byrne, D. M., J. G. Fernald, and M. B. Reinsdorf (2016). Does the united states have a productivity slowdown or a measurement problem? *Brookings Papers on Economic Activity 2016*(1), 109–182.

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. *Cafe research paper* (13.23).

Chudik, A., K. Mohaddes, M. H. Pesaran, and M. Raissi (2017). Is there a debt-threshold effect on output growth? *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.

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.

Decker, R. A., J. Haltiwanger, R. S. Jarmin, and J. Miranda (2016). Where has all the skewness gone? the decline in high-growth (young) firms in the us. *European Economic Review 86*, 4–23.

Feldstein, M. (2017). Underestimating the real growth of gdp, personal income, and productivity. *Journal of Economic Perspectives 31*(2), 145–64.

Fernald, J. G. (2015). Productivity and potential output before, during, and after the great recession. *NBER macroeconomics annual 29*(1), 1–51.

Ghosh, S. (2009). Do productivity and ownership really matter for growth? firm-level evidence. *Economic Modelling 26*(6), 1403–1413.

Gopinath, G., Ş. Kalemli-Özcan, L. Karabarbounis, and C. Villegas-Sanchez (2017). Capital allocation and productivity in south europe. *The Quarterly Journal of Economics 132*(4), 1915–1967.

Gordon, R. J. (2017). *The rise and fall of American growth: The US standard of living since the civil war*, Volume 70. Princeton University Press.

Haltiwanger, J. (2012). Job creation and firm dynamics in the united states. *Innovation policy and the economy 12*(1), 17–38.

Haltiwanger, J., I. Hathaway, and J. Miranda (2014). Declining business dynamism in the us high-technology sector. *Available at SSRN 2397310*.

Herndon, T., M. Ash, and R. Pollin (2014). Does high public debt consistently stifle economic growth? a critique of reinhart and rogoff. *Cambridge journal of economics 38*(2), 257–279.

Hsieh, C.-T. and P. J. Klenow (2009). Misallocation and manufacturing tfp in china and india. *The Quarterly journal of economics 124*(4), 1403–1448.

Kalemli-Ozcan, S., L. Laeven, and D. Moreno (2015). Debt overhang in europe: Evidence from firm-bank-sovereign linkages. *University of Maryland*.

Kim, Y. E. and N. Loayza (2017). Productivity and its determinants: Innovation, education, efficiency, infrastructure, and institutions. *Unpublished Working Paper*.

Kumar, M. and J. Woo (2010). Public debt and growth. *IMF working papers*, 1–47.

Levinsohn, J. and A. Petrin (2003). Estimating production functions using inputs to control for unobservables. *The review of economic studies 70*(2), 317–341.

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), 422–58.

Moll, B. (2014). Productivity losses from financial frictions: Can self-financing undo capital misallocation? *American Economic Review 104*(10), 3186–3221.

Nicoletti, G. and S. Scarpetta (2003). Regulation, productivity and growth: Oecd evidence. *Economic policy 18*(36), 9–72.

Nucci, F., A. Pozzolo, F. Schivardi, et al. (2005). Is firm's productivity related to its financial structure? evidence from microeconomic data. *Rivista di politica economica 95*(1), 269–290.

Olley, G. S. and A. Pakes (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica: Journal of the Econometric Society 64*(6), 1263–1297.

Ollivaud, P., Y. Guillemette, and D. Turner (2016). Links between weak investment and the slowdown in productivity and potential output growth across the oecd.

Panizza, U. and A. F. Presbitero (2014). Public debt and economic growth: is there a causal effect? *Journal of Macroeconomics 41*, 21–41.

Pellegrino, B. and L. Zingales (2017). Diagnosing the italian disease. Technical report, National Bureau of Economic Research.

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews 34*(6-10), 1089–1117.

Pesaran, M. H., Y. Shin, and R. P. Smith (1997). Estimating long-run relationships in dynamic heterogeneous panels, dae working papers amalgamated series 9721.

Pesaran, M. H., Y. Shin, and R. P. Smith (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association 94*(446), 621–634.

Pesaran, M. H. and R. Smith (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of econometrics 68*(1), 79–113.

Reinhart, C. M. and K. S. Rogoff (2010). Growth in a time of debt. *American economic review 100*(2), 573–78.

Reis, R. (2013). The portuguese slump and crash and the euro crisis. *Brookings Papers on Economic Activity*.

Restuccia, D. and R. Rogerson (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic dynamics 11*(4), 707–720.

Rovigatti, G. and V. Mollisi (2018). Theory and practice of total-factor productivity estimation: The control function approach using stata. *The Stata Journal 18*(3), 618–662.

Schivardi, F., E. Sette, and G. Tabellini (2017). Credit misallocation during the european financial crisis. *Bank of Italy Temi di Discussione (Working Paper) No 1139*.

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters 104*(3), 112–114.

GEE Papers

70: Portugal: a Paradox in Productivity
Ricardo Pinheiro Alves

71: Infrastructure Investment, Labor Productivity, and International Competitiveness: The Case of Portugal
Alfredo Pereira | Rui Pereira

72: Boom, Slump, Sudden stops, Recovery, and Policy Options. Portugal and the Euro
Olivier Blanchard | Pedro Portugal

73: Case Study: DBRS Sovereign Rating of Portugal. Analysis of Rating Methodology and Rating Decisions
Annika Luisa Hofmann | Miguel Ferreira | João Lampreia

74: For Whom the Bell Tolls: Road Safety Effects of Tolls on Uncongested SCUT Highways in Portugal
Alfredo Pereira | Rui Pereira | João Pereira dos Santos

75: Is All Infrastructure Investment Created Equal? The Case of Portugal
Alfredo Pereira | Rui Pereira

76: Why Virtuous Supply-Side Effects and Irrelevant Keynesian Effects are not Foregone Conclusions: What we Learn from an Industry-Level Analysis of Infrastructure Investments in Portugal
Alfredo Pereira | Rui Pereira

77: The Role of Gravity Models in Estimating the Economic Impact of Brexit
Graham Gudgin | Ken Coutts | Neil Gibson | Jordan Buchanan

78: Infrastructure Investment in Portugal and the Traded/Non-Traded Industry Mix
Alfredo Pereira | Rui Pereira

79: Goods and Factor Market Integration: A Quantitative Assessment of the EU Enlargement
Lorenzo Caliendo | Fernando Parro | Luca David Opromolla | Alessandro Sforza

80: Understanding productivity dynamics:a task taxonomy approach
Tiago Fonseca | Francisco Lima | Sonia C. Pereira

81: On the Effects of Infrastructure Investments on Industrial CO2 Emissions in Portugal
Alfredo Pereira | Rui Pereira

82: Assessing Competition With the Panzar-Rosse Model: An empirical analysis of European Union banking industry
Suzana Cristina Silva Andrade

83: Health Care Investments and Economic Performance in Portugal: An Industry Level Analysis
Alfredo Pereira | Rui Pereira | Pedro G. Rodrigues

84: Is deregulation of product and labour markets promoting employment and productivity? A difference-in-differences approach
Hugo Correia | Ana Fontoura Gouveia

85: Foreign acquisition and internal organization
Paulo Bastos | Natália P. Monteiro | Odd Rune Straume

86: Learning, Prices, and Firm Dynamics
Paulo Bastos | Daniel A. Dias | Olga A. Timoshenko

87: The Diffusion of Knowledge via Managers' Mobility
Giordano Mion | Luca David Opromolla | Alessandro Sforza

88: Empresas Zombie em Portugal - Os sectores não transacionáveis da Construção e dos Serviços
Gabriel Osório de Barros | Filipe Bento Caires | Dora Xarepe Pereira

89: Collective bargaining through the magnifying glass: A comparison between the Netherlands and Portugal
Alexander Hijzen | Pedro Martins | Jante Parlevliet

90: A Lower VAT Rate on Electricity in Portugal: Towards a Cleaner Environment, Better Economic Performance, and Less Inequality
Alfredo Pereira | Rui Manuel Pereira

91: Who Seeks Re-Election: Local Fiscal Restraints and Political Selection
Susana Peralta | João Pereira dos Santos

92: Assessing the Competitiveness of the Metalworking Sector
João Marinho | Pedro Carvalho

93: The efficiency of Portuguese Technology Transfer Offices and the importance of university characteristics
Aurora Teixeira | André Monteiro

94: Persistence in innovation and innovative behavior in unstable environments
Joana Costa | Anabela Botelho | Aurora Teixeira

95: The effect of entrepreneurial origin on firms' performance - The case of Portuguese academic spinoffs
Natália Barbosa | Ana Paula Faria

96: Absorptive Capacity and Firms' Generation of Innovation - Revisiting Zahra and George's Model
Dina Pereira | João Leitão

97: Innovations in digital government as business facilitators: implications for Portugal
João Martins | Linda Veiga

98: Innovation and the economic downturn: Insights from Portuguese firms
Hugo Pinto | Tiago Santos Pereira | Elvira Uyarra

99: European Funds and Firm Dynamics: Estimating Spillovers from Increased Access
João Pereira dos Santos | José Tavares

100: Corporate Leverage and Investment in Portugal
Ana Martins | José Henrique Gonçalves | João Mário Ferreira Duque

101: The effects of official and unofficial information on tax compliance
Filomena Garcia | Luca David Opromolla | Andrea Vezzulli | Rafael Marques

102: Competition effect on innovation and productivity - The Portuguese case
Anabela Santos | Michele Cincera | Paulo Neto | Maria Manuel Serrano

103: Measuring the Welfare of Intermediation in Vertical Markets
Javier D. Donna | Pedro Pereira | Tiago Pires | Andre Trindade

104: Of course Collusion Should be Prosecuted. But Maybe... Or (The case for international antitrust agreements)
Filomena Garcia | Jose Manuel Paz y Minõ | Gustavo Torrens

105: Product market competition and gender discrimination
Dudley Cooke | Ana P. Fernandes | Priscila Ferreira

106: Integration of Small Technology-Based Firms in Aeronautics
Anabela Reis | Joana Mendonça | Ligia Urbina

107: The Effects of Highway Tolls on Private Business Activity – Results from a Natural Experiment
João Pereira dos Santos | David B. Audretsch | Dirk Dohse

108: Competition and Firm Productivity: Evidence from Portugal
Pedro Carvalho

109: Do Exchange Traded Funds (ETFs) Outperform the Market? Evidence from the Portuguese Stock Index
Carlos Manuel Pinheiro | Hugo Hilário Varela

110: Assessing the Competitiveness of the Portuguese Chemical Sector
Ana Rita Marques | Cátia Silva

111: A General Equilibrium Theory of Occupational Choice under Optimistic Beliefs about Entrepreneurial Ability
Michele Dell'Era | Luca David Opromolla | Luis Santos-Pinto

112: O Mercado Segurador em Portugal: O Papel dos Gestores na Constituição de Provisões
Soraia de Sousa Bornett | Carlos Manuel Pinheiro

113: Exploring the implications of di erent loan-to-value macroprudential policy designs
Rita Basto | Sandra Gomes | Diana Lima

114: The Determinants of TFP Growth in the Portuguese Service Sector
Ana Martins | Tiago Domingues | Catarina Branco

115: Agglomeration and Industry Spillover Effects in the Aftermath of a Credit Shock
José Jorge | Joana Rocha

116: Entrepreneurial Human Capital and Firm Dynamics
Francisco Queiró

117: Global Value Chains and Vertical Specialization: The case of Portuguese Textiles and Shoes exports
Tiago Domingues

118: Firm heterogeneity and exports in Portugal: Identifying export potential
Frederico Oliveira Torres

119: Vantagens Comparativas Reveladas e suas determinantes: Uma Aplicação à Economia Portuguesa
Guida Nogueira | António Portugal Duarte

120: A Look at the main channels of Potential Impact of Brexit on the Portuguese Economy
Guida Nogueira | Paulo Inácio

121: How internationalization and competitiveness contribute to get public support to innovation? The Portuguese case
Anabela Santos | Michele Cincera | Paulo Neto | Maria Manuel Serrano

122: Grande Guerra e Guerra Colonial: Quanto Custaram aos Cofres Portugueses?
Ricardo Ferraz

123: Financing a Renewable Energy Feed-in Tariff with a Tax on Carbon Dioxide Emissions: A Dynamic Multi-Sector General Equilibrium Analysis for Portugal
Rui M. Pereira | Alfredo M. Pereira

124: Brown Sugar, how come you taste so good? The impact of a soda tax on prices and consumption
Judite Gonçalves | João Pereira dos Santos

125: ARFIMA Reference Forecasts for Worldwide CO2 Emissions and the National Dimension of the Policy Efforts to Meet IPCC Targets
José Beirute | Alfredo M. Pereira

126: Reference Forecasts for CO2 Emissions from Fossil-Fuel Combustion and Cement Production in Portugal
José M. Belbute | Alfredo M. Pereira

127: Regulated Early Closures of Coal-Fired Power Plants and Tougher Energy Taxation on Electricity Production: Synergy or Rivalry?
Alfredo Marvão Pereira | Rui Manuel Pereira

128: Picking Our Environmental Battles: Removal of Harmful Subsidies or Carbon Taxation?
Alfredo Marvão Pereira | Rui Marvão Pereira

129: Financing Future Feed-in Tariffs from Currently Installed RES-E Generating Capacity
Alfredo Marvão Pereira | Rui Marvão Pereira

130: Foreign Direct Investment, Income Inequality and Poverty in Portugal, 1973-2014: What does cointegration analysis tell us?
Aurora Teixeira | Ana Sofia Loureiro

131: On the Spillover Effects of CO2 Taxation on the Emissions of other Air Pollutants
Alfredo Marvão Pereira | Rui Marvão Pereira

132: On the Macroeconomic and Distributional Effects of the Regulated Closure of Coal-Operated Power Plants
Alfredo Marvão Pereira | Rui Manuel Pereira

133: The China Shock and Employment in Portuguese Firms
Lee Branstetter | Brian Kovak | Jacqueline Mauro | Ana Venâncio

134: Energy Taxation Reform with an Environmental Focus
Alfredo Marvão Pereira | Rui Manuel Pereira

135: ARFIMA Reference Forecasts for Worldwide CO2 Emissions and the Need for Large and Frontloaded Decarbonization Policies
José M. Belbute | Alfredo M. Pereira

Gabinete de Estratégia e Estudos