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Special Issue: Financing, Investment and Productivity in Portuguese Firms

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Editorial

Financing, Investment and Productivity in Portuguese Firms

Portugal is experiencing a slowdown of productivity growth, similar to the one occurring in advanced economies. Given that aggregate productivity growth is the main source of per capita income growth, this slowdown is associated with a slower improvement of living standards. In a neoclassical world, Portugal, poorer than most developed economies, would be expected to converge both in the level of productivity and in the average wealth of the population.

A number of hypotheses may explain why this is not happening: a decline in the birth rate of innovative firms able to deal with greater regulatory complexity, insufficient investment in infrastructure, equipment, R&D and information and communication technology, a slower pace of technology diffusion, non-competitive product markets and capital misallocation, rigid labour markets leading to skills and labour mismatches or insufficient knowledge-based and human capital accumulation.

The Public Policy Portuguese Journal invited Ricardo Pinheiro Alves (Strategy and Research Office of the Portuguese Ministry of Economy and Universidade Europeia) and Gabriel Osorio de Barros (Strategy and Research Office of the Portuguese Ministry of Economy), as Guest Editors of this special issue - Financing, Investment and Productivity in Portuguese Firms -, wich aims to deal with this subject by bringing together six studies aiming to discuss the importance of different factors on the productivity of firms, in particular investment, financing, employment and competition.

All articles in this special issue have been previously published by the Strategy and Research Office of the Ministry of Economy (GEE Papers) or together with the Office for Economic Policy and International Affairs of the Ministry of Finance (Monthly Bulletin of the Portuguese Economy - BMEP), between November 2016 and May 2018. The series of GEE Papers aims to disseminate academic and technical studies on the Portuguese economy. The BMEP is a publication that includes information on the international environment, the national environment and international trade, as well as in-depth technical articles on specific issues.

The first article – "Structural reforms and long-term growth – a model based analysis" – by Ana Fontoura Gouveia and Ana Filipa Fernandes, assesses the impact on potential growth of selected structural reforms foreseen in the 2017 Portuguese National Reform Programme. The assessment focus on four areas: educational attainment, incentives to innovation, employment incentives and financing of the economy. The estimates show that the implementation of the selected reforms could bring significant long-term gains in terms of potential growth, derived from a boost in investment, improvements in productivity and employment growth.

The second, by João Duque, José Gonçalves and Ana Martins, is entitled "Corporate leverage and investment in Portugal". This article aims to assess the decrease of investment induced by an increase in debt of an excessively indebted corporate sector in Portugal, testing empirically the relationship between corporate indebtedness and investment. The results, for the period 2010-2015, point to asymmetric effects around a threshold level of indebtedness, namely a debt-to-asset ratio of 45.6%, because greater access to debt can help increase investment levels, but excess leverage can reverse these benefits by raising corporate financial vulnerabilities. This type of relation between these variables suggests the need for companies to deleverage. The relationship between debt and investment was also tested along firm sectors due to their heterogeneity, and a similar relationship was also found in the three major ones: Wholesale and retail, Manufacturing and Construction. The lack of investment, partially associated with an excessive financial leverage by firms, and the low capital/labour ratio in the Portuguese economy have negative effects on the growth rate of productivity.

The third article – "Zombie companies in Portugal. The non-tradable sectors of construction and services" – by Gabriel Osório de Barros, Filipe Bento Caires and Dora Xarepe Pereira, considers the phenomenon of zombie companies in Portugal. This phenomenon has already been deeply analyzed, particularly in the case of Japan. Several authors relate the economic crisis experienced in the 1990s and the stagnation that Japan has been witnessing to the deterioration of the Japanese banking system, while continuously attributing credit to weaker companies, many of which were in a

situation of insolvency, preventing them from closing or restructuring, on one hand, and credit to being channelled to more productive sectors, on the other. Considering that zombie companies had a role to weak economic growth in Japan, it is relevant to identify the weight of this type of entities in Portugal and its evolution over time. The study shows that from 2008 to 2015, in the Portuguese non-tradable sectors of Construction and Services, between 5.2% (2008) and 12.5% (2013) of companies in the market were zombies. The authors also confirm the theoretical predictions and previous empirical results that a greater zombie presence in Construction and Services has significant negative implications on healthy companies operating in the same sector, namely reducing investment and employment and increasing the productivity gap between more and less productive companies in each sector.

The fourth article is entitled "Competition effect on innovation and productivity - The Portuguese case" and its authors are Anabela Santos, Michele Cincera, Paulo Neto and Maria Manuel Serrano. The aim is to assess the effect of competition on innovation (patent applications) and on productivity (TFP and Labour Productivity), using data from 654 Portuguese firms, according to 208 NACE 4-digits sectors, and over the period 2007 to 2015. For this purpose, two different methodological approaches were used, a Poisson regression model for the patent function and a log-log fixed effect model for the productivity function. The results reveal that, on average, competition has a negative, U-shaped form effect on innovation in the short term, and a positive effect in the medium-long term. Nevertheless, the model focusing only on manufacturing sectors shows some differences from the model considering all economic activities, namely a linear positive effect of competition on innovation. Concerning the effect of competition on productivity, a positive effect on TFP emerged from the analysis, while for labour productivity a negative one prevails.

The fifth article, by Hugo Correia and Ana Fontoura, is entitled "Is deregulation of product and labour markets promoting employment and productivity? A difference-in-differences approach". This chapter examines the impact of labour and product market reforms on sectoral employment and productivity, following a difference-in-differences approach. Using industry-level data for the period 1997-2013, the authors show that employment protection deregulation has a positive effect on sectoral employment for industries more exposed to labour market legislation, despite having a non-positive impact on productivity. Upstream product market deregulation also increases sectorial employment for the downstream sectors more dependent on upstream inputs (i.e. more exposed to deregulation upstream). Nevertheless, it has mixed effects on sectorial productivity: while upstream sectors face productivity losses, the downstream sectors more exposed to the deregulated sectors grasp productivity gains.

Finally, the sixth article is authored by Daniel Gonçalves and Ana Martins and is entitled "The determinants of TFP [Total Factor Productivity] growth in the portuguese manufacturing sector". The authors consider that, given the linkage between TFP growth and economic growth, it becomes relevant to understand, at the firm level, which are the main determinants of such growth path. In a first phase, the work assesses the main determinants of TFP. In a second stage estimation is presented a fixed-effects model that captures different dimensions of firm level characteristics that impact TFP growth, thus suggesting some policy measures from the model's results. The results show that age and debt influence negatively TFP growth, whereas size, exports and training expenses prompt TFP growth.

The conjunction of the different determinants of productivity assessed on these studies help us with the essential discussion about the need to change public policies so that a better allocation of resources (capital and labour) is achieved, market inefficiencies are reduced, the correct incentives are implemented and there is a reinvigorated effort to foster human capital, innovation and R&D investment. Those are key factors if the Portuguese society is willing to enhance productivity growth, and thus its living standards, in a near future.

Évora, December 2018

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Structural reforms and long-term growth – a model based analysis[1]

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ABSTRACT

This paper assesses the impact on potential growth of selected structural reforms foreseen in the 2017 Portuguese National Reform Programme. Relying on QUEST III, a dynamic stochastic general equilibrium model with semi-endogenous growth developed by the European Commission, we focus our assessment on four areas: educational attainment, incentives to innovation, employment incentives and financing of the economy. The estimates show that the implementation of the selected reforms could bring significant long-term gains in terms of potential growth, derived from a boost in investment, improvements in productivity and employment growth.

Keywords: Structural reforms, potential growth, DSGE model
JEL classification: O43, E20, E27

1. INTRODUCTION

Well-designed structural reforms are crucial to unlock growth potential and boost jobs. In Portugal, the so-called National Reform Programme (NRP) presents, in detail, the medium-term strategy to tackle the country's main structural bottlenecks.[2]

The structural measures envisaged in the 2017 NRP are organized along six pillars, namely enhancing skills, boosting innovation, promoting territorial cohesion, strengthening administrative modernisation, tackling indebtedness and reinforcing social cohesion and equity. For each pillar, there are a set of concrete structural measures.

In this paper, we estimate the effect of some of these measures on potential growth, by reform area, using a widely used tool, a dynamic stochastic general equilibrium model, a macroeconomic model with micro foundations that results from the aggregation of optimal decisions by the different economic agents. In particular, we rely on a model developed by the European Commission and

[1] The opinions expressed are those of the authors and not necessarily of the institutions.

[2] The NRP is presented by each Member State in the context of the European Semester, the cycle for economic policy coordination across the European Union, together with the Stability or Convergence Programmes, which expose the fiscal strategy for a four years period. For more information on this subject, see https://ec.europa.eu/info/strategy/european-semester_en.

calibrated for the Portuguese economy: the QUEST III model with semi-endogenous growth, which is particularly suited for this type of analysis.

There are several studies assessing the impact of hypothetical reforms, where countries close half the gap for EU or EA top performers. These distance-to-frontier assessments are important, by providing estimates of potential impact on growth of hypothetical reform efforts (see, for instance, Varga et al, 2013 for the case of Greece, Italy, Spain and Portugal and Pinelli et al, 2016, for Italy), but they entail a comparison to a setting that does not actually exist in any country (as no country is consistently the top performer in the different reform areas). Also, the optimal choice of the policy mix depends on the specificities and preferences of the different countries, which means that the best framework can be different across countries. National policy mixes differ, based on a set of efficiency and equity considerations and based on national preferences. In this context, quantification exercises of on-going reform efforts (see, for instance, European Commission, 2016) are particular important to contribute to the reform momentum and to deepen the understanding on the reform channels into the economy.

In this paper, we focus on the second approach and we rely on a model which is widely used by other European countries and by the European Commission, allowing for a more transparent methodology and an easier comparison across exercises.

The reforms covered in our analysis are those in the 2017 National Reform Programme of Portugal and for which (i) the impact on structural indicators can be quantified and (ii) it is possible to capture their effects in the context of the QUEST model (via "shocks to the model"). For instance, as argued by European Commission (2016), the model is not well suited to fully capture the effects of judicial reforms or of measures affecting the insolvency framework. An earlier exercise for the Portuguese economy (Aguiar, Ribeiro and Gil, 2017), exploring different transmission channels, estimated an impact for the increase of judiciary efficiency fairly small (output effects between 0.02% and 0.6% after 10 years, depending on the channel) and an impact of the insolvency framework improvement between 1.7% and 3.4% in 10 years.

In this exercise, further improvements of the judicial system and the reduction in red tape were, in a first stage, also included, as structural indicator estimates were available. However, the modelization strategy is that of European Commission (2014), i.e. via a reduction in entry costs inducing the estimated increase in entry rates. As the entry costs for the Portuguese economy are those of Doing Business from the World Bank and are already very low, we could not fully incorporate the estimated decrease. For this reason, we opted not to include these measures.

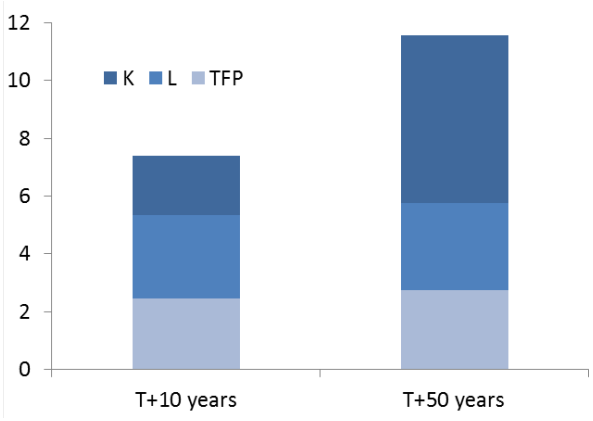
As it becomes clear from the above explanation, the fact that a measure is not included does not mean that it does not have an impact on growth. Therefore, our results provide only a partial picture of the potential outcome of the overall strategy and should be seen as illustrative of the potential growth effects.

In this context, we organize our analysis in four main areas: increases in educational attainment, promotion of innovation via R&D employment, incentives to investment via financing lines and employment incentives.[3]

The overall results for the estimated areas, presented in Figure 1, point to the relevance of pursuing the envisaged growth agenda as a way to decisively boost growth, with broad-based contributions from capital, employment and productivity.

[3] For more details on these reform efforts and for an overview of all reforms, please refer to http://www.portugal.gov.pt/pt/o-governo/pnr/pnr-2017.aspx.

FIGURE 1: SUM OF OUTPUT EFFECTS FOR THE SELECTED REFORM AREAS, BROKEN DOWN BY CAPITAL, LABOUR AND TFP CONTRIBUTIONS (%)



Source: Authors own computations using QUEST model. The figures presented are the sum of individual estimates for the selected reform areas. For presentational purposes, in this chart we consider the mean value of the two estimates computed for ALMP; for the measures providing financing to the economy, we consider that 50% of the amounts are translated into productive investment. Please refer to section 3 for further details.

2. THE MODEL

In this exercise, we use a version of QUEST III with semi-endogenous growth, as developed by the European Commission (Roeger et al., 2008 and Varga et al. 2013, for instance). QUEST III is a dynamic stochastic general equilibrium (DSGE) model, with micro-foundations that result from the aggregation of the optimal decisions of a broad set of agents, operating in a context of frictions in the financial, product and labour markets.

The model is based on the product-variety paradigm in which innovation generates endogenous productivity growth by creating new varieties of products. It is an extension of Jones (1995, 2005), with endogenous development of R&D within the framework of a standard DSGE model. Endogenous growth is driven by total factor productivity (TFP), endogenously generated by purposeful knowledge investment decisions of firms and households and technological change increasing product variety (intermediate goods). The model relates the process of technological change to the underlying market.

This type of models are widely used to estimate the impact of structural reforms on potential GDP and its components, generating results that are presented in the standard format of deviations from a "no-reform" baseline.

In the QUEST model, there are two types of households (liquidity constrained and non-liquidity constrained) that supply three types of labour according to their skill level (low, medium and high) to firms, with unions acting as wage setters in monopolistically competitive labour markets.

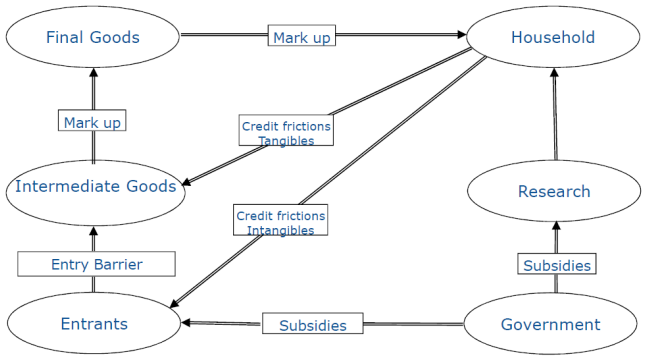
The liquidity constrained households consume their (wage and non-wage) income in each period while the non-liquidity constrained (Ricardian) (i) maximise their intertemporal utility function in consumption and leisure, (ii) buy new patents and designs developed by the R&D sector and license them to intermediate goods sector and (iii) rent tangible capital.

There are three productive sectors: R&D, intermediate goods and final goods. The R&D sector (i) employs only high-skilled workers, (ii) produce patents and new designs and (iii) features intertemporal externalities and international technology linkages. The intermediate sector operates in a monopolistically competitive market where firms (i) pay a license fee and fixed administrative costs to enter the market, (ii) use new designs to produce a unit of intermediate goods from a unit of capital and (iii) fix their prices with a mark-up over marginal costs. Finally, each firm of the final goods sector produces imperfect substitute goods (i) acting as a monopolistic competitor, (ii) using intermediate inputs and all the three types of labour and (iii) paying fixed entry costs.

Additionally, there is a monetary authority that fixes interest rates based on a Taylor rule, in response to changes in inflation and output gap. As expected, euro area members do not have an independent Taylor rule, as it is the ECB that sets the interest rate based on euro area weighted averages. Also, there is a fiscal authority that charges taxes and gives transfers, subsidies and benefits following a tax rule that forces debt convergence to target.

Figure 2 provides an overview of the model, the interlinkages between the different agents and the frictions considered.

FIGURE 2: OVERVIEW OF THE QUEST MODEL



Source: European Commission, DG-ECFIN

The model is calibrated for Portugal and also includes two other economic areas: the other euro area countries and the rest of the world, from which households and firms import and export goods and technology.

There are three main areas in which it is possible to test shocks – knowledge/innovation, product market and labour market – through a large spectrum of channels, namely R&D subsidies, investment in human capital, mark-ups, fixed entry costs, capital costs, tax-shifts, wage mark-ups, participation rates and benefit replacement rates, among others.

3. SETTING THE SCENE

Educational attainment

Portugal has considerably improved its educational outcomes in the last decade. Between 2006 and 2016, the share of those with at most lower secondary education (ISCED levels 0-2) – henceforth the low-skilled ratio – decreased by almost 19pp, from 72% to 53%. However, Portugal still lags behind its European partners. Although the gap is being progressively reduced since 2008 (Figure 3), it is still large (26 and 23pp above the EU28 and the euro area, respectively).

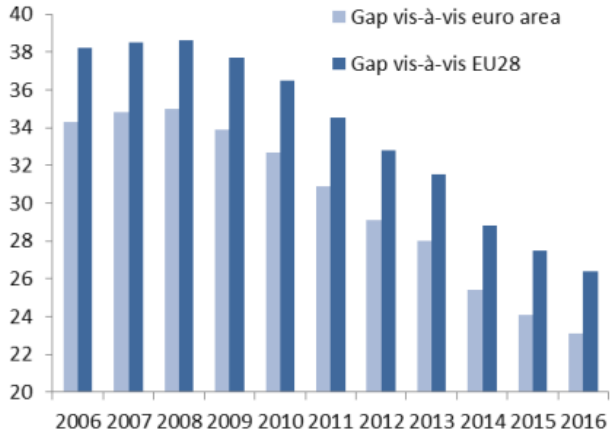
It is worth noting that the results for the younger generations are much closer to those of the EU (Figure 4). However, the legacy of the older generations, with worse educational attainment, can only be overcome with time, as earlier cohort effects fade out.

It is therefore crucial that the country maintains the positive path achieved so far. In this vein, the 2017 National Reform Programme includes a number of measures aimed at increasing educational attainment such as (i) the promotion of the generalization of secondary education, namely through the diversification of the training offers, including vocational education; (ii) the modernisation of the education system, based on digital education resources, in order to innovate learning, manage, monitor and evaluate information and promote digital skills development; and (iii) the reinforcement of the support for disadvantaged students and the promotion of educational attainment, namely through the National Programme for the Promotion of Educational Attainment, the generalisation of the pre-school education since the age of 3, the gradual gratuity of the schoolbooks, the limitation of

the number of students per class, among other measures, aiming to reduce retention and early withdrawal.

The goal of these measures is to reduce dropouts (from 14% to 10% by 2020) and failure rates (retention at 15 years old from 35% to 25% by 2020), reaching a ratio of low-skilled of 50% by 2020.

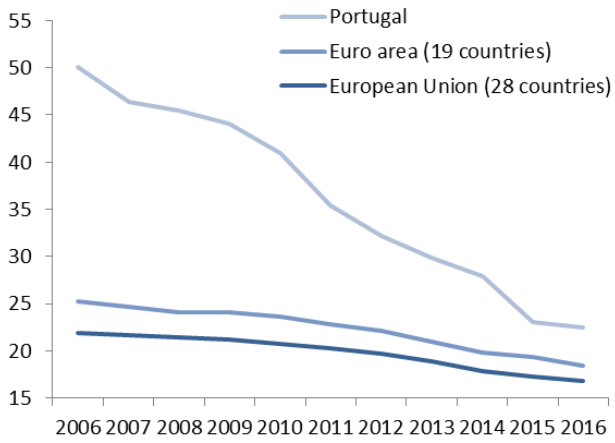
FIGURE 3: SHARE OF LOW-SKILLED IN THE POPULATION AGED 15 TO 64 YEARS OLD



Source: Eurostat

Notes: Low-skilled defined as ISCED levels 0-2 – Less than primary, primary and lower secondary education. The gap is the difference between the share for Portugal and the one for the reference area.

FIGURE 4: SHARE OF LOW-SKILLED IN THE POPULATION AGED 20 TO 24 YEARS OLD



Source: Eurostat

Notes: Low-skilled defined as ISCED levels 0-2 – Less than primary, primary and lower secondary education.

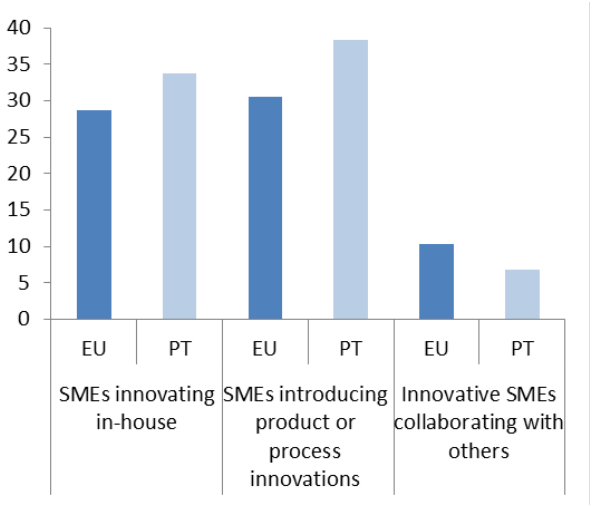
Incentives to Innovation

Portugal is a high-performing country in a number of important innovation related variables.[4] For instance, and despite the weaknesses in the qualifications of its labour force (as discussed in the previous sub-section), the number of new doctorates per 1000 population aged 25-34 clearly outperforms the EU, with a figure of 3.1 vis-à-vis 1.8 (2015 data). The number of international scientific co-publications per million population has more than doubled since 2008 and is, in 2015, 795 (459 in the EU).

[4] Data in this section are sourced from the Innovation Union Scoreboard of the European Commission.

It is important to understand if these innovation enhancing variables translate in actual innovative activities. While the share of SMEs innovating in-house and that of small and medium enterprises (SMEs) introducing innovations is high for EU standards (Figure 5), the collaboration between them has scope for improvement (7% vis-à-vis 10%). This is even more pronounced in terms of public-private partnerships, with the number of co-publications per million population significantly lagging behind its EU partners (7 and 34, respectively).

FIGURE 5: SHARE OF SMES ENGAGING IN INNOVATIVE ACTIVITIES (2015)



Source: Innovation Union Scoreboard, European Commission

This lack of interconnections translates in comparably low levels of employment in knowledge-intensive activities, modest results in terms of PCT (Patent Cooperation Treaty) patents applications per billion GDP and a wide scope for improvement in terms of the share of medium and high-tech product and knowledge-intensive services exports.

To overcome the existing bottlenecks, the 2017 National Reform Programme outlines a number of measures potentiating the employability of recent doctorates and collaborative innovation. Examples of these measures are (i) stimulus to higher education success through pedagogical monitoring and modernisation, to reduce drop out; (ii) stimulus to scientific employment in universities and research centres, by hiring young professors/researchers with doctorates; (iii) the Interface Programme, aiming at the development of R&D capacity in firms trough Collaborative Laboratories and Technological and Engineering Centres together with Business Innovation Contracts, also fostering the collaboration between firms and universities and strengthening the capacity of research centres; (iv) scientific and technological infrastructure re-equipment, fostering businesses internationalisation; (v) the CapaCITar Programme, supporting innovation centres and promoting the increase of competitiveness by the hiring of qualified personnel. These measures are expected to increase scientific employment by nearly 8500 until 2020.

Employment incentives

Unemployment rates have been steadily declining since the peak in 2013 (16.2%), reaching 11.1% in 2016 (9.5% in April 2017, the most recent data available). Despite the positive path, unemployment is still high, in particularly for the youth (28.0% in 2016, after a reduction of 10.1pp after the 2013 peak). Long-term unemployment is also decreasing since 2013 but is still at 6.2% in 2016, affecting more than half of the unemployed.[5]

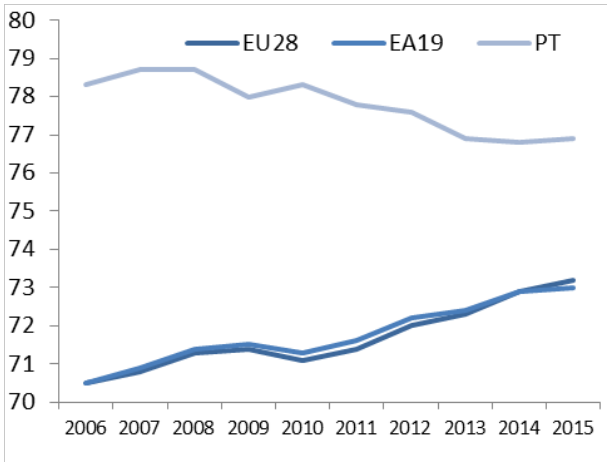
These developments contribute to discourage work. Indeed, participation rates, although high in relative terms, presented a declining trend up to 2014 (even more pronounced for those with lower

[5] Data sourced from Statistics Portugal (INE).

skills), which contrasts with the positive trend in the EU and euro area (Figure 6). The decline was recently interrupted and participation is again improving.

The NRP includes a set of measures to promote participation and tackle youth and long-term unemployment. In our assessment, we focus on a sub-set of measures, namely (i) *Contrato Emprego*, through the allocation of financial support to hire registered unemployed, privileging open-ended contract, and (ii) professional internships, aiming to insert youth in the labour market and to the retrain long-term unemployed, including thought financial support when companies hire trainees after the traineeship, which are expected to increase employment by 2.25pp by 2020 (cumulative effect), due to both direct employment effects and to the increased employability of those benefiting from these programs.

FIGURE 6: ACTIVE POPULATION AS A SHARE OF ACTIVE AGE POPULATION



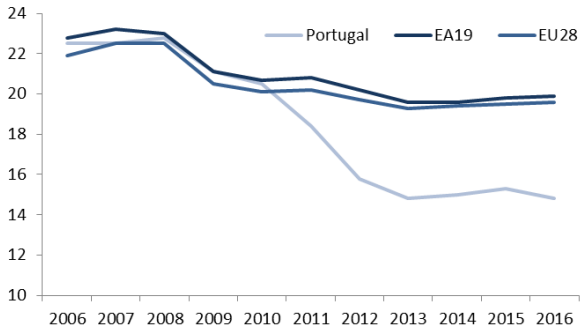
Source: Pordata based on Eurostat
Note: There is a break in the series in 2011

Financing the economy

Gross fixed capital formation decreased sharply between 2008 and 2013. Despite the modest recovery in 2014 and 2015, in 2016 the investment was still below 15% of the GDP, lagging behind EU and euro area averages of around 20% (Figure 7). While there are important composition effects, due to a reallocation of resources in the aftermath of the crisis, boosting investment is a policy priority.

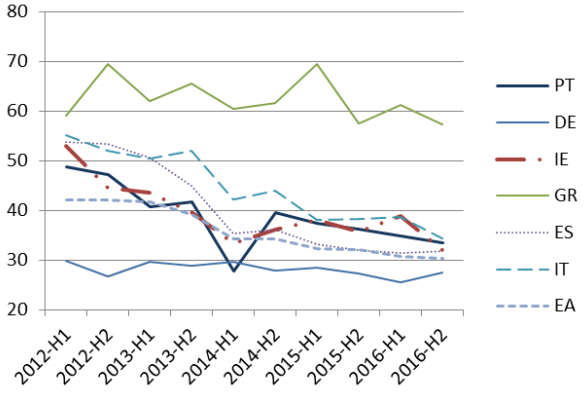
The share of SMEs reporting access to finance as a significant problem has decreased sharply since 2012. However, in Portugal like in other euro area countries, there are still one-third of SMEs reporting access to finance as an important issue for their companies (Figure 8).

FIGURE 7: GROSS FIXED CAPITAL FORMATION, % OF GDP



Source: Pordata based on Eurostat

FIGURE 8: PERCENTAGE OF SMES SIGNALLING ACCESS TO FINANCE AS AN IMPORTANT PROBLEM



Source: Survey on the Access to Finance of Enterprises (SAFE), ECB

Indeed, the 2017 NRP foresees a broad package of measures targeting investment, promoting innovation and fostering firms' capitalisation. Examples of these programmes include Capitalizar Fund, Start-up Portugal Programme and Indústria 4.0. The funds made available to firms until 2020 through the investment lines amount to 2.75% of GDP.

4. METHODOLOGY AND RESULTS

As it is common in this type of exercises (e.g. European Commission, 2016), we depart from actual reform measures and translate them into structural indicators that feed the macroeconomic model. This mapping may be direct, for instance in the case of education reforms which improve the skills ratio, or indirect, as in the case of innovation, where the wage subsidy to R&D workers is adjusted in order to achieve the estimated impact on R&D employment.

Table 1 summarizes the reform areas and methodological approach followed, which are further discussed in the following sub-sections.

There are different options in the literature concerning the modelization of budgetary costs of the measures. Given the information available on the measures being modelled in this paper, we consider that in the short- to medium-run there is no budgetary implication, as the potential costs of the reforms are financed through a reorganization of existing funds. In the longer-run, we consider a debt stabilizing rule, ensuring that debt to GDP ratio is kept constant.

TABLE 1: MODELLING STRATEGY BY REFORM AREA

Reform area	Input	QUEST modelling strategy
Educational attainment	Reduction of the share of population with low-skills	Direct via the reduction of low-skilled share and increase of medium-skilled share
Incentives to Innovation	Increase in R&D employment	Indirect via an increase in the subsidies to R&D wages such that the model delivers the estimated increase in R&D labour
Employment incentives	Increase in employment	Option A: Indirect via an increase in participation rates resulting in the expected increase in employment Option B: Indirect via a decrease in the tax on labour income inducing the expected increase in employment
Financing of the economy	Total amounts of funds available in the form of financing lines	The reduction of the cost of capital such that the model delivers the potential increase in investment, considering different degrees of take-up of the available funds

Source: authors' own elaboration

Educational attainment

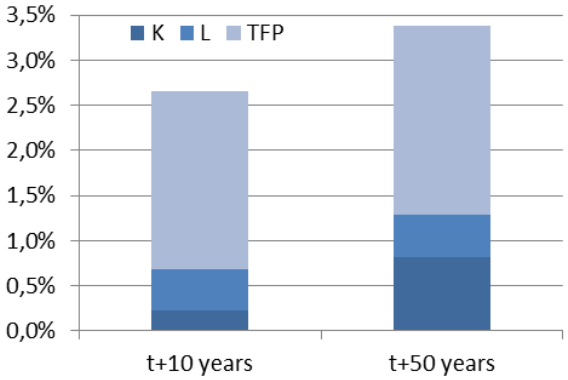
The educational reforms described in Section 3 can be directly modelled in QUEST by reducing the share of low-skilled to 50% and correspondingly increasing the share of medium skilled.[6]

Given that the model is calibrated with 2015 data, this implies a gradual reduction of 4pp until 2020. The outcome is an improvement of GDP by 2.7% after 10 years and of 3.4% after 50 years. As expected, these gains are mainly driven by total factor productivity improvements, although there are also employment and investment gains (Figure 9).

The intuition behind these results is as follows: the higher supply of medium skilled workers decreases their skill premium and implies lower relative wages for this group of workers. Given the imperfect substitution between different types of workers, relative wages for the low-skilled increase, given that they are relatively scarcer. This brings overall employment gains. The larger availability of medium-skilled workers, who are more productive, increases productive efficiency, bringing TFP gains. In addition, as capital and labour are complements, investment also increases.

[6] Low-skilled correspond to the standard classification of ISCED 0-2 education levels while high-skilled are human resources in science, mathematics and computing, engineering, manufacturing and construction. Medium-skilled correspond to those not classified as high-skilled or low-skilled in the model.

FIGURE 9: OUTPUT EFFECTS OF EDUCATION RELATED MEASURES, BROKEN DOWN BY CAPITAL (K), LABOUR (L) AND TOTAL FACTOR PRODUCTIVITY (TFP) CONTRIBUTIONS



Source: Authors own computations using QUEST model

Incentives to Innovation

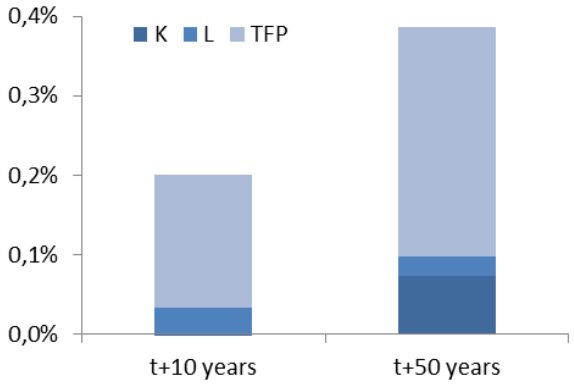
Given the policies being implemented and the possibilities of the QUEST model, the starting point of our estimate is the number of direct R&D employment opportunities created up to 2020. We translate this into the model as an increase in the share of workers allocated to R&D activities. Another option would have been to model this as an increase in the share of high-skilled workers (reducing that of medium and low-skilled). We opted for the first approach given that these policies are primarily aimed at shifting human resources to R&D activities rather that increasing the overall number of doctorates.

Given that the share of R&D labour in the model is endogenous, and considering the nature of the policies being implemented, we model this change as an increase in the government' subsidy to high-skilled workers wage in the R&D sector.[7] Note that in QUEST, high-skilled labour can be allocated to the final goods production or the R&D sector. A wage subsidy in the R&D sector reduces the costs in the sector and increases high-skilled labour allocated to R&D, fostering innovation. The increased supply of patents implies new intermediate varieties, lowering entry costs and increasing mark-ups in this sector, turning it more profitable and boosting output.

Indeed, after 10 years, output is expected to expand by 0.2% vis-à-vis the baseline scenario and by close to 0.4% after 50 years (Figure 10). As expected with innovation-related reforms, most gains are due to the TFP contribution. Employment gains are rather limited, given the reduced weight of R&D employment on total employment and the fact that an increase in high-skilled workers in R&D sectors reduces their availability in the final goods sector.

[7] An alternative would be to consider an R&D subsidy in the form of tax credits, as done, for instance in Pinelli et al (2016). The results are broadly similar: 0.14% in 10 years and 0.50% after 50 years.

FIGURE 10: OUTPUT EFFECTS OF INNOVATION RELATED MEASURES, BROKEN DOWN BY CAPITAL, LABOUR AND TFP CONTRIBUTIONS



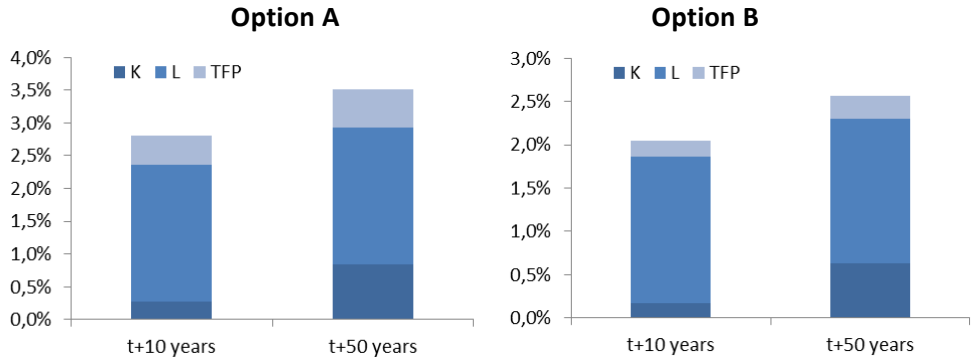
Source: Authors own computations using QUEST model

Employment incentives

Given the outset of our model, we consider two alternative modelling strategies[8]. The first assumes that the labour market reforms described above have a direct positive impact on participation rates (of low and medium-skilled agents), inducing the estimated change in employment.

Increasing the participation rate will increase competition in the labour market, pressuring wages of low and medium-skilled workers downwards and fostering employment. The operating costs of the final goods sector decrease, increasing the demand for new varieties and, consequently, for new patents, thus promoting growth.

FIGURE11: OUTPUT EFFECTS OF LABOUR-MARKET MEASURES, BROKEN DOWN BY CAPITAL, LABOUR AND TFP CONTRIBUTIONS



Source: Authors own computations using QUEST model

The other option assumes that the measures envisaged work as an incentive to labour supply, which we mimic in the model by lowering the tax on labour (in an amount that allow us to reach the expected employment change).

The increase in after tax wage income increases the cost of leisure and thus increases the incentives to work for all skill groups, leading to an increase of labour supply and a decrease in wages. As in the

[8] A third option would have been to reduce leisure incentives by decreasing the unemployment benefit replacement rate, increasing labour supply. However, our modelling strategy reflects more closely the type of reforms being implemented given the structure of our model.

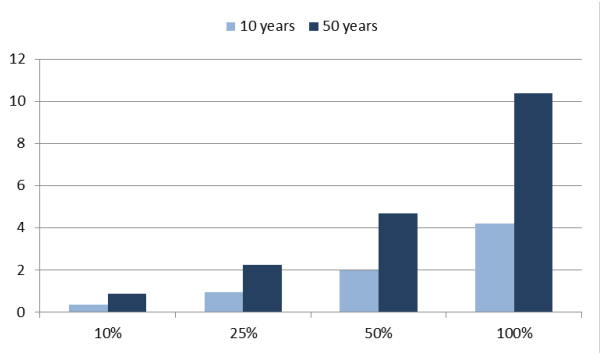
first option, this decreases operating costs for final goods production and therefore demand for new intermediate varieties, resulting in more patents and R&D.

The results point to an effect on GDP between 2.1% and 2.8% after 10 years and between 2.6% and 3.5% after 50 (Figure 11). While up to 2020 the two options deliver the same employment gains, as the model adjusts the further increases in employment are higher in Option A as it leads to a stronger reduction in wages.

Financing of the economy

Given the outset of the model, we calibrate the risk premium for investment on tangible assets such that we reach the potential boost in investment. Given that the uptake of the funds is not yet known, we consider different scenarios. Broadly speaking, according to our estimates, for each 10pp of invested funds, GDP would grow by around 1% vis-à-vis a no policy change scenario (Figure 12). As expected, the largest share of GDP gains is due to capital accumulation (Figure 13).

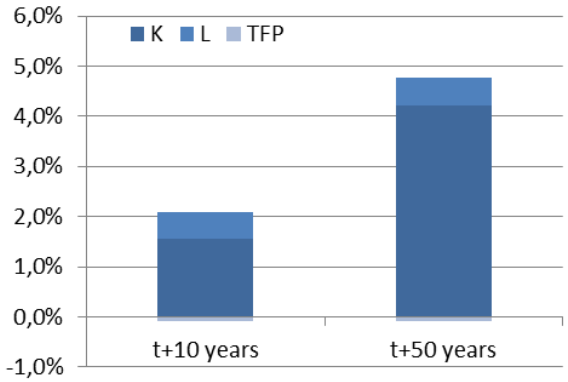
FIGURE 12: OUTPUT EFFECTS OF FINANCING MEASURES, BY PROPORTION OF FINANCING CONSIDERED



Source: Authors own computations using QUEST model

Intuitively, the reduction of tangible capital costs decreases the rental rates for tangible capital, reducing the operating costs in the intermediate sector, increasing supply and boosting demand for new varieties. This, in turn, increases the production of patents, increasing output growth.

FIGURE 13: OUTPUT EFFECTS OF FINANCING MEASURES, BROKEN DOWN BY CAPITAL, LABOUR AND TFP CONTRIBUTIONS



Source: Authors own computations using QUEST model

5. CONCLUSION AND WAY FORWARD

This paper provides an assessment of the impact on potential growth of selected reform areas. Unlike some other studies in the same field, we do not focus on hypothetical reform plans (e.g. closing half the gap vis-à-vis top performers) but on actual reform measures, already foreseen by the national authorities.

In that context, taking into account the availability of estimates of underlying structural indicators and the channels foreseen in the QUEST model, we estimate the impact on potential growth of a sub-set of measures included in the 2017 Portuguese National Reform Programme, organizing them around four main areas: educational attainment, incentives to innovation, employment incentives and financing of the economy.

The estimated effects, summarized in Table 2, highlight the relevance of fully implementing the envisaged reform strategy, given the significant growth impact. Earlier studies have also provided evidence of the relevance of a well-targeted reform agenda to boost growth (see, for instance, European Commission, 2016 or Aguiar, Ribeiro and Gil, 2017).

TABLE 2: SUMMARY OF THE ESTIMATED IMPACT ON GDP, BY POLICY AREAS

Effects		Policy Area			
		Educational attainment	Incentives to innovation	Employment incentives	Financing of the economy
GDP growth	t+10 years	2.7	0.2	2.1-2.8	2.0
	t+50 years	3.4	0.4	2.6-3.5	4.7

Source: Authors own computations using QUEST model. The figures reported for the financing of the economy assume that 50% of the available funds are translated into productive investment (for different options, see Section 4).

It is important to note that, for several reform measures, it is not possible to reliably estimate the foreseen impacts on the structural indicators that can then be used as inputs in the model. Examples of measures not included are those related to administrative simplification (SIMPLEX+), promotion of digital skills, adults qualifications, territorial cohesion, among others. This does not mean that they would not have an important impact on growth.

Even in the cases where this is possible, there is an important degree of uncertainty surrounding the structural indicators estimates and their translation as inputs into the model that needs to be acknowledged. Our estimation tool is a model which, by its very nature, is a simplification of reality and thus cannot capture all types of reforms nor the full range of the effects of the measures for which an estimate is actually made.

For instance, in the case of education, we focus on quantity changes from low to medium skill. However, there are also quantity effects from further increases in the share of high skilled or from boosts in quality, which could not be quantified in this exercise and that are likely to be high. Also, while we account for the impact of digitalization on school attainment, the full impact of the digitalization strategy is much broader.[9]

Finally, the analysis presented for each reform area is *ceteris paribus*, i.e. assumed that all other reform areas are kept unchanged. In reality, there are spillovers across reforms areas that call for an adequate sequencing and bundling of reform efforts (e.g. incentives to R&D may boost innovation and therefore render the use of available funding for investment more efficient).

Also, the modelling strategy assumes that reforms in all other countries are kept constant. However, this is not the case in reality and, as described in Varga and In't Veld (2014), there are different types of spillovers at play, namely demand spillovers, competitiveness effect, international financial flows

[9] For instance, concerning the share of high-skilled in Portugal, Varga et al (2013) estimate that the impact of closing half the gap for top performers in the EU would be, in the long-run, 5.8%. Also, Aguiar, Ribeiro and Gil (2017) estimate that the schooling quality improvement in Portugal from 2010 to 2012 increased potential growth by 0.12% in 10 years and 0.74% in the longer-run. Lorenzani and Varga (2014) estimate that the impact of the Digital Agenda for Europe in the long-run would entail additional 3% of GDP growth for Portugal over the baseline, on top of the 1% already achieved from past efforts (respectively, 0.5% and 1,7% in 10 years).

and knowledge spillovers. Although they act in different directions, the authors estimate that the joint implementation of reforms further increases the overall GDP impact.

Finally, we do not focus on distributional considerations, which are a key ingredient for a proper assessment of the impact of reforms. While the model allow us to have a rough estimate of these effects – for instance, in the case of educational attainment reforms, increasing the share of medium-skilled workers relatively to that of low-skilled improves the wages of low-skilled, given the imperfect substitutability between skill types – a more thorough and robust assessment is only possible with an extension of the model, further exploring differences across households.

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Corporate Leverage and Investment in Portugal[10]

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ABSTRACT

This analysis aims at assessing the decrease of investment induced by an increase in debt of an excessively indebted corporate sector in Portugal, testing empirically the relationship between corporate indebtedness and investment. The results show evidence of a negative relationship between firms' investment-to-capital ratio and their indebtedness over the period 2010-15. This type of relation between these variables suggests the need for companies to deleverage. Results also point to asymmetric effects beyond a certain threshold level of indebtedness, namely a debt-to-asset ratio of 45.6%, because greater access to debt can help increase investment levels, but excess leverage can reverse these benefits by raising corporate vulnerabilities. Relationship between debt and investment was also tested along firm sector to deepen the role of firm sector heterogeneity and a negative relationship was also found in the three major sectors (*Wholesale and retail, Manufacturing and Construction*).

Keywords: Corporate debt, leverage, investment, threshold.
JEL classification: E22, F34, G31, G32

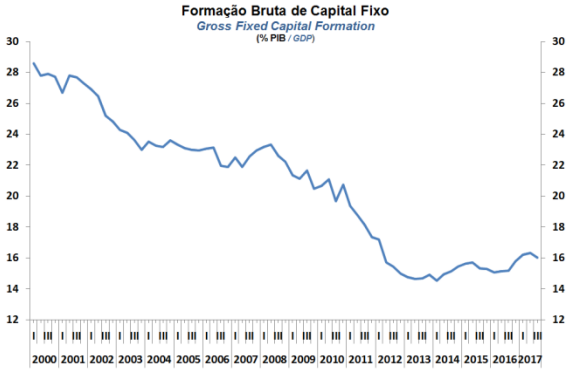
1. INTRODUCTION

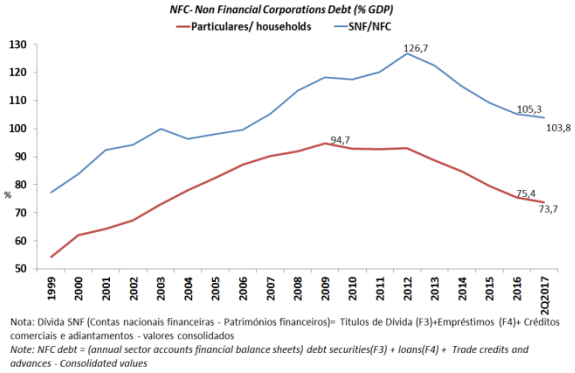
The Indebtedness of Portuguese non-financial corporations grew significantly since the accession of Portugal to the Euro Area. This is mainly the reflection of the sharp reduction in interest rates resulting from the convergence process which led to a noticeable increase in lending - an idea that is corroborated by Gebauer et. al (2017) which stands that corporate debt increased rapidly in many peripheral euro area countries in the years before the financial crises and the build-up of debt was largely driven by easy access to credit.

Following the global crisis and the sovereign debt crisis suffered by the peripheral euro area countries, the financing conditions of Portuguese companies deteriorated sharply (interest rates faced by Portuguese companies increased strongly in 2011 and 2012 and ECB Survey on the Access to Finance of Enterprises results also pointed out to a more restrictive credit offer in Portugal between

[10] The opinions expressed are those of the authors and not necessarily of the institutions.

2009 and 2012) which had a recessive impact on the economy, notably through the contraction of investment.





This analysis aims to be an econometric exercise that intends to assess the decrease of investment induced by the increase in corporate sector debt in Portugal, testing empirically the relationship between corporate indebtedness and investment. This objective stems from the fact that there is no agreed method of measuring over-indebtedness and the size of deleveraging needs, discussion for which we hope this study will contribute to.

Using firm-level data, our empirical results show evidence of a negative relationship between firms' investment-to-capital ratio and their indebtedness over the period 2010-15. This type of relation between these variables suggests the need for companies to deleverage.

Results also point to asymmetric effects beyond a certain threshold level of indebtedness. The reason is that greater access to debt can help increase investment levels, but excess leverage can reverse these benefits by raising corporate vulnerabilities.

This paper is organized as follows: section 2 presents the theoretical framework of the analysis, section 3 the adopted methodology, section 4 describes the data and presents the descriptive analysis, section 5 shows the empirical results and section 6 presents conclusion remarks.

2. LITERATURE REVIEW

Assuming a world with perfect capital markets, a neoclassical approach reflecting Modigliani-Miller theorem (1958), capital structure does not affect investment decisions. However, market failures, as asymmetrical information between firms and financial intermediaries, establish a link between the corporate financial standing and investment. Firms with weak balance sheets may have limited availability of external financing and are, thus, more likely than financially healthy firms to experience large contractions in investment (Goretti and Souto, 2013).

The literature on the relationship between corporate indebtedness and investment is significant. Some authors sustain that the need to repair balance sheet weaknesses to make financing costs lower may lead to increasing savings to the detriment of investment (Myers, 1977). Similar works as Fazzari et al. (1988) provide empirical results of linkages between financial ratios and investment interpreting this as being consistent with the presence of financing constraints on the investment of firms. Also, Farinha (1995) concludes that the availability of internally generated funds affects investment decisions of firms (except for large firms), Kyotaki et al. (1997) show that increases in leverage could lower investment and Barbosa et al. (2007) found a negative relation between firms financial pressure and their investment. Also Cecchetti et. Al (2011), ECB (2013) and Kalemli Ozcan et al. (2015) point out that corporate indebtedness in euro area countries inhibits investment when debt levels are excessively high. Several other empirical studies find evidence that high corporate leverage can have negative effects on investment (such as Benito and Hernando, 2007, Martinez-Carrascal and Ferrando, 2008; Pal and Ferrando, 2010; Barbiero et al., 2016).

Other branches of the literature focus on the additional accelerating effects of sales and financial factors on investment. The latter draw attention to the aggravation of the adverse shocks to the

economy made by the worsening of credit market conditions. Based on the work of Fazzari et al. (1988) and Bernanke et al. (1999), Vermeulen (2000) find evidence of a financial accelerator effect and shows that weak balance sheets tend to raise adverse shocks on firm investment. The analysis of Farinha (1995) and Barbosa et al. (2007), using a sales-accelerator specification, also show that firms financial structure affect their investment decisions.

Deepening the complexity of the relationship between indebtedness and investment, in addition to identifying the existence of a relationship between companies' balance sheet and their level of investment, some literature shows that this relationship is not linear. The rationale combines literature of the negative effect of debt on investment and some literature that identifies potentially positive effects of debt on investment, since not only debt allows to finance investment projects debt may it can also give rise to tax advantages as compared to other sources of financing (Modigliani and Miller, 1963) and it can reduce internal costs incurred from asymmetric information or conflicts of interest between shareholders and managers (Ross, 1977; Grossman and Hart, 1982). Commonly this literature stands that there is a threshold effect. Jaeger (2003) finds leverage effects on corporate investment for Germany and the US, particularly if leverage exceeds a certain threshold. Gunduz (2004) investigates potential leverage threshold effects of Portuguese firms finding strong evidence that the firm' balance sheet composition has an impact on investment. Hernando and Martinez-Carrascal (2008) provide firm-level evidence for Spanish firms of threshold effects, indicating that a negative impact of indebtedness on investment exists only above the 75th percentile of indebtedness. Coricelli et al. (2010) identifies a threshold level of leverage (for a group of emerging European countries) beyond which further increases in leverage lower TFP growth. Cecchetti et al. (2010) based on a sample of 18 OECD countries find evidence that corporate debt becomes a drag on growth for levels beyond 90 percent of GDP. Goretti and Souto (2013) assess the drag on investment engendered by corporate sector debt overhang in periphery countries and find a negative relationship between firms' investment-to-capital ratio and their debt but also a non-linear behavior of the interaction of these two variables (finding strongly negative effects of debt on investment once the debt to equity threshold exceeds the 25th percentile). Gebauer et. al (2017) find a threshold effect on euro area periphery (that was innovative by deriving the threshold with statistical inference instead of testing it in a exogenously determined way) above a debt-to-asset ratio of 80-85 percent.

3. METHODOLOGY

We propose to empirically test the relationship between investment and corporate sector balance sheet in Portugal, in the period 2010-2015. Our analysis is based on the work by Goretti and Souto (2013) and we follow a panel-data approach to test if firms' investment decisions are affected by their financial structure. We also use a panel data approach to test for the existence of non-linearities in the relationship between investment and debt if this exceeds certain threshold levels. The specification for our investment equation is as follows:

$$IK_{it} = \alpha + \beta IK_{it-1} + \gamma SK_{it-1} + \overline{\delta} D_{it-1} I\{D_{it-1} \geq \tau\} + \underline{\delta} D_{it-1} I\{D_{it-1} < \tau\} + \varepsilon_{it}$$

IK_{it} (Investment to Capital Ratio)

IK_{it-1} (Lagged Investment to Capital Ratio)

SK_{it-1} (Lagged Sales to Capital Ratio)

D_{it-1} (Lagged Debt)

$I = \{1 \text{ if } D_{it-1} \geq \tau; 0 \text{ if } D_{it-1} \leq \tau\}$-

i – Index firms

$\tau - \text{Threshold}$

t – time period

The dependent variable IK is the investment-to-capital ratio (gross investment in tangible assets over tangible assets). Debt is proxied by the standard leverage measure debt to assets and also

(alternatively) by ICR (Interest Coverage Ratio - EBITDA over total interest expenses), since there is no commonly agreed method to measure over-indebtedness (Gebauer et al, 2017). The specification includes the lagged sales-to-capital ratio SK (turnover over the tangible assets) to control for sales-accelerator effects.

The coefficient δ is the parameter that measures the sensitivity of the investment rate to changes in the debt variable. Rejecting the null hypothesis (δ equal to zero, underlying the perfect capital market theory) indicates that firms' investment decisions are affected by their financial structure. The coefficient sign is expected to be negative.

Since the specification of the model introduces lag of the dependent variable to control for endogeneity, the standard fixed effect estimator is inconsistent. Following Goretti and Souto (2013), in order to address this issue, we use the GMM two-step system estimator by Blundell and Bond (1998), and we apply Roodman (2003) stata module. Applying first differences to the initial specification removes the fixed effects and produces an equation that can be estimated by instrumental variables (we used lags of the independent variables as instruments).

The Generalized Method of the Moments (GMM) consists of the determination of θ (a vector of parameters to be estimated) that minimizes $\bar{g}$ (an objective function) so it estimates the parameters that better approximate this function to zero (the closer to zero this function is, the more optimized will be the vector of parameterers to be estimated). Two sets of variables that can explain the behavior of Y (in this case Investment) are considered, the first denoted by X (the dependent variables), which values can be perfectly observed, and the other defined by Z which corresponds to the instrumental variables, i.e., those which are correlated to explanatory variables of Y but which values are not easily observable.

In these assumptions, Y conditioned to X, Z and θ follow a certain statistical distribution. Usually the Gaussian is the most common. $g(Y, X, Z, \theta)$ is defined as a function (not necessarily linear) on the variables and the parameters, for which the expected value is always equal to zero as shown below:

$$E[g(Y, X, Z, \theta)] = 0$$

For the method of the moments theory, the estimator of $E[g(Y, X, Z, \theta)]$ is given by

$$\bar{g} = \frac{1}{T}\sum_{t=1}^{T} g(Y_t, X, Z, \theta)$$

Relative to the estimation of the threshold we followed the work by Girma (2005) that introduces a threshold regression approach due to Hansen (1996). We follow this methodology that consists of a minimization problem (conditioned to the significance of the parameters and signal change) solved by a grid search over the following 393 quantiles $\{1.00\%, 1.25\%, 1.50, \ldots, 98.75\%, 99\%\}$, but instead of using the conditional OLS we chose, following Hwan (2014), the GMM criterion function J given by:

$$J = T\bar{g}_T' W_T \bar{g}_T$$

Given the variable Y (Investment) observed at different moments of the time $t = 1, 2 \ldots T$. and W_T the weighted matrix that initially equals the identity matrix (or any positive definite matrix).

Also, we allow for the threshold variable $D_{it-1}$to be endogenous, and develop a two-step GMM estimation. The vector (with dimension 6 – 2010 a 2015) of the sample moment conditions is given by[11]

$$\bar{g}_n(\theta) = \frac{1}{n}\sum_{i=1}^{n} g_i(\theta)$$

The moment equation is $g_t(\theta) = x_t\left(y_t - x_t'(\theta)\right)$ and W_T is the weighted matrix that initially equals the identity matrix (or any positive definite matrix, as previously mentioned).

[11] T-Number of periods. $\overline{g_n}(\theta)$- Average of $g_t(\theta)$

The one step GMM takes $W_T = I$ and computes a preliminary GMM estimate. The two-step GMM evaluates the weighting matrix several times until the estimator achieves asymptotic efficiency. Essentially, the idea of GMM is to set the vector $\bar{g}_T$ to zero for some W_T, minimizing J.

4. DATA AND DESCRIPTIVE ANALYSIS

This analysis uses INE microdata of Integrated Enterprise Accounts System (SCIE) database (information from Informação Empresarial Simplificada - IES) which collects balance sheet and financial statements from all Portuguese corporate firms in the Portuguese Economy. The analyzed period is 2010 until 2015.

One of the main benefits of using IES microdata is the possibility of capturing the heterogeneity of the different companies. It allows to analyzing not only average effects but also to perform a more detailed analysis, in which asymmetric effects on subgroups can be analyzed.

We focus on private non-financial indebted firms (self-employed individuals were excluded) and removed all firms that have less than five workers (following Barbosa and Pinho, 2016). We include firms belonging to 12 sectors (see annex for further detail) covering the primary sector, manufacturing, construction, trade and service industries. Observations that did not have positive values of debt, tangible fixed assets and interest paid were removed from the database. Observations with negative total assets or negative business turnover were also dropped. Firms that did not appear in the dataset for a minimum of three consecutive years were removed (following Barbosa et al. (2007) and Farinha (2013)). For econometric purposes (according to Farinha et al. (2013)) only firms with positive gross operating income (measured by EBITDA) were considered. This condition is necessary in order to preserve the monotonicity of the relation between the interest burden ratio and firms' financial standing - the interest burden resulting from a negative operative income with a large absolute value is lower than the interest burden resulting from a negative operating income with a small absolute value.

Also, following Farinha et al. (2013), to deal with outliers and extreme variations, we excluded firms that had an increase in fixed assets of more than 500% or a decrease bigger than 75%. Furthermore, observations below (and above) the 5th (and 95th) percentile of the relevant variables were winsorized. Consequently, the data used in this study are an unbalanced panel of 118.213 observations, corresponding to 30.921 firms observed in the period between 2010 and 2015.

TABLE 1: SUMMARY STATISTICS OF REGRESSION VARIABLES

Summary Statistics of regression variables

	Mean	Std. Deviation	25th Percentile	Median	75th Percentile
IK: Investment to capital ratio	0,19	0,24	0,01	0,09	0,29
SK: Sales to capital ratio	12,8	18,3	2,3	5,2	13,6
DA: Debt to asset ratio	0,28	0,17	0,13	0,26	0,40
ICR: Interest Coverege Ratio	23,3	38,2	3,3	7,6	21,4

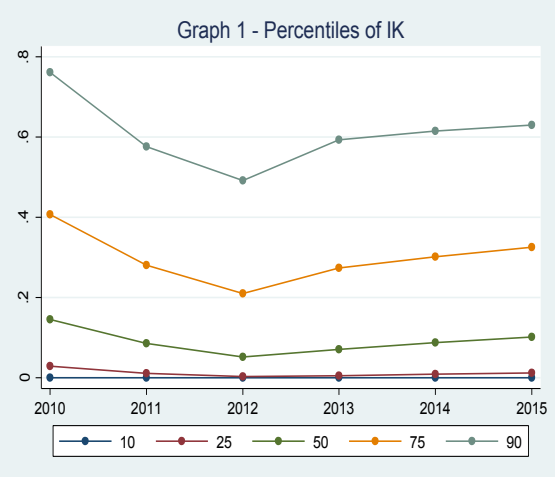
Note: IK: Investment to capital ratio (gross investment in tangible assets over tangible assets); SK: Sales to capital ratio (turnover over tangible assets); DA: Debt to assets ratio (financial debt over total assets); ICR: Interest coverage ratio (EBITDA over total interest expenses).

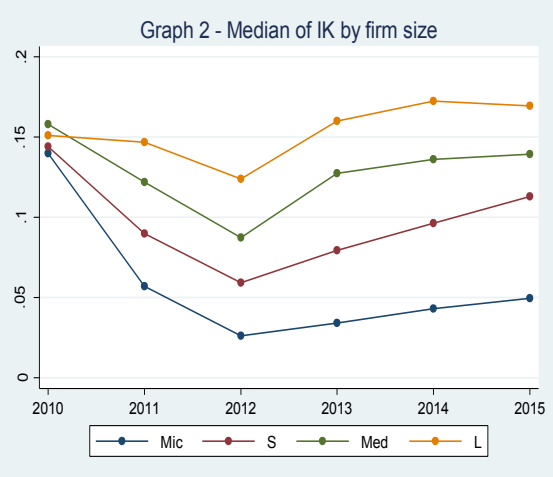
This section is divided into two parts. The first one aims to present the overall behavior of the variables in study whereas the second part intents to graphically illustrate possible relationships between the hypothetical explanatory variables and the investment level.

To understand how each indicator behaves, two graphs were plotted for each variable. The first one presents the percentiles 10, 25, 75 and 90, as well as the median for time spanned between 2010 and 2015. This illustration is especially relevant when variables follow asymmetric distributions as it is known to happen with financial ratios. The second graph will consider the median by year of each variable given the size of the firm (micro, small, medium and large).

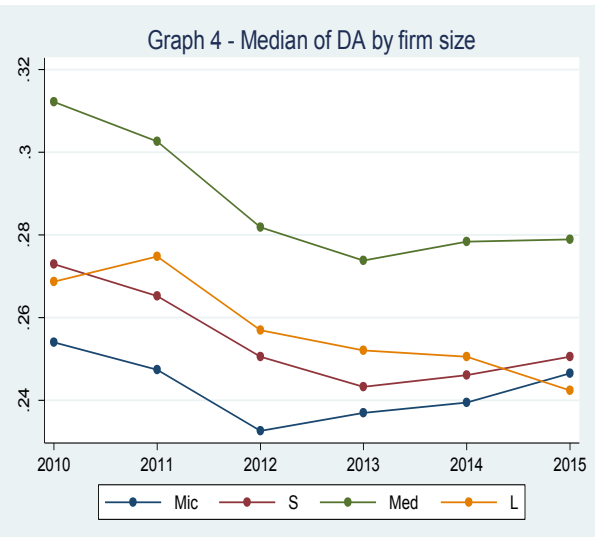
Graph 1 shows that the Portuguese firms with the 10% and 25% lower investment values tend to have almost null investment ratios. For the other percentiles it is noticeable a sharp decrease

between the years of 2010 and 2012, with a slight rebound thereafter. The spread between the firms with the lower and the higher levels of investment was in 2015 narrower than it was in 2010. Graph 2 presents a slightly different picture. If in Graph 1, every type of firm had a similar decrease, Graph 2 hints that the bigger the firm, the more able it was to deal with the crisis. So much so that if in 2010 small, medium and large firms had roughly the same median level of investment, in 2015 there is a clear stratification by size.



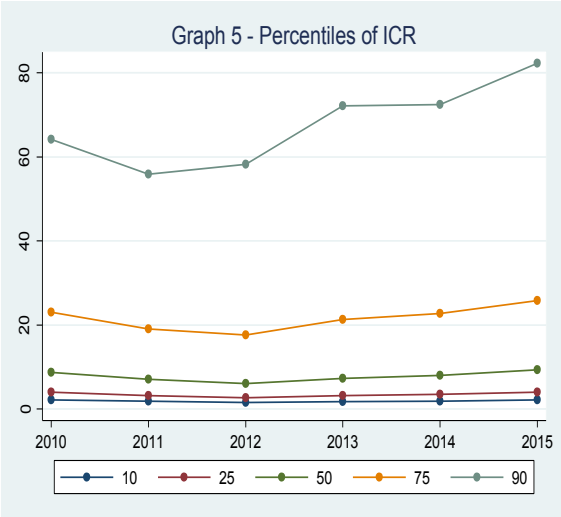


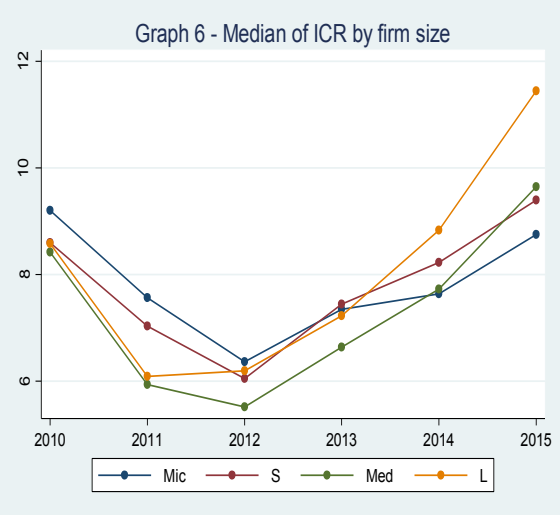
The next two pair of graphs displays the indebtedness level as measured by the debt to assets ratio. Graph 3 and 4 show the slow deleveraging of Portuguese firms, especially noticed in the latter graph. Furthermore, the latter also shows that this deleveraging was more prominent in large firms, whereas micro and small firms increased their leverage after 2013. Medium firms are also the ones with the highest values of leverage, especially when compared to all the other firm sizes that had roughly the same level of indebtedness at the end of 2015.



The interest coverage ratio (a complementary measure that also allows measuring debt overhang) plotted in graphs 5 and 6 also shows how the crisis has affected the economy in 2011 and 2012, having firms at that time lower results when comparing to the interest expenses. However, thereafter this ratio increased, hinting a lower level of financial pressure, possibly explained by the aforementioned deleveraging. Even though larger firms ended with a higher interest coverage ratio

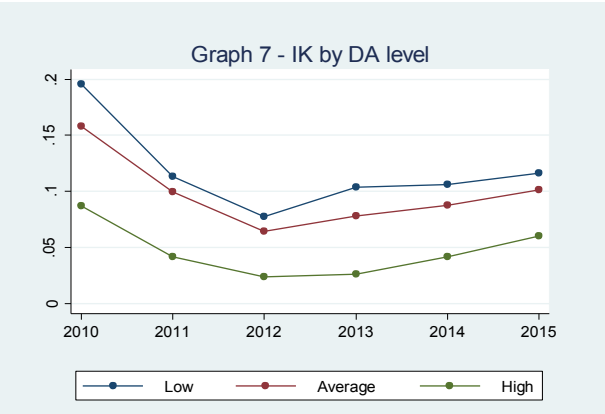
in 2015, the firm size doesn't appear to be a relevant factor to determine the financial pressure incurred.

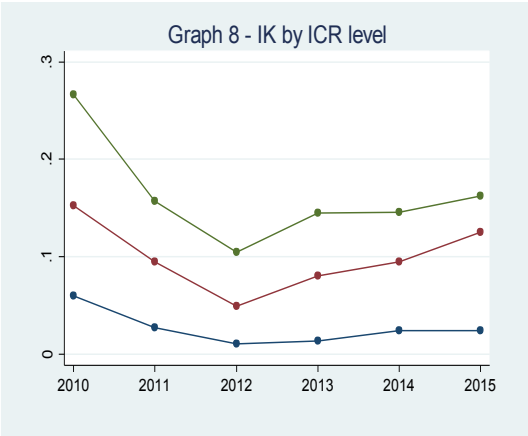


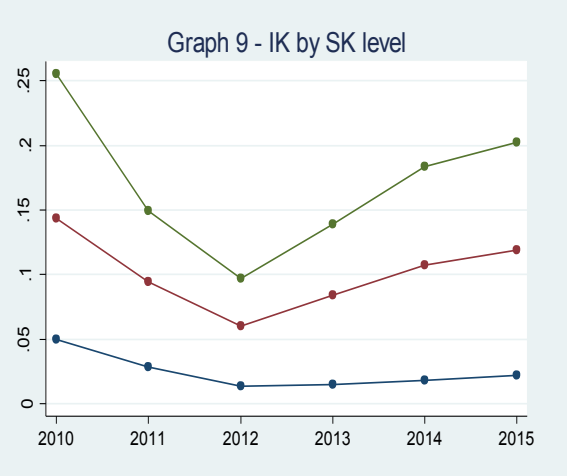


The second part of this analysis shows how the explanatory variables will affect investment. To do so, each variable was split into three groups: the low group (which comprises firms with levels below the 10th percentile of the variable), the medium group (that grouped firms with levels between the 45th and 55th percentiles) and the high group (that corresponded to firms with values higher than the 90th percentile). Afterwards, the median of investment was taken to each specific group.

Graph 7 shows that firms with lower and average levels of indebtedness level will tend to have higher levels of investment than the firms with high debt. Graph 8 presents similar results, but in this case investment is completely stratified by the ICR ratio, with lower levels of financial pressure firms (high ICR level) presenting higher levels of investment. Finally and for controlling purposes, graph 9 also indicates that sales to capital directly affect the ability of a firm to invest.







5. RESULTS

The results confirm the existence of a negative coefficient which demonstrates the negative relation between leverage and investment. Namely, a 1 percentage point increase in company's debt to assets ratio is related to a 0,076 percentage point decline in investment (as a share of capital stock). Also as expected, sales to capital ratio have a statistically significant positive relation with investment accounting for the existence of a sales accelerator effect (although not very accentuated).

There is no evidence of second-order serial correlation of the first-differenced residuals (according to the Arellano-Bond test) and the regression passes the Hansen test of over-identifying restrictions. The absence of second order serial correlation of the Sargan test at conventional confidence levels indicate that there are no problems with the model specification and the validity of instruments used.

TABLE 2: RESULTS OF ESTIMATION (DEBT TO ASSETS)

	D=DA	
	(1)	(2)
Constant	0,183***	0,043*
Ik_{it-1}	0,075***	0,102***
Sk_{it-1}	0,000021***	0,006***
D_{it-1}	-0,076***	
$D_{it-1}I\{D_{it-1}<\tau\}$		0,311**
$D_{it-1}I\{D_{it-1}>\tau\}$		-0,082***
AR(1) Test	-64,80***	-63,35***
AR(2) Test	0,05	1,46
Sargan Test	1373,75***	1574,77***
Hansen Test	606,73***	725,31***
Firms	30921	
Obs.	118213	

Note: Dynamic panel data with GMM two-step system estimator. ***, **, * indicates significance at 1, 5, and 10 percent level.

As a second step, we test the existence of asymmetric effects between investment and corporate debt. We find evidence of non-linearity once the debt to asset threshold exceeds 45.6% (the 82nd percentile). The estimates suggest that for relatively low leverage levels indebtedness can support

firms' investment behavior, as shown by the positive coefficient. But they also suggest there is excessive leverage in a considerable amount of firms, with 22.5 percent of firms recording leverage above the threshold.

Then we conduct further regressions along firm sector to deepen the role of firm sector heterogeneity on the type of link between leverage and investment. We show results for the three largest sectors in the sample, namely *Wholesale and retail*, *Manufacturing* and *Construction*. These sectors account for 73% of the observations in our sample.

TABLE 3: RESULTS OF ESTIMATION (DEBT TO ASSETS) – BY SECTOR

	Wholesale and retail		**Manufacturing**		**Construction**	
	(1)	(2)	(1)	(2)	(1)	(2)
Constant	0,1499***	0,067***	0,2***	0,054**	0,24***	0,135***
Ik_{it-1}	0,0582***	0,093***	0,081***	0,115***	-0,0031	0,106***
Sk_{it-1}	,0000415**	0,004***	0,00013***	0,011***	-1,17E-06	0,004***
D_{it-1}	-0,0272		-0,151***		-0,142***	
$D_{it-1}I\{D_{it-1}<\tau\}$		0,021		0,186*		
$D_{it-1}I\{D_{it-1}>\tau\}$		-0,088		-0,354***		-0,112***
AR(1) Test	-37,12***	-38,86***	-34,96***	-36,16***	-19,78***	-23,89***
AR(2) Test	-0,33	0,5	0,2	0,63	-1,49	0,77
Sargan Test	435,50***	466,19***	420,54***	432,88***	314,20***	289,63***
Hansen Test	223,15***	228,52***	231,81***	207,76***	182,54***	145,54***
Firms	9970		8496		3904	
Obs.	38556		33845		13690	

Note: D=DA

We find a negative relationship between debt and investment in all these sectors, although there is some heterogeneity in the results. Leverage thresholds estimates for the two biggest sector (*Wholesale and retail* and *Manufacturing*) are in high percentiles (95th and 92th percentile, respectively) while that of *Construction* is found very soon in the sample (in the 5th percentile). These thresholds correspond to debt to asset values of 59.4% in case of *Wholesale and retail*, 54.4% in case of *Manufacturing* and 2.6% in the case of *Construction* (the proportion of companies that are above the threshold are 9.1%, 12.9% and 90.8% in these sectors, respectively[12]). This low threshold in *Construction* suggests a high debt overhang level of the firms across virtually the entire sector in this period.

In line with the previous conclusions, debt overhang is found to reduce investment wether proxied by debt to assets or interest coverage ratio (ICR) and we also find evidence of non-linearity if we proxy debt with ICR (Interest coverage ratio - EBITDA over total interest expenses). We find evidence of non-linearity once ICR exceeds 1,48.

[12] In 2015 the proportion of companies that are above the threshold are 17.4% for the whole economy, 5.2%, 8.1% and 93.4% in *Wholesale and retail*, *Manufacturing* and *Construction* , respectively.

TABLE 4: RESULTS OF ESTIMATION (INTEREST COVERAGE RATIO)

	D=ICR	
	(1)	(2)
Constant	0,163***	0,130***
Ik_{it-1}	0,068***	0,076***
Sk_{it-1}	0,000023***	0,005***
D_{it-1}	0,00000016***	
$D_{it-1}I\{D_{it-1}<\tau\}$		-0,405***
$D_{it-1}I\{D_{it-1}>\tau\}$		0,0002***
AR(1) Test	-64,03***	-33,79***
AR(2) Test	-0,48	-0,79
Sargan Test	1179,03***	991,6***
Hansen Test	333,19***	482,48***
Firms	30921	
Obs.	118213	

Note: Dynamic panel data with GMM two-step system estimator. ***, **, * indicates significance at 1, 5, and 10 percent level.

6. CONCLUDING REMARKS

This paper aims to assess the relationship between debt and investment in Portugal in the period between 2010 and 2015. We use firm – level data to account for this link and for possible non-linearities. Our analysis also intends to endogenously determine a debt threshold.

Our empirical results show evidence of a negative relationship between firms' investment-to-capital ratio and their indebtedness over the period 2010-15. The estimations suggest that there is a threshold in the relationship between debt and investment, and that, when debt exceeds it, it holds back investment. This level is found in the debt-to-asset ratio of 45.6%. Both the existence of a threshold and the negative relationship between debt and investment are robust to different ways of measuring debt overhang (Debt-to-assets or Interest Coverage Ratio). Thus, our results show that the constraint is not only the level of Debt-to-asset ratio but also the low capacity to service debt (measured by ICR).

However, we find evidence of heterogeneity across the major sectors. The negative impact of debt on investment is much more transversal in *Construction* as opposed to *Manufacturing*. This suggests that the deleveraging effort should be differentiated not only according to the level of indebtedness but also taking into account the sector of activity.

Overall, these results support that there is over-indebtedness in the portuguese corporate sector and suggest the need to deleverage to support more investment. However, the dimension of deleveraging needs should be differentiated according to the level of indebtedness and sector of activity. This differentiated behavior between sectors, with industry showing a more positive situation than construction (with a higher threshold and a much lower percentage of companies above it) may result from the fact that it is a more external market oriented sector, a fact that may have dampened the effects of the crisis that occurred in Portugal during the analyzed period. Also, measures such as those included in Program Capitalizar (RCM 81/2017, 8th of June 2017) also contribute positively to increased investment by contributing to the deleveraging of companies through the replacement of financial debt by capitalization.

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ANNEX

Data Description - Sectors Used (according to NACE):

A - Agriculture, forestry and fishing

B - Mining and quarrying

C - Manufacturing

D - Electricity, gas, steam and air conditioning supply

E - Water supply, sewerage, waste management and remediation activities

F - Construction

G - Wholesale and retail trade; repair of motor vehicles and motorcycles

H - Accommodation and food service activities

I - Transportation and storage

J - Information and communication

M- Professional, scientific and technical activities

N- Administrative and support service activities

Following the criteria of Statistical classification of economic activities in the European Community (NACE): http://ec.europa.eu/eurostat/documents/1965800/1978839/NACEREV.2INTRODUCTORYGUIDELINESEN.pdf/f48c8a50-feb1-4227-8fe0-935b58a0a332

Description of the variables:

IK: Investment to capital ratio (gross investment in tangible assets over tangible assets)

SK: Sales to capital ratio (turnover over tangible assets)

DA: Debt to assets ratio (financial debt over total assets)

ICR: Interest coverage ratio (EBITDA over total interest expenses)

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Zombie Companies in Portugal - The non-tradable sectors of Construction and Services[13]

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ABSTRACT

The phenomenon of zombie companies has already been deeply analyzed, particularly in the case of Japan. Several authors relate the economic crisis experienced in the 1990s and the stagnation that Japan has been witnessing to the deterioration of the Japanese banking system, while continuously attributing credit to weaker companies, many of which were in a situation of insolvency, preventing them from closing or restructuring on one hand and credit to from being channeled to more productive sectors.

Considering that the phenomenon of zombie companies in the case of Japan jeopardized the growth of that country in the twentieth century, it is relevant to identify the weight of this type of entities in the Portuguese enterprise sector and its evolution over time.

The present study shows that between 2008 and 2015, in the Portuguese non-tradable sectors of Construction and Services, between 5.2% (2008) and 12.5% (2013) of companies in the market were zombies.

We also confirm the theoretical predictions and previous empirical results that a greater zombie presence in Construction and Services has significant negative implications on healthy companies operating in the same sector, namely reducing investment and employment and increasing the productivity gap between companies more and less productive in each sector.

Keywords: Zombie Companies, Construction, Services, Non-Tradable Sectors, Resource Allocation, Financing, Investment, Employment.

JEL classification: E22, E24, G32, L25, O47

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

1. INTRODUCTION

The ease of obtaining credit, allied to a long period of very low interest rates, created conditions for the appearance, fixation and permanence of companies in the market, which otherwise would not be possible. If there are no significant barriers for companies to obtain credit and if interest rates are particularly low, there are conditions that allow companies without economic viability and with very low productivity (especially of the labor factor) to remain on the market[14].

These companies, which have been called zombies, are on the market for at least 10 years, survive with credit granted by the banking system because they are unable to generate enough revenue to carry out their normal activities, pay wages above the productivity of their sector and are not very innovative.

The main consequences of remaining in the market of companies with these characteristics are, among others, that they (i) create solvency problems in the banking system, (ii) reduce competitiveness in the market where they operate, (iii) prevent new, more innovative and more competitive companies from entering (iv) affect the aggregate growth of the economy and (v) constitute a factor of macroeconomic stagnation (Caballero, 2008).

Based on the bibliographical review, our objective was to identify the factors that allow characterizing the situation in Portugal regarding the existence of zombie companies. In this sense, this work intends, essentially, to analyze the existence and persistence of zombie companies in the national economy. To do so, we used the information contained in the annual statements of corporate income, as reported to the Ministry of Finance, worked through a statistical tool (STATA).

Taking into account that identifying zombie companies is not an easy task since, although its well-defined characteristics, there are some factors that can contribute to lead to erroneous conclusions, we followed the strategy used by Caballero et al (2008) and McGowan et al. (2017), and we intend to observe the following parameters:

- Its extent and its effects;
- The model used is a standard variant of the ones studied in the literature on creative destruction, where one can understand to what extent and under what conditions the theory underlying the definition of the perfect market is present (companies are born and die, of course, according to market conditions);
- The modeling of the presence of zombies presents itself as a constraint to the "destruction" of companies (as would normally happen to companies that do not have the economic and financial conditions to continue in the market), demand or credit;
- We expect to find what Caballero and Hammour (1998, 2000) called "sclerosis", situation in which companies would not survive without the loans granted by the banks, and "scrambling", which is the congestion of inefficient companies that prevent the entry of young, innovative and more productive companies.
- Thus, the work will provide a frame to the problem, referring to the characteristics intrinsic to zombie companies, based on the typology referred in the literature on the subject. Finally, the results of the econometric study performed on the basis of the existing data and the final considerations will be presented.

2. LITERATURE REVIEW

There is a large set of bibliography describing the constraints related to the impact of active zombie companies, consuming financing that could be directed to more productive companies, especially those of the tradable sectors and, among them, of companies with an export vocation.

As reported by McGowan et al. (2017), various approaches have been used to define zombie companies, characterizing them as companies with more than a decade of existence that do not

[14] According to the BPstat of Banco de Portugal, the increase in unit labor costs in Portugal during much of the period between 1996 and 2016 (with the exception of 2004, 2010, 2011, 2012 and 2014) results from a more than proportional increase in earnings in relation to productivity. In fact, wages paid, even if they are low, are above the productivity of the companies, which creates problems of competitiveness in the sectors where they are inserted.

generate sufficient revenues in their regular activity, persistently dependent on bank credit and that usually pay high wages considering the productivity of the sectors in which they operate.

The productivity of these companies is much lower, contributing to decrease productivity in the different sectors where they are installed. This performance causes congestion and inefficiency in the market, among other factors, because[15]:

- Encourages inefficient companies to remain in the market, since easy access to bank credit gives them the possibility to continue their activity;
- Attracting financial resources through the banking system reduces available credit and makes it impossible for viable companies to stay and progress; and
- Prevent the entry of new companies, willing to innovate and to be more productive.

The awakening to this problem arose from the stagnation in Japan since the beginning of the 1990s, known as the "lost decade" (Hoshi, 2000), in which the particularities of the Japanese banking system helped establish a large-scale crisis, provided by the close relationship between companies and the banking system, which reflected in the stagnation of the economy. The negligent banking regulation allowed for years the successive default of solvency ratios by the banking system. In order to continue to maintain credit flow, Japanese banks continued to lend and restructure corporate debt without meeting their financial conditions, thereby incurring substantial non-performing loans.

In this way, insolvent companies, which otherwise would leave the market, ended up perpetuating its existence, even without the conditions to do so. The congestion of the market with companies with these characteristics caused a generalized decrease of its profits, including of the companies considered healthy, and the discouragement of the entry of young and innovative companies (Caballero, 2008; Know, 2015; McGowan et al, 2017).

According to Peek and Rosegren (2005), the situation in Japan was due in part to banking regulation and supervision policies that lead banks with high bad debt and depreciated capital to have little incentive to be strict with debtors, ie a policy of "evergreening loans" from banks where a bank assigns additional credit to a company in difficulty to enable the company to pay interest on the outstanding loans, avoiding or postponing its bankruptcy/restructuring. In this way, they avoid overloading their balance sheets by avoiding non-performing loans.

In particular, Hoshi's (2000) study considers that there was no immediate political and regulatory response, and it was found that the actions occurred at more advanced stages of the problem in which it was necessary to recognize the bankruptcy of banking institutions and their nationalization.

Although banks were meeting international standards for minimal capital requirements (Basel), many began to face large volumes of non-performing loans, which would oblige them to amortize existing capital, reducing capital levels. While facing this situation, banks chose to continue to finance insolvent companies. The study by Hoshi (2000) argues that by making the roll over of debt, banks increased recession by failing to finance more productive firms, creating a distortion in the economy.

The definition considered by Caballero et al. (2008), precursors of the approach of zombie companies, faces a common embarrassment: the difficulty in obtaining necessary information. In fact, banks and debtors will hardly be available to provide information to verify the existence of subsidized credit. Bruche & Llobet (2013) raise the hypothesis that the banking regulator may offer a "reward" to banks that are willing to provide information about zombie companies, expecting that they are able to exploit this informational advantage to maximize the transfers they receive, obtaining income from the information they hold.

Caballero et al. (2008) emphasize the banks' incentive to restructure the debt of companies presenting non-performing loans, since they only have to make reservations, usually 15%, while, by recognizing the existence of credit at risk, that percentage rises to 70%.

Their study sought to establish an approximation to the definition of zombie company considering them as companies that receive sufficient financial support from their creditors to survive despite their poor profitability and explored strategies to identify the zombie business set from the calculation of interest difference between companies.

They concluded conclude that, in the Japanese case, regulators failed to identify the high cost of allowing zombie companies to remain active and that capital injected into bank recapitalization in

[15] Caballero, 2008; Know, 2015; McGowan et al, 2017

the late 1990s was not enough to discourage funding to those companies. Peek and Rosengren (2005) found that bank credit extended to low-income enterprises increased sharply between 1993 and 1999.

During times of underperformance by firms, banks have become more likely to lend to zombie companies, especially where there are strategic alliances between companies and banks, facilitating access to finance. There is evidence that this is the typical case of Japan, since there were differences between the situations where the companies and banks were affiliated with keiretsu[16], and in the situations where this was not the case.

The study by McGowan et al. (2017) uses as a definition, within the scope of his work, a classification of zombie company based on the interest coverage ratio, introducing as criterion the age of the company.

In this sense, companies with 10 or more years of age, with an interest coverage ratio of less than 1 for at least 3 consecutive years, with large turnover of debt service and successive losses (negative profits) and with low multi-factor productivity (especially regarding the labor factor).

The criterion of age is important in distinguishing zombie companies from innovative start-up companies. The study by McGowan et al. (2017) also identifies a relationship between the size of companies and the prevalence of zombies, considering that the percentage of zombie companies is higher among larger companies. It will be interesting to assess this information for the Portuguese reality based on the available sample.

The empirical study by McGowan et al. (2017) adopts a model, based on the model presented by Caballero et al. (2008), which uses available information on 9 countries between 2003 and 2013, in order to measure the activity of a company using the data as follows:

$$Y_{isct}^{k} = \beta_1 nonZ_{isct} + \beta_2 nonZ_{isct} \times Z_{sct} + \beta_3 Firmcontrols_{isct-1} + \delta_{sct} + \varepsilon_{isct}$$

where Y refers to the measure of activity (the investment rate, the percentage change in employment or the multifactorial productivity level, k = 3) in firm i, in industry s, in country c, at time t, where Z is the share of the capital of the industry sunk in zombie companies and company controls include dummy variables for firm age (young = 1 if age <6) and for company size in terms of number of workers (1-10, 11- 19, 20-49, 50-99, 100-249 and 250+).

Taking into account the heterogeneity in the productivity of firms between sectors, McGowan et al. (2017) use a model to test the potential for the distortion effect of excess of zombie companies on resource allocation, taking into account a model in which firms with higher productivity (MFP) grow faster than the rest (Doster et al. Decker et al., 2016), also using information about nine countries, in the period between 2003 and 2013. The model is as follows:

$$Kgrowth_{isct} = \alpha + \beta_1 MFP_{isct-1} + \beta_2 MFP_{isct-1} \times Z_{sct} + \beta_3 Formcontrols_{isct-1} + \delta_{sct} + \varepsilon_{isct}$$

in which $Kgrowth$ is the change in the real capital stock for firm i, in industry s, in country c, at time t; MFP is a multi-factor productivity measure at company level that is a deviation from the country-industry-year average to control MFP differences between industries and countries; Z is the non recoverable part of the industrial (labor or capital) resources of zombie companies; company controls are dummies for age and size.

The study by McGowan et al. (2017) concludes that the survival of zombie companies that remain in limbo with financial weaknesses, while consuming financing, reduces the productivity growth of the labor factor, since this trend is associated with low investment and low employment growth in these companies.

It also concludes that the probability of a company being zombie tends to increase with the size of the company, with age (in older companies the probability increases), and that over time there has been an increase in both the prevalence of zombie companies limiting the expansion of viable

[16] *Keiretsu* is an expression used in Japan that name strategic alliances linking various economic agents, including banking entities, which are strategic partners as access to finance is facilitated.

companies and the entry of young and innovative companies into the market, making it difficult to efficiently relocate capital and increase productivity.

In the identification of a zombie phenomenon, what one hopes to find is what Caballero and Hammour (1998, 2000) called "sclerosis", situation in which companies would not be saved without the loans granted by the banks, and "scrambling", which is a congestion of companies that prevent the entry of young, innovative and more productive companies.

Experience in Japan is important in helping to understand the evolution of contemporary productivity in Europe in general and in Portugal in particular, and is even more important because the financial system is, by excellence, the main financier of companies. The European tradition lies in free market theory, where companies enter and exit the market, the unviable "die" and leave and the most efficient remain. However, there are studies that indicate that this mechanism may be "failing".

There are at least two reasons that may be leading to this:

- On one hand, the banking system with the need to grant credit imposed by the management objectives, granted on the basis of overvalued guarantees and
- On the other hand, the political constraints imposed by the need to avoid the growth of unemployment rates.

In Portugal, to this reality was added another, the economic and financial crisis that began in 2008, which was reflected in the request for financial rescue and the consequent Financial Assistance Program in 2011, which eventually led to severe credit restrictions, with consequences for people and businesses.

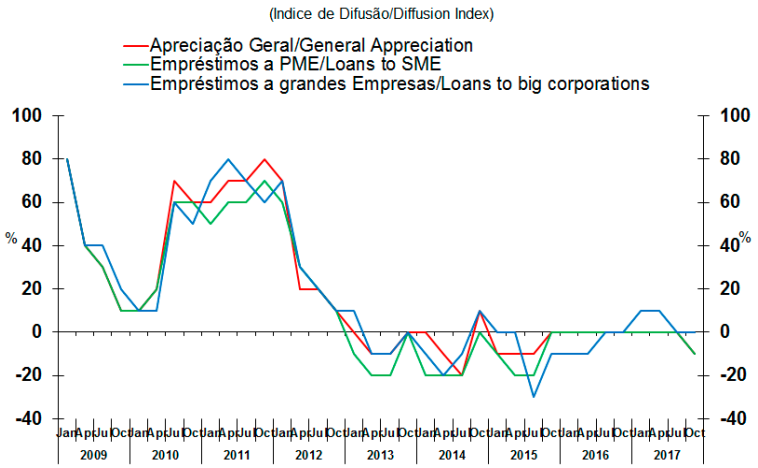
Following these seminal analyzes, it is intended to apply the existing models to the reality of companies in Portugal, seeking to characterize the business fabric of companies so that the size and prevalence of the phenomenon of zombie companies in Portugal can be gauged. As with other countries that have undergone adjustment programs, it is important to gauge the impact of the financial crisis on the phenomenon of zombie companies.

At the beginning of 2017, a study - McGowman et al. (2017) - was published by the OECD - whose objective was to explore the possibility of a productivity slowdown over the last decade in the economies of countries that are part of the institution motivated by the existence and prevalence of zombie companies. Although the working paper by McGowman et al (2017) includes Portugal, it does so only for the year 2013, which is manifestly insufficient to characterize the reality of the national economy in relation to the problem, taking into account the characteristics used for detect the presence of zombie companies.

3. Macroeconomic Environment of Portugal

For a better framing of the question, it is necessary to make a macroeconomic framework of Portugal. After the global financial crisis of 2008, Portuguese companies have faced difficulties in obtaining financing under favorable conditions, particularly when compared to companies in other Member States, due to the contraction of credit offered by the Portuguese financial system. Since that year, there has been an increase in the tightening of credit supply conditions, although there is evidence of a slight decrease in the tightening of lending to SMEs since 2013.

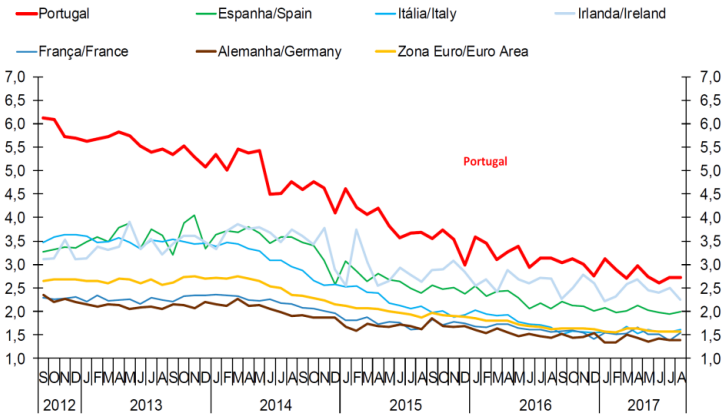
GRAPH 1: SUPPLY OF LOANS TO COMPANIES, BY SIZE



Source: Banco de Portugal e Gabinete de Estratégia e Estudos

Indeed, despite the accommodative monetary policy of the ECB, with interest rates at historically low levels, the financial fragmentation of the Euro Zone has prevented the transmission of the policy to the countries of southern Europe, in particular Portugal, where companies continue to face higher interest rates (Leão et al., 2012).

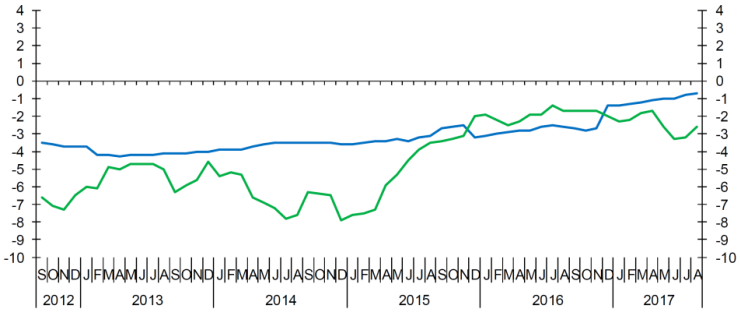
GRAPH 2: INTEREST RATES ON NEW LOANS TO NON-FINANCIAL CORPORATIONS (%)



Source: Banco Central Europeu e Gabinete de Estratégia e Estudos

This factor, on one hand, and the high level of indebtedness and decapitalization of many companies, on the other hand, have made access to bank financing for investment difficult, creating constraints to the growth of the Portuguese economy.

GRAPH 3: ANNUAL RATE OF CHANGE OF BANK LOANS STOCK

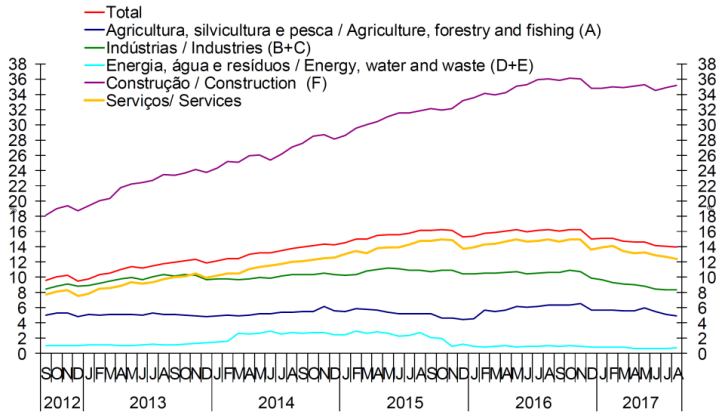


Source: Banco Central Europeu e Gabinete de Estratégia e Estudos

Companies are the engine of the economy, creating jobs and generating value, so it is essential to guarantee the necessary financing. Without it, many companies will not be able to invest and there will be no room for the emergence of new businesses, damaging the growth potential of the economy.

In addition, there has been an increase in overdue credit, burdening the banks' balance sheet and preventing financing other companies.

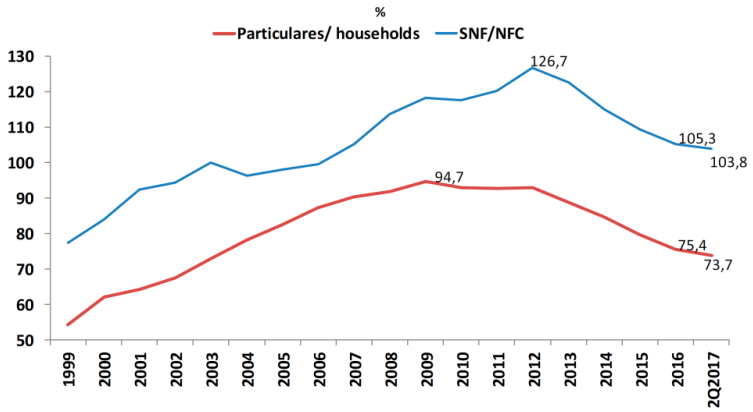
GRAPH 4 - LOANS OVERDUE BY SECTOR (% OF LOANS GRANTED)



Source: Banco Central Europeu e Gabinete de Estratégia e Estudos

It is also essential to ensure the financial deleveraging of companies by freeing up resources for the financing of productive activities, as has happened in recent years, without undermining economic growth.

GRAPH 5: DEBT OF NON-FINANCIAL CORPORATIONS (% OF GDP)



Source: Banco de Portugal / Gabinete de Estratégia e Estudos

The difficulty of obtaining credit varies, according to Matthew (2004), according to the size and age of the company. According to the author, smaller firms use commercial credit more often than bank credit, not for preference but for ease of acquisition. On the other hand, younger companies, because they do not have a history with banking institutions, will also find it more difficult to obtain bank credit.

The study by OECD (2009), considers that "these firms are more vulnerable now for many reasons: not only has the traditional challenge of accessing finance continued to apply, but new, particularly supply-side, difficulties are currently apparent".

Farinha and Félix (2015) estimated "the likelihood of a company facing financing constraints in the years 2010-2012" and consider that the data analyzed indicate that "a significant fraction of Portuguese SMEs were affected by financing constraints in this period."

Bernardo (2015) points out that access to bank credit is "closer to returning to normal", although there remain "doubts about the possibility of these companies financing themselves in the same way they have done in the past, namely in terms of maturities and amounts, and these doubts led to the search for financing alternatives for these companies."

In a scenario of scarce financial resources, with a strong presence of low productivity companies that consume financing, and with overdue credit increasing, this study is of particular importance in order to assess the situation in Portugal regarding the prevalence of that type of companies and the impact of funding allocated to zombie companies in reducing funding to most companies, looking to take into account companies with:

- Great turnover of the debt service (and with negative profits);
- Interest coverage ratio <1 (for at least 3 consecutive years);
- Low multifactorial productivity, but especially of the labor factor;
- Negative added value.

4. COMPANIES AND SECTORS TO CONSIDER

The various studies on zombie companies have considered sectors based on different criteria. Some authors chose to restrict their analysis to the manufacturing industry (Fukao & Kwon (2006), Kwon et al. (2015)), to listed companies (Peek & Rosengren (2005)) or excluding larger firms, of capital or the number of employees - Imai (2016); Stortz et al (2017)). McGowan et al. (2017) consider the entire universe of non-agricultural and non-financial private enterprises.

Schivardi et al. (2017) consider only those that exceed a minimum amount of loans contracted. Caballero et al. (2008) and Fukuda & Nakamura (2011) consider only listed companies in the "Manufacturing, construction, real estate, retail, wholesail (...) and service sector" sectors.

In this study, the objective is to analyze the problem of zombie companies in the context of non-tradable sectors. The analysis of the non-tradable sectors is justified with the intention of understanding the real relevance of the zombie prevalence in this group of companies, and to verify how the inefficient allocation of resources in these sectors is undermining its application to more productive companies that export and the improvement of the balance of the national current account.

In the study, for the definition of small and medium-sized enterprises (SMEs), we follow the definition given by the European Commission Recommendation 2003/361/EC of 6 May 2003 on the definition of micro, small and medium-sized enterprises. Such a definition is summarized in Table 1.

TABLE 1: MICRO, SMALL, MEDIUM AND LARGE COMPANIES

	Number of Employees		Annual turnover		Annual balance sheet total
Micro	<10	and	≤2M	or	≤2M
Small	<50	and	≤10M	or	≤10M
Medium	<250	and	≤50M	or	≤43M
Large	≥250	or	>50M	and	>43M

In its theoretical characterization, tradable sector are those whose final products:

- Compete in the international market,
- May be consumed in a country other than that in which they are produced or
- Can be consumed in national territory by foreigners.

This characterization is nonetheless subjective, and it is therefore necessary for a practical approach to define concrete criteria.

International institutions have used the manufacturing and extractive industries as an approximation for tradable sectors, for simplicity. However, the finding that several non-processing sectors have tradable potential (notably a significant part of the exported product) has led to the adoption of new criteria.

Amador and Soares (2012a, 2012b), in addition to the aforementioned sectors, consider tradable, the entire sector whose export / sales ratio exceeds 15%. The choice of gross value added over sales (exports / gross value added) is justified by the relative insensitivity to business cycles when compared to sales, for example. Gouveia and Canas (2016) update the above definitions by accounting not only for exports but also for imports by type of final product in a given sector[17]. Thus, they believe to fully account for the tradable potential of a given sector. They consider tradable all sectors for which the ratio is higher than 10%.

$$\frac{\text{Exports} + \text{Imports by type of final product}}{\text{Gross Value Added}}$$

The European Commission (2016) states that the non-tradable sector includes: construction, financial and insurance activities, real estate activities, professional and scientific activities, administrative and support activities, public administration, defense, education, health and social activities, artistic, entertainment and recreational activities, as well as other services. This study follows the criteria defined by Gouveia and Canas (2016) and will focus on companies of the Construction and Services sectors while not tradable[18].

[17] The logic is that if a final product is being imported by an economy, the same economy will eventually have the ability to export it when it reaches sufficient efficiency and scale.

[18] The sectors described correspond to sections E - Water distribution services, Sanitation, Waste management and depollution; F - Construction; G - Wholesale and retail, Repair of cars and motorcycles; and L - Real Estate Activities; which corresponds to Divisions 36 to 47 and 68 of the Portuguese Classification of Economic Activities, Revision 3 and NACE-Rev.2.

5. DEFINITION OF ZOMBIE COMPANIES

In the different empirical studies, several criteria have been used to define zombie companies, from the least restrictive ones that consider as criterion only the existence of losses in successive years, to the more restrictive ones that consider as zombies companies in which the type of financing is tendentially subsidized. In order to be able to select the definition used in the light of the information available, we briefly analyze the criteria previously used in this definition.

The generality of the current literature on zombie companies characterizes them, as already mentioned, as companies with more than a decade of existence that do not generate sufficient revenues in their regular activity, persistently dependent on bank credit and who normally pay wages taking into account the productivity of the sector in which they work.

Caballero et al. (2008) classify a company as being zombie based on the relation of such company with access to subsidized credit, setting aside criteria of profitability and productivity. Being unprofitable, such companies rely on the benefit of special conditions given by the lenders to survive. These conditions include the postponement of payment periods and interest relief to be paid, among others.

In particular, they consider as zombie a company whose interest expenditure is less than a hypothetical measure of interest payable, which serves as the lower border and which is constructed according to the following formula:

$$R^*_{i,t} = rs_{t-1}BS_{i,t-1} + \left(\frac{1}{5}\sum_{j=1}^{5} \mathrm{rl}_{t-j}\right)BL_{i,t-j} + rcb_{min\ over\ last\ 5\ years,t}\times Bonds_{i,t-1}$$

Above, $BS_{i,t-1}$, $BL_{i,t-1}$ e $Bonds_{i,t-1}$ respectively represent short-term bank loans, long-term bank loans and debt securities in circulation; rs_{t-1}, rl_{t-j} e $rcb_{\min.over\ last\ 5\ years,t}$ respectively represent the average short-term prime rates in year t, long-term at year teo minimum coupon paid to any convertible bond issued in the last 5 years[19].

Fukuda and Nakamura (2011) start from the definition of Caballero et al. (2008), trying to mitigate errors of type one and type two[20]. Thus, they add two criteria for the decision to classify a company as a zombie.

The first, a profitability criterion, immediately excludes an enterprise from being classified as a zombie if the pre-tax result and financing expenses (EBIT) is higher than the hypothetical lower boundary defined by Caballero et al. (2008).

The second, a criterion to control for evergreen loans[21], defines a company as zombie whenever:

- EBIT exceeds this measure,
- The total external debt is more than half the value of total assets in the previous period and
- whose loans have increased during the current period.

Kwon et al. (2015) consider two criteria in the definition of zombie companies. One of them, of financial support, following the definition of Caballero et al. (2008) and also defines as zombie companies whose total debt level at the end of the current period is higher than the level of long-term debt at the end of the previous period. The second, of insolvency, classifies as zombie companies that present for three consecutive years a sum of operating result and non-operating income or a lower EBIT than the hypothetical measure.

Imai (2016) further explores the measurement of Fukuda and Nakamura (2011) (FN), creating the criterion which he calls "modified FN". This dynamic measure classifies as zombie a company whose sum of the differences between EBIT and the hypothetical measure such as constructed by Caballero et al. (2018) over the last m periods is negative, as demonstrated by the formula below. It does so in order to isolate cyclical or temporary effects on companies' EBIT.

[19] For detailed information see Annex 1 of Caballero et al. (2008).

[20] As type one error is meant the likelihood of identifying a healthy company as being zombie. Type two error refers to the likelihood of not identifying a zombie company as being zombie.

[21] Evergreen lending refers to loans granted by banks in order to allow companies to repay interest on past loans, thus prolonging the debt cycle and avoiding incurring in impairment losses.

$$\sum_{m=0}^{T} \left(EBIT_{i,t-m} - R^{*}_{i,t-m} \right) < 0$$

Schivardi et al. (2017) consider, for their definition of zombie companies, two measures of profitability that in turn combine a measure of leverage. First, if the return on assets of the company is lower than the prime rate (the lowest rate at which the firm is able to borrow) and if its level of leverage is greater than a threshold L, the firm is classified as a zombie. In the second definition, this same measure of leverage is complemented by an alternative profitability measure in which the company is considered a zombie if the EBITDA ratio for interest expenses is less than one for three consecutive years.

Common to all of the definitions mentioned is their requirement regarding the abundance and detail of information on the distribution of debt of each company in the sample. In this sense, we will seek an alternative definition that is referred to by McGowan et al. (2017), with contributions from Bank of Korea (2013) and Bank of England (2013), consisting of framing zombie companies according to three criteria:

- Companies with an interest coverage ratio (the ratio between operating income and bank interest expense) of less than one for three consecutive years (Bank of Korea, 2013) - in our analysis we use EBITDA for reasons of availability of data;
- Companies with negative profits (Bank of England, 2013);
- Companies with negative added value - this factor was not considered in our analysis.

The study by McGowan et al. (2017) uses as a definition, within the scope of their work, a zombie company classification based on the definition of interest coverage ratio, introducing as criterion the age of the company - companies older than 10 years - important to distinguish zombie companies from startup companies. So that we can also make this distinction in the Portuguese case, we add the criterion of age so we will only consider as zombies companies aged 10 years or more.

In this study, we intend to assign the zombie classification to companies that have remained in the market for more than 10 years, and that present an interest coverage ratio of less than 1 for at least 3 consecutive years.

6. AVAILABLE INFORMATION AND VARIABLE CONSTRUCTION

In order to assess the extent of the problem and characterize the behavior of companies in relation to financing and investment options, and then to select companies considered as zombies, we use panel data on companies. This information, drawn from annual income statements as reported to the Ministry of Finance, and included in the Simplified Business Information (IES), is provided by the Bank of Portugal through its Microdata Laboratory (BPLim) and relates to the period of 2006 to 2015.

In order to be able to analyze with relative precision the credit relationships of the companies, we would need to isolate the interest expense referring exclusively to banking relations or financial companies. Detailed information on the nature of corporate interest expenses exists only as of 2010 and has appeared with the amendments to Annex A of the IES Annual Statement. Thus, there is a temporal limitation in the availability of data that justifies the consideration of a less strict zombie measure - which includes consideration of the total amount of interest incurred.

In addition, the period in question largely coincides with the Economic and Financial Assistance Program (PAEF) that was in force in Portugal between 2011 and 2014, following the financial crisis. Thus, in addition to a short period of time, it is an atypical period, in which economic activity is extraordinarily withdrawn. Although it is a time of interest to analyze the impact of the PAEF in the context of zombie companies, a longer time period would also be necessary.

One measure that considers the effect of zombie prevalence in the economy is the productivity of the labor factor, measured as Gross Value Added (GVA) per full-time paid employee. The database does not include GVA measurement but includes a GVA indicator as a percentage of turnover. To obtain the GVA, we multiplied this indicator by the turnover of each company. For the productivity of

the labor factor, for computational reasons, we considered only companies with one or more employees paid full time (avoiding division by 0).

Since measuring the zombie impact on investment is another of the main goals of this study, choosing and building a variable investment is essential. Investment is understood as the change in the logarithm of tangible and intangible fixed assets (real and intangible capital, hereinafter "capital").

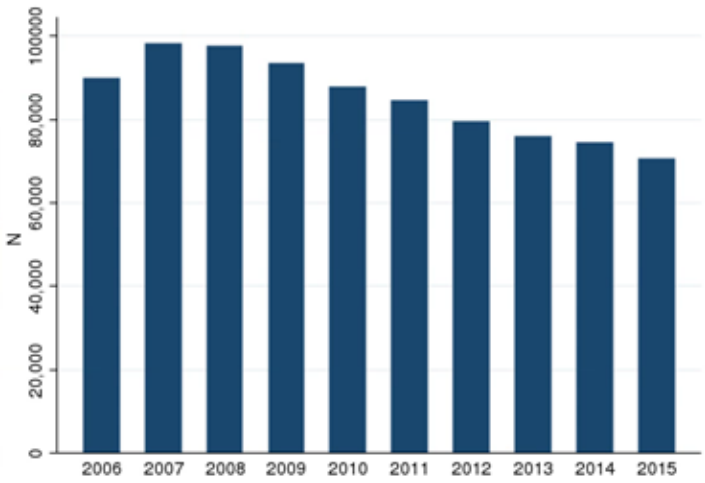
7. EMPIRICAL STUDY

This section starts by presenting a brief characterization of the business fabric under study, particularly as to its composition both in terms of number of companies and in terms of their size. Next, we identify the zombie prevalence in the selected sample and time period, exploring its various dimensions. In the penultimate subsection a description of the econometric procedure is elaborated and in the last subsection the main empirical results are presented.

7.1. The business fabric

In this study, we considered a final sample of 179,512 companies over 10 years. We only consider companies that declare activity in consecutive years and with available information about the key variables (such as number of employees, value of their assets or turnover) and that operate in the sectors of interest (see subsection "Companies and Sectors to Consider").

GRAPH 6: NUMBER OF COMPANIES CONSIDERED PER YEAR



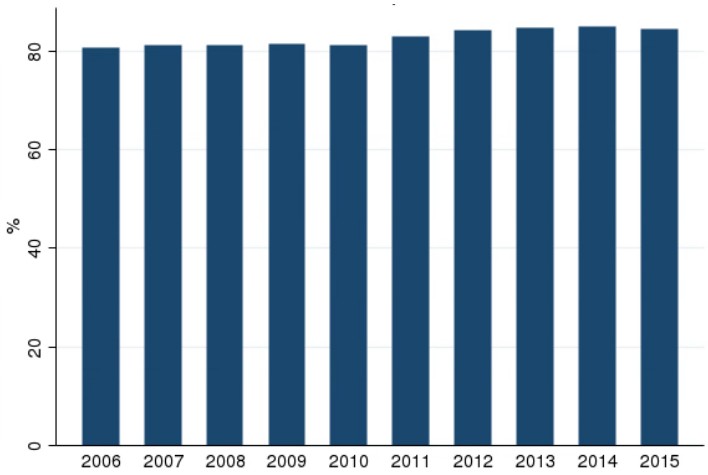
Source: Bank of Portugal (IES) and own calculations

Graph 6 shows the number of companies considered per year. Although there is a slight increase in the number of companies between 2006 and 2007, there has been a sharp decline in the number of companies in the remaining years. This effect is not unexpected, as this was the period of economic and financial crisis as well as the Economic and Financial Assistance Program period.

The business fabric in Portugal differs from that observed in other works on zombie companies in multiple factors, one of the most important being its composition with regard to the size of companies. The Portuguese business fabric is clearly dominated by micro-enterprises.

As can be seen in Graph 7, over the entire period under review the fraction of microenterprises in the sectors considered remains close and slightly above 80%. Thus, the criteria used by some studies that restrict the zombie definition to companies with a relatively high number of employees are not justified in the Portuguese context, since we would be considering a sample that is not representative of the national economy.

GRAPH 7: PERCENTAGE OF MICROENTERPRISES



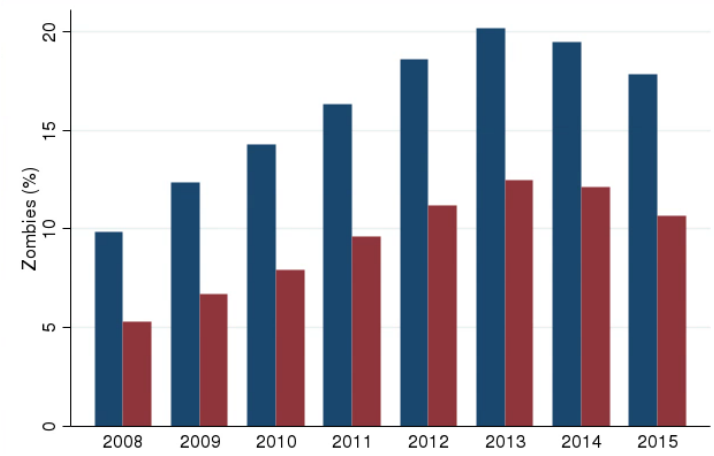
Source: Bank of Portugal (IES) and own calculations

7.2. Prevalence of zombie companies in the Portuguese economy

In this section we analyze the real zombie prevalence in the economy according to the previously defined criteria - interest coverage ratio (ICR) of less than 1 for three consecutive years and age of 10 years or more.

In graph 8 we can see the real prevalence of the zombie phenomenon in the economy as a percentage of the universe of companies, either considering only the ICR criterion (blue bars) or considering age as well (red bars).

GRAPH 8: PREVALENCE OF ZOMBIE COMPANIES



Source: Bank of Portugal (IES) and own calculations

It is immediately apparent that by adding the age criterion, the percentage of zombie companies in the economy drops considerably compared to when we consider only the ICR criterion. In the case where the complete criterion is considered, a prevalence of zombie is observed between approximately 5.2 and 12.5%, quite significant values.

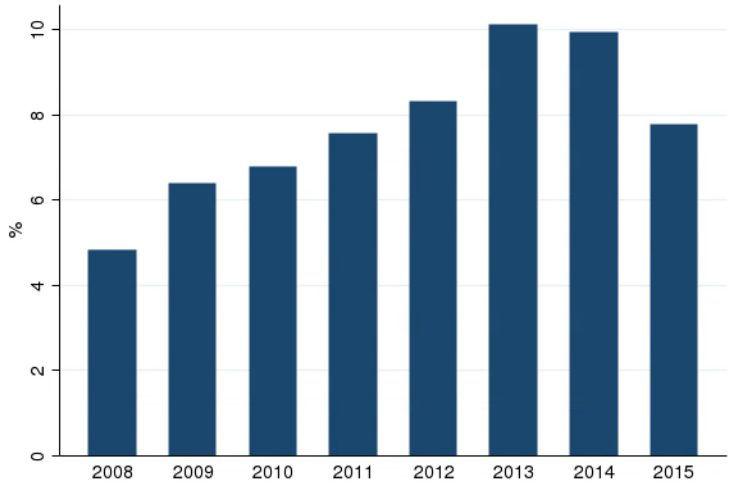
There is also a clear worsening of the zombie problem over the period that coincides with the sovereign debt crisis and PAEF, a period of extraordinary difficulties for companies. There is also a slight improvement in the years 2014 and 2015 but it would be premature to comment on the sustainability of this improvement without examining the most recent years.

Although the zombie prevalence alone reveals the extent of the problem in the Portuguese economy, the phenomenon is relatively more worrying when coupled with the fact that the total number of companies is decreasing in the same period in which the proportion of zombie companies is increase. This phenomenon can mean both a more than proportionate increase in the number of companies that become zombie or those that have already been considered and that are still active, revealing in this case an extraordinary inefficiency of the "market clearing mechanism" - an increase in barriers to exit zombie companies from companies that cease activity but that do not include the definition of zombie.

Important for measuring the zombie impact on the economy is not only the prevalence of this type of companies but also the resources they capture. This is the measure used to quantify the zombie presence when estimating its impact on healthy companies. Thus, in graph 9 we can see the percentage of asset "stuck" in zombie companies over the period. The value of each year represents the average percentage of assets stuck in zombie companies in each sector.

Asset values "trapped" in zombie companies track the movement of zombie prevalence over the period, increasing consistently until 2013 and declining in subsequent years, ranging from about 5 to 10 percent. The value is lower than that relative to the prevalence, but still very significant, evidencing the zombie phenomenon as a real problem in the Portuguese economy in the period under analysis.

GRAPH 9: AVERAGE ASSET "STUCK" IN ZOMBIE COMPANIES BY SECTOR

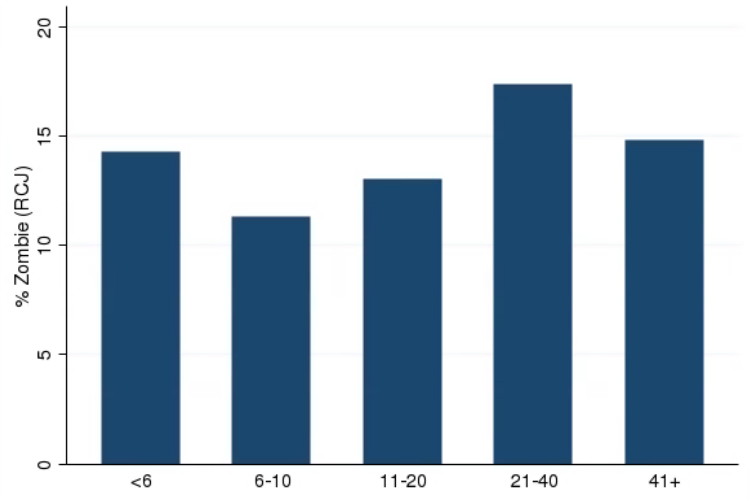


Source: Bank of Portugal (IES) and own calculations

Contrary to what is observed in the work of McGowan et al. (2017), the relationship between zombie prevalence and both age and firm size is not monotonic. In the graphs below it is possible to observe this relation, corresponding the first to the size groups and the second to the age groups.

In the first, the zombie criterion used is only that of the interest coverage ratio - for obvious reasons it is not justified here to include the criterion of age. It is observed a higher prevalence with age up to 40 years, and a reduction in the group with 41 or more years of age. The relatively high prevalence among companies younger than 5 years may reflect the presence of startup companies growing or settling in the market.

GRAPH 10: INTEREST COVERAGE RATIO IN ZOMBIE COMPANIES BY AGE

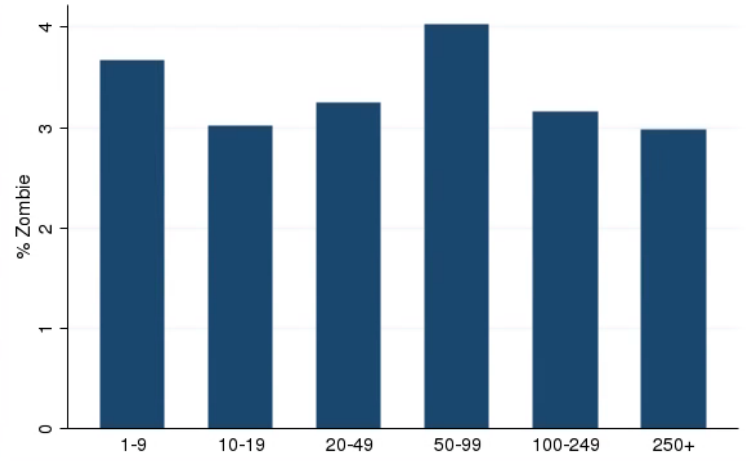


Source: Bank of Portugal (IES) and own calculations

The behavior is similar when we analyze the zombie prevalence by size of the companies. There is a higher presence among the smaller companies (less than 10 employees) and companies with between 50 and 99 employees.

The differences between the realities of Portugal and other comparable studies lie not only in the different development of the zombie phenomenon in the different contexts but also in the different natures of the business structures themselves, and in Portugal there is an unequivocal prevalence of smaller and relatively younger companies.

GRAPH 11: PERCENTAGE OF ZOMBIE COMPANIES BY SIZE (NUMBER OF EMPLOYEES)



Source: Bank of Portugal (IES) and own calculations

7.3. Econometric Models and Forecasts

The econometric study focuses on pooled microdata analysis and aims to identify adverse effects of zombie prevalence on "healthy" companies, particularly in terms of investment and employment.The specifications are applied for the period between 2008 and 2015, unless otherwise indicated.

The basic specification of the study follows Caballero et al. (2008), and can be represented as follows:

$$Y_{imt} = \beta_1 NonZ_{imt} + \beta_2 NonZ_{imt} * Zashare_{mt} + Zashare_{mt} + \gamma'_t + \delta'_m + \varepsilon_{imt} \quad (E-5.1)$$

In the above equation, Y_{imt} represents the explained variable - investment, employment or labor factor productivity. Investment (I/K) is calculated as the annual change in the natural log of capital. Employment (E) is calculated as the annual percentage change in employment, measured by the number of full-time paid employees. $NonZ_{imt}$ is a dummy that identifies healthy companies (= 1). $Zashare_{mt}$ represents the fraction of sector assets (2 digits) "trapped" in zombie companies in each period. γ'_t and δ'_m respectively represent year and sector dummy vectors.

Labor factor productivity is calculated as gross value added on the number of full-time paid employees. The choice of gross value added as well as the number of full-time paid employees is intended to avoid cyclical effects which could be manifested in either outcome measures or turnover or in more volatile employment measures such as the total number of persons employed.

The main objective of the model is to test the harmful effects of an increase in zombie prevalence in the activity of healthy companies. Thus, the main coefficient of interest is β_2. The prediction is that the coefficient shows a negative sign for both investment and employment - a higher zombie prevalence (measured by the fraction of assets held in these companies) presupposes a greater retention of resources linked to the sector in non-productive companies, reducing ability of healthy companies to thrive.

As for the productivity of the work factor, the model predicts that β_2 is positive, meaning that those sectors where there is a higher prevalence of zombie are those where the productivity gap between zombie and healthy companies widens. The congestion that the presence of less productive zombie companies causes in the market creates additional barriers to the entry of new and more productive enterprises (scrambling effect), so that, in order to be competitive, new companies must be capable of achieving a higher level of productivity *a priori*. Thus, differences in productivity are accentuated.

There is no concrete prediction for the coefficient β_1. While on the one hand it is reasonable to assume that healthy companies have greater ability to invest, develop their business and expand, including the number of people they employ, it is also possible to elaborate the opposite argument that zombie companies, by receiving sufficient "aids" to remain active, do not feel the need to constrain their investment actions or employment variation. The exception appears in the productivity regression, where it is clearly predicted that the average productivity will be higher for healthy companies than for zombie companies, thus expecting a positive β_1. Moreover, the discussion focuses mainly on the coefficient β_2.

The sector and year dummies vectors are included to control shocks, cyclical effects or characteristics not observable both at the sector specific level and at the aggregate level of the economy.

For reasons of robustness, we tested two alternatives to the base specification defined by E-5.1. In the first alternative, the E-5.2 specification based on McGowan et al. (2017), we include in the equation characteristics of the company, namely a vector of dummies of size (micro, small, medium or large company) and dummy $young_{imt}$, equal to 1 if the company is less than 6 years. We also included unobservable fixed effects at the sector-year level, and we removed the $Zashare_{mt}$ variable because, because of the alternative fixed-effects structure, it was not possible to identify its coefficient. The inclusion of unobservable sector-year effects is intended to confirm that the negative effect found is not explained by some unobservable factor that makes a sector particularly harmful in a given year, thus controlling for all factors affecting sector m in year t. Equation E-5.2 is represented as follows:

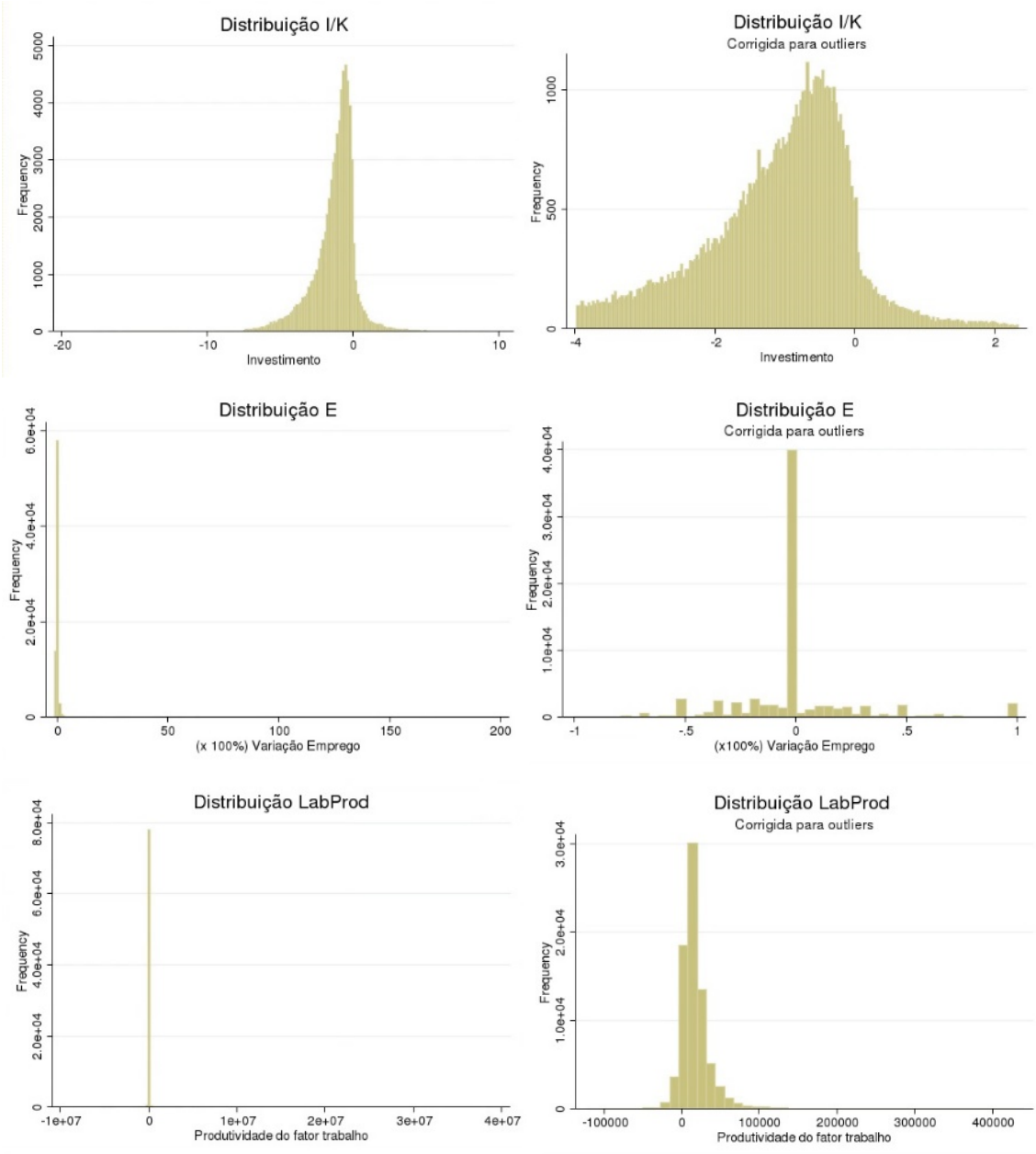
$$Y_{imt} = \beta_1 NonZ_{imt} + \beta_2 NonZ_{imt} * Zashare_{mt} + \gamma' size_{imt} + \delta young_{imt} + \varphi'_{mt} + \varepsilon_{imt} \quad (E-5.2)$$

The second alternative is to study investment and employment in the cross-section of 2015. We do it for being the most recent year and for being a year of economic recovery. The impossibility of studying a pre-crisis period makes it an appealing alternative.

7.4. Investment, Employment and Productivity

The following figure shows the distribution of each of the explanatory variables for the year 2010. The annual distributions of each variable are identical, so we choose to show only one.

GRAPH 12: DISTRIBUTION OF EXPLAINED VARIABLES (TOTAL AND CORRECTED FOR OUTLIERS)



The presence of outliers affects the different variables explained in a heterogeneous way. Of all, the investment variable is the least sensitive to the presence of outliers, with a stable distribution relatively centered around the mean. The distribution of the variation of employment variable is extremely affected by the presence of high and positive outliers and the distribution of the labor productivity variable also reveals the presence of some values too high (in absolute value) that can disproportionately affect the results.

Given these characteristics, we have chosen, in all regressions, to restrict the sample to observations above the percentile 1 and below the 99th percentile for the case of investment and labor factor

productivity and below the 97.5th percentile for employment. The corrected distributions for the outliers are also represented in the figure above. For homogenization of procedures we have equated the correction of outliers for investment and productivity, and the unique characteristics of the distribution of employment have motivated a different approach.

Not correcting for outliers never affects the direction of the effects found and may impact the statistical significance of the coefficients. Stricter constraints, that is, restricting the sample to more central values of the distribution of each explained variable, has a monotonic impact in the sense of increasing the statistical significance of the coefficients and the explanatory capacity of the models (R^2).

7.5. Main Empirical Results and Concluding Remarks

The results of the base specifications (equations E-5.1 and E-5.2) for the panel can be analyzed in Table 2.

TABLE 2: ZOMBIE PRESENCE AND EFFECT ON NON-ZOMBIES

	(E-5.1)			*(E-5.2)*		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Log(I/K)	ΔE	LabProd	Log(I/K)	ΔE	LabProd
$NonZ_{imt}$	**0. 1647***** (0.0121)	**0.0812***** (0.0105)	**10588.74***** (2541.33)	**0.1061***** (0.0136)	**0.0576***** (0.0094)	**11718.25***** (2241.26)
$NonZ_{imt} * Zashare_{mt}$	**-0.5869***** (0.0758)	**-0.1386*** (0.0604)	**35981.82**** (16927.23)	**-0.5359***** (0.0732)	**-0.1160*** (0.0596)	**35546.94*** (17916.25)
$Zashare_{mt}$	**0.5058***** (0.0950)	**0.1218*** (0.0635)	**-55285.12***** (16900.35)	-	-	-
Company characteristics	NO	NO	NO	YES	YES	YES
Dummies year	YES	YES	YES	YES	YES	YES
Dummies sector	YES	YES	YES	YES	YES	YES
Dummies sector-year	NO	NO	NO	YES	YES	YES
Observations	529,781	548,161	409,437	529,781	448,161	409,437
R^2	0.2650	0.0176	0.0814	0.2810	0.0305	0.1266

Note: Log (I / K) refers to the annual change in the natural logarithm of the capital stock (tangible + intangible). ΔE refers to the annual percentage change in employment, measured by the number of full-time paid employees. Standard errors clustered at sector level. Sector always refers to 2-digit CAE. CAEs-Rev3 selected: 36 to 47 and 68. Zashare refers to the fraction of the sector's assets held in zombie companies, defined as companies over the age of 10 years and the ratio of interest coverage lower than the unit for three consecutive years. Panel under review: 2008-2015. To avoid outcomes disproportionately influenced by outliers, observations below the percentile 1 and above the 99th percentile of the investment distribution and labor factor productivity were eliminated, and below the 97.5 percentile for employment. *** p-value <0.01 ** p-value <0.05 * p-value <0.10

The estimated coefficients are, as expected, negative and significant in both specifications for both investment (columns 1 and 4) and employment (columns 2 and 5). The sign of the coefficient of non-zombie interaction with the share of assets "trapped" in zombies in a given sector-year shows that increases in the relative amount of resources "stuck" in zombie companies are related to reductions in investment and job creation by the average healthy companies.

These results indicate not only that the presence of zombies in these sectors of the Portuguese economy may have amplified the negative consequences of the crisis but also that they may be slowing the recovery of the economy, distorting the capture and application of resources by healthy companies. Taking into account all the companies studied, the implications for product growth and job creation (not destruction) are especially relevant at the aggregate level. The cross-sectional analysis of 2015, the most recent in the available sample and the year in which there is some

improvement in economic conditions and even a reduction in the zombie presence in the economy, confirms that the zombie prevalence in the economy continues to have statistically significant negative effects both on investment as in employment, which seems to support this hypothesis[22].

The coefficients for labor factor productivity are positive and significant for both specifications (columns 3 and 6), confirming that an increase in the fraction of assets "trapped" in zombie companies is related to an increase in the productivity gap between zombie companies and healthy companies.

This result highlights two important issues. On one hand, the prevalence and persistence of zombie companies that, in normal conditions, would terminate activity causes a reduction in the level of productivity of the sectors and consequently in the economy, undermining their growth. On the other hand, new companies wanting to enter the market need to achieve higher levels of productivity to compensate for the reduction in market profitability caused by zombie congestion and to be able to compete with the most productive companies in their sector. This process perpetuates the productivity gap between zombies and non-zombies, while the former continue to be able to survive.

Finally, we verified that neither in the working paper of McGowan et al. (2017) nor in any others were analyzed the public policies implemented in Portugal, in order to allow to gauge how they could have contributed to the existence of zombie companies and to identify the need for implement policy measures to prevent companies from remaining in business, so as to allow the channeling of investment to more productive companies. These may be research lines for a more in-depth study on this topic.

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[22] However, if we remove smaller firms (firms employing only 1 person), where the variation in employment is naturally more rigid, the coefficient is again statistically significant.

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Competition effect on innovation and productivity - The Portuguese case[23]

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ABSTRACT

The aim of the present paper is to assess the effect of competition on innovation (patent applications) and on productivity (Total Factor Productivity and Labour Productivity), using data from 654 Portuguese firms, according to 208 NACE 4-digits sectors, and over the period 2007 to 2015. For this purpose, two different methodological approaches were used, a Poisson regression model for the patent function and a log-log fixed effect model for the productivity function. The results reveal that, on average, competition has a negative, U-shaped form effect on innovation in the short term, and a positive effect in the medium-long term. Nevertheless, the model focusing only on manufacturing sectors shows some differences from the model considering all economic activities, namely a linear positive effect of competition on innovation. Concerning the effect of competition on productivity, a positive effect on Total Factor Productivity emerged from the analysis, while for labour productivity a negative one prevails.

Keywords: Competition, Innovation, Productivity
JEL classification: L10, O31, D24

[23] Award-winning work by the Call for Competition in the Markets, a partnership between the Office for Strategy and Studies of the Ministry of Economy (GEE) and the Associação Mutualista Montepio.
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1. INTRODUCTION

Competition refers to a rivalry process between individuals, groups, firms or nations, aiming to achieve a specific objective. In the business context, the object of rivalry is e.g. sales, profits, market share or corporate control, and the instruments used in this attempt for market power could be e.g. price, improved product or service quality, patenting or cost reduction (Vickers, 1995). Competition is considered a key driver to enhance consumer welfare and efficient allocation of resources, because it forces firms to react in order to become more efficient and able to offer a greater choice of products and services at lower prices (OECD, 1993). From this definition of competition two main concepts emerge: i) innovation which is connected with the introduction of new or improved products or services in the market, and can be measured e.g. through research and development (R&D) activity or the patenting process; ii) productivity which is linked with cost reduction, economies of scale and lower prices.

The relationship between competition and innovation or with productivity has been studied in recent decades by many authors (for a survey of the literature see e.g. Symeonidis, 1996; Gilbert, 2006; Holmes and Smitz, 2010). Nevertheless, there is no consensus as to the direction of the effect. While some defended the existence of an inverted U-shaped relationship, due to escaping the competition and the Schumpeterian effect, such as Aghion et al. (2005), others defended a monotonic impact (e.g. Arrow, 1962; Correa and Ornaghi, 2014).

The objective of this paper is to contribute to the literature and to assess the effect of competition on innovation strategy (patent applications) and on productivity, based on 654 Portuguese firms. The present empirical study intends to answer the following research questions: How do Portuguese firms react to competition pressure? Can competition lead to an increase in innovation performance and firm productivity in Portugal?

The methodological approach is based on a Poisson regression model for the patent function and a log-log fixed effect model for the productivity function. Competition will be measured through a profitability index following the framework of Aghion et al. (2005).

The originality and contribution of this study lies in two main aspects. Firstly, few studies assess this relationship between competition and firm performance in Portuguese firms. Secondly, better understanding of this phenomenon could help policy-makers to improve public intervention in the market and help them upgrade public policies supporting firm competition, innovation and performance.

The paper is structured in five sections. After the introduction, section 2 presents the different measures for quantifying competition in the market, as well as a brief description of the main findings about the effect of competition on innovation and productivity. Section 3 describes the data and methodological approach. Section 4 presents the empirical results. Section 5 reports the conclusion.

2. BACKGROUND THEORY [24]

2.1. Measuring competition

Market power and market share are the two main measures used in the scientific literature to quantify the level of competition in the market.

Market power refers to firms' ability to control, raise and maintain price above the level that would prevail under (perfect) competition (OECD, 1993). The indicator most commonly used to assess the degree of market power is the Lerner (1934) Index, which corresponds to the ratio of price (P) minus marginal cost (MC) over price (1), where marginal cost refers to the cost of producing one additional unit of product or services.

$$\text{Lerner Index (LI)} = \frac{P - MC}{P} \;;\; where\ \text{MC} = \frac{\partial Cost}{\partial Quantity} \qquad (1)$$

A particularity of the LI equation (1) is its similarity to the inverse formula for the elasticity demand, if the marginal cost is replaced by marginal receipts (Lerner, 1934). Since the LI is related to the market

[24] See Appendix A for a summary of the main studies assessed in this section.

price elasticity of demand, it is also able to capture the threat effect of substitute products outside the industry, which means that a firm in a monopoly market facing strong competition from substitute products, could have weak market power or a low LI (Besanko and Braeutigam, 2011:457).

The LI ranges between 0 and 1, where 0 (price = marginal cost) indicates perfect competition and values above 0 some degree of market power. This mean that the higher the index, the lower the level of competition (higher level of market power). Therefore, to have an indicator to assess the inverse relationship – higher values equal to a higher level of competition – it is common to transform it. Authors using the LI as a baseline to measure competition (e.g. Aghion et al., 2005; Okada, 2005; Correa and Ornaghi, 2014) usually estimate an industry-year indicator, and not a firm-year one, using the average value across firms within the industry. In this case, competition measures ($c_{j,t}$) reported in equation (2), where i indexes firm, considers the number of firms (N) in industry j in year t, to estimate the average LI across all firms within an industry j. Values near to 1 indicate a higher level of competition and those close to 0 a higher level of market power.

$$c_{j,t} = 1 - \frac{1}{N_{j,t}} \sum_{i \in j} LI_{i,t} \tag{2}$$

Nevertheless, despite its popularity, the LI shows some limitations[25] and difficulties in computation. First, the marginal cost is not directly observed (Correa and Ornaghi, 2014) and it is not easy to measure empirically (OECD, 1993). Alternatively, authors (Okada, 2005; Czarnitzki and Kraft, 2011; Dhanora et al., 2017) have used statistical data about the variable cost, since in the presence of constant returns to scale[26]the LI, when all the variables in (1) are multiplied by the quantities (Q) sold, the index is equal to the ratio of sales less variable cost by sales (3). For example, Dhanora et al. (2017) defined variable cost as the sum of labour cost, electricity cost and raw material, whereas Czarnitzki and Kraft (2011) considered it as the sum of labour, capital and raw material cost.

$$LI = \frac{P - MC}{P} = \frac{Q * P - Q * MC}{Q * P} = \frac{sales - variable\ cost}{sales} \tag{3}$$

A second main restriction of the Index, reported by Lindenberg and Ross (1981), lies in not covering fixed costs, since by definition, in marginal cost only variable costs are considered. To overcome this limitation, and also due to data availability, different alternative measures of LI are utilized for empirical calculation. Lindenberg and Ross (1981) used the ratio of difference between sales less operating expenses to sales. Nickell (1996) and Aghion et al. (2005), as well as Inui et al. (2012) and Correa and Ornaghi (2014), considered operating profit, minus financial cost, divided by sales (4), where financial cost takes into account the amount of capital stock and the cost of capital. The index reported in equation (4) is an approximation to the LI, which Aghion et al. (2005) call price cost margin and Correa and Ornaghi (2014) call the profitability index.

$$Price\ cost\ margin\ or\ Profitability\ index = \pi_{i,t} = \frac{operating\ profit_{i,t} - financial\ cost_{i,t}}{sales_{i,t}} \tag{4}$$

Another way to measure competition is by using the market share, which measures the relative size of a firm in an industry in terms of the proportion of total output (OECD, 1993). The concentration index most commonly used is the Herfindahl (1950) and Hirschman (1945) Index (HHI), which takes into account the number and size of firms in the industry, to estimate their contribution to the total

[25] For a survey about the uses and limitations of the Lerner Index see (Elzinga and Mills, 2011).

[26] One assumption of the Lerner (1934) index is to consider that many firms produce with constant returns to scale and with a marginal cost equal to those firms with a monopoly power (Elzinga and Mills, 2011:558).

activity in this industry[27]. This indicator is expressed in equation (5), where s_i represents the relative measure of the economic activity of the i^{th} firm and n is the total number of firms in the industry. To estimate the HHI, authors (Okada, 2005; Kato, 2009; Inui et al., 2012) generally used firms' sales to quantify their economic activity.

$$HHI = \sum_{i=1}^{n}(s_i)^2, \text{ where } \sum_{i=1}^{n} s_i = 1 \quad (5)$$

The HHI is a concentration index, and like other concentration measures, describes market structure and is a *prima facie* indicator of market power or competition among firms (OECD, 1993). Nevertheless, according to some authors market power indicators have some advantages over market share ones.

Market structure and market concentration do not precisely reflect the nature of competition intensity (Correa and Ornaghi, 2014), particularly when this comes from price influences. Secondly, concentration measures, compared to the price-cost margin, can mislead the analysis of market competition, when the sample includes firms operating in international markets but the data available only includes firms established in a national market (Aghion et al., 2005).

The LI (and its variants) and HHI have in common that the main source of data for estimating them comes from firms' financial statistics. More recently, a new way to measure market power and market share appears using survey data and the entrepreneur's own perception about the competitive environment.

Among questions to which entrepreneurs are asked to give their opinion, studies reported, as a proxy for market share or structure, their opinion about the number of competitors in the market for the main product sold by the firm surveyed (e. g. Carlin et al. 2004; Soames et al., 2011; Friesenbichler and Peneder, 2016; Crowley and Jordan, 2017) or about how easy it is for competitors to enter the market (Tang, 2006). Market power, in turn, is measured by the perception of customer behaviour when the firm surveyed increases the price of its product (Carlin et al. 2004) or competitors' capacity to influence product price (Amin, 2015).

Despite its advantage, providing a new vision of the issue, the main limitations of using the survey data approach are linked with its subjective measure, limited to one period of time (usually cross-sectional analysis) and aggregated level of activity sectors[28].

2.2. The effect of competition on innovation

As summarized by Gilbert (2006) and Im et al. (2015), in the background theory about competition's effect on innovation, four main studies exist, Schumpeter (1934), Arrow (1962), Boone (2001) and Aghion et al. (2005), and all of them present different conclusions.

Schumpeter (1934) defended that despite competition stimulating innovation, this only happens at a low level of competition. According to the author, when competition is high, modest and less efficient innovators are discouraged from innovating, and in the end a negative correlation is found between competition and innovation. Arrow (1962) predicted the opposite (a positive relationship), explaining that in a monopoly situation due to profit maximization criteria, a firm has less incentive to innovate compared to the situation in a competitive environment. So, in this case, firms faced with a high level of competition innovated more to rise above the competitors.

Boone (2001) and Aghion et al. (2005) both supported a non-linear relationship between competition and innovation, but Boone (2001) presented a model leading to a U-shaped relationship and Aghion et al. (2005) found an inverted U-shaped relationship. Aghion et al. (2005), using data from UK stock market listed firms and patents as the output measure of innovation, found that faced with a higher degree of competition in a sector, firms closer to the technology frontier will innovate more in order to escape the competition, whereas firms far from the frontier, and trying to catch up, will be discouraged by this higher degree of competition, and consequently innovate less (Aghion, 2017:11).

[27] The index could be computed on the basis of 1, 1.000 or 10.000, where this extreme value represents a monopoly situation (only one firm).

[28] For example, Crowley and Jordan (2017) only make a distinction between low, medium and high technology industry.

Additionally, Boone (2011) sustained in his theoretical model that despite competition reducing firms' profit, they only react by introducing an innovation, depending on the industry's cost and the value of product market competition. This author explained that, in the presence of a low level of competition less efficient firms are active and consequently the incentive to innovate is lower, since the profit from greater efficiency is still positive and higher than that of competitors. However, when competition becomes more intense and interaction between firms becomes more aggressive, only highly efficient firms are active in the market and the leader is more likely to innovate (Boone, 2001).

Such divergence about the direction of competition has led several researchers and academics to focus their work on trying to confirm or reject the findings of the previously cited authors. For example, following the same empirical framework as Aghion et al. (2015), Correa and Ornaghi (2014) applied the same exercise to US manufacturing firms, but only found a linear positive effect of competition on patents, justifying their findings (absence of an inverted-U relationship) due to the well-defined intellectual property rights in the market.

More recently, as the results of a survey database based on a new type of competition indicators, authors have been trying to find similarities or differences concerning the conclusions of Schumpeter (1934), Arrow (1962), Boone (2001) and Aghion et al. (2005). Some research based on a market structure indicator - n° of competitors - pointed to an inverted-U shaped relationship, using as the innovation measure the type of innovation (Carlin et al., 2004; Crowley and Jordan, 2017) or R&D expenditure (Friesenbichler and Peneder, 2016), whereas other authors found a positive effect of the constant arrival of competing products (Tang, 2006) and market share on the propensity to innovate (Soames et al, 2011). As regards studies based on market power indicators, Carlin et al. (2004) revealed that the ability to raise prices has a positive effect on the decision to innovate, while Soames et al. (2011) reported a negative effect of perception of the price-cost margin. These last authors interpreted their findings, explaining that firms with a smaller margin, due to competition pressure, are more likely to innovate. The study by Tang (2006) also showed a negative effect of market power, measured by easy product substitution, on R&D expenditure and innovation activities.

2.3. The effect of competition on productivity

Concerning the effect of competition on productivity, as for innovation, the findings in the literature are not unanimous, despite a positive relationship prevailing.

Based on UK data, Haskel (1991) found that a high level of market power (or fewer competitors), leads to inefficient work practices and consequently to a low level of productivity, since the concentration ratio falls and rising productivity is observed. Nickell (1996), using both measures of competition, the number of competitors and rent levels, found they had a positive effect on total factor productivity growth for UK firms. Kato (2009), using market share indicators of Indian manufacturing industries, reported a positive effect of HHI on the growth rate of total factor productivity. Similar conclusions were also found by Correa and Ornaghi (2014) for US firms and using a profitability index to measure the level of competition. Even authors using survey data, such as Amin (2015) and Friesenbichler and Peneder (2016), showed the same relationship with indicators linked with the ability to influence product price and number of competitors, respectively.

Carlin et al. (2004) come to different conclusions depending on the indicator used. The results presented in their paper about transition countries only showed a linear positive relationship when competition is measured by market power. When the number of competitors (market share) is used, an inverted U-shaped relationship with productivity growth is revealed. Okada (2005) and Inui et al. (2012), in turn, studying the effect of competition on the Japanese economy, found robust evidence of an inverted-U relation between competition and productivity, but only for firms engaged in R&D activities. Market power and market share indicators are used in both scientific analyses and the conclusions are the same, irrespective of the index employed. The non-linear relationship concerning the impact of competition on productivity was strongly defended by Aghion (2017), due to the positive *escape competition effect* and negative *discouragement effect*.

3.DATA AND METHODOLOGY

3.1. Relevant market definition

As the profitability index (4) used by Aghion et al. (2005), Inui et al. (2012) and Correa and Ornaghi (2014) will be used, the first step consists of defining the relevant market of each firm included in the sample. The relevant market should cover all the geographical area where the firm faces constraints from both demand and supply side substitution (OECD, 2012). Two main concepts emerge from this definition: i) the product substitution effect and ii) the geographical influence of producers on customers' decision to buy a product.

Concerning the first dimension, most studies cited in the previous section used the economic activity classification to define substitute products. Nevertheless, a high level of disaggregation should be used to avoid bias and to identify products as close as possible to their substitutes (Amador and Soares, 2013).

As regards the second item, since the firm's market can be at the local, regional, national or international level, knowledge of customers' geographical area of influence is necessary. For example, a small retail store located in the south of Portugal has no competition pressure from a similar shop situated in the north of country at least 400 kilometres away. To include the latter, to assess the former's market power or market share would not be correct, because the relevant market, in this case, is defined at a local level and should include only competitors influencing local customers' choice. Nevertheless, this information is not available on the database used in the present study and consequently the analysis excludes all firms with a potentially relevant market at the local and regional level. Several assumptions have been made based on firm size, economic activity and the number of subsidiaries. Bigger firms and firms with subsidiaries are more likely to have a relevant market beyond the regional level. Also, firms operating in some economic activities are more likely to have only a demand for the product at a local or regional level than others. This is particularly the case for small firms operating in the retail trade and tourism sectors[29] (hotels and restaurants). So, it is important to identify only sectors likely to sell their goods and services at a national and international level. Scientific literature has usually focused on the manufacturing sector (e.g. Okada, 2005; Tang, 2006; Kato, 2009; Inui et al., 2012; Correa and Ornaghi, 2014), because goods produced are easily tradable and transportable among regions and countries. Similarly, support services to firms have the same characteristics, even if the final product, e.g. a report or a design can be sent electronically. The service sector was assessed together with manufacturing industry by Soames et al. (2011).

To sum up, firms included in the present analysis were selected by the following steps. Firstly, all medium and large firms in all activity sectors[30]. Secondly, all firms with more than 1 subsidiary in all activity sectors. Thirdly, micro and small firms in manufacturing industry, construction[31] and service support to firms (specialized, scientific and technical activities; information and communication; administrative and support services activities).

3.2. Data source

The study covers 654 Portuguese firms, between 2007 and 2015, with patent applications at the national and international level from 1956, and included in the economic activities listed previously. This sample represents around 65% of all Portuguese firms with patent applications from 1956[32].

The database comes from several sources. Financial and patent information[33] comes from AMADEUS, a database created by Bureau van Dijk. The list of firms with an R&D tax incentive was taken from the Portuguese tax and customs authority's statistical department. The names of firms receiving public

[29] Usually tourists choose the hotel and restaurant as a function of the place that they want to visit and not the place according to the hotel and restaurant where they will stay and eat.

[30] Aghion et al. (2005) used a sample of stock market firms, which are likely to be bigger.

[31] The construction sector was considered because it is also included in the secondary sector, which corresponds to all economic activities using raw material from the primary sector (Agriculture, livestock production, hunting, forestry and fishing) to transform it in new goods, products or construction.

[32] According to the AMADEUS database, in Portugal, 1.012 firms submitted at least one patent application between 1956 and 2016.

[33] AMADEUS is a source of data for PATSTAT patent statistics, which is in turn a worldwide database.

support for R&D and innovation[34] were extracted from the Information System of the Portuguese National Strategic Reference Framework (NSRF) 2007-2013 Incentive Systems.

3.3. Competition indicator

Following the work of Aghion et al. (2005) and Correa and Ornaghi (2014), the present study used as competition measure ($c_{j,t}$) an index of the average profits in the industry.

$$c_{j,t} = 1 - \frac{1}{N_{j,t}} \sum_{i \in j} \pi_{i,t}; \qquad where\ \pi_{i,t} = \frac{EBIT_{i,t}}{sales_{i,t}} \tag{2}$$

The first step consists of estimating the profitability index ($\pi_{i,t}$) of the most representative firms in the Portuguese economy[35] by NACE code 4-digit. EBIT (Earnings Before Interest and Taxes) is used as an equivalent to "operating profits less financial cost". Taking into account the data available, EBIT seems to be the best proxy, as explained in Table 1. After estimating the average profitability index across all firms for each year, this value is subtracted to one, in order to get an indicator measuring the level of competition (and not the inverse, market power). The competition measure is later attributed to each firm taking their economic activity into account.

TABLE 1. PROFITABILITY INDEX: AGHION ET AL. (2005) VERSUS CORREA AND ORNAGHI (2014)

Authors	Operating profits	Financial cost = capital stock * capital cost
Aghion et al. (2005)	Operating profits net of depreciation and provisions ➔ similar to EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) if amortization is not taken into account	▪ Capital stock = Perpetual inventory method➔ similar to tangible fixed assets with depreciation and amortization ▪ Capital cost = 8.5% ↳ Financial cost is similar to amortization cost
Correa and Ornaghi (2014)	Operating Income Before Depreciation ➔ similar to EBITDA (earnings before interest, taxes, depreciation, and amortization)	▪ Capital stock = Total Gross Property, Plant and Equipment ➔ similar to tangible fixed assets without depreciation and amortization ▪ Capital cost = 8.5% ↳ Financial cost is similar to amortization cost
Operating profits less financial cost is similar to EBIT (Earnings Before Interest and Taxes) = EBITDA less depreciation and Amortization		

Source: Authors' own elaboration based on Aghion et al. (2005) and Correa and Ornaghi (2014).

3.4. Methodological framework

As the aim of the present study is to assess the effect of competition on innovation and on productivity and since the competition indicators used were defined above, the present section provides information about the dependent variables, explanatory variables and econometrics used.

Innovation will be measured through patent application and productivity using two indicators: Total Factor Productivity (TFP), estimated through a Cobb-Douglas production function[36], and Labour Productivity (LP), which is equal to the ratio between value added and number of employees.

[34] Through the following incentive systems of the Portuguese National Strategic Reference Framework (NSRF) 2007-2013:**SI** I&DT – incentive system for technology research and development in companies, SI Innovation – innovation incentive system and SI Qualification SME – incentive system for the qualification and internationalization of SMEs.

[35] AMADEUS database lists approximately 292,000 firms operating in the sectors selected for the present study, which have recorded a total amount of sales above €291,230 million. The most representative firms (around 95,593) are those with annual sales higher than €100.000 which accounts for 92% of the total sales of the sectors under analysis.

[36] For more details about Cobb-Douglas production function see Appendix B2.

The first model, which assesses the effect of competition on innovation, used a count data model, namely a Poisson regression model, because the dependent variable only assumes non-negative integer values $\{0, 1, 2, 3, 4, 5, \dots\}$. Indeed, linear regression model could be inconsistent or inefficient when used with count outcomes (Long and Freese, 2014). The Poisson regression model is reported in equation (6) where $\mu_{i,t}$ is the expected outcome given a random variable $y_{i,t}$ (number of patent applications of firm i during the period t) and a set of explanatory variables $x_{i,t}$. The Poisson regression model (6) takes an exponential form and consequently $\mu_{i,t}$ assumes only positive value, which is needed because $y_{i,t}$ is only equal to zero or positive.

$$\mu_{i,t} = E(y_{i,t}|x_{i,t}) = \exp(x_{i,t}\beta) \quad (6)$$

Additionally to competition level, the explanatory variables include in the model (6) is based on those commonly used in the scientific literature about patent and innovation decision[37], namely:

- Past innovative performance, measured through the growth rate of patent stock per employee, where the stock is estimated using the perpetual inventory method[38];
- Firm size measured by the number of employees (Scherer, 1965; Crépon *et al.*, 1998);
- Qualification of human resources (Beneito *et al.*, 2014), which in this model is measured by the labour cost per employee because this indicator is positively correlated with the education and competence of the workforce.
- Firm age (Beneito *et al.*, 2014);
- Access to public support (Tang, 2006; Chan, 2010; Rizzo and Ramaciotti, 2014), measured through R&D tax incentive, R&D grants, subsidized loans and grants for innovation. A dummy variable was created assuming the value of 1 if the firm received any kind of direct or indirect public support to R&D or innovation (RDI). A distinction between the differences policy tools is not performed because it is not the target of the present study.

As regards the second model, once the dependent variable assumes continuous values a linear regression model (7) will be used, namely random-effects (RE) and fixed-effects model (FE). Both equations are indexed to firm i under the period t, and contain the error term $\varepsilon_{i,t}$ composed by a time-invariant component α_i and an idiosyncratic error term $u_{i,t}$.

$$y_{i,t} = \beta_0 + x_{i,t}\beta + \varepsilon_{i,t} \text{ , where } \varepsilon_{i,t} = \alpha_i + u_{i,t} \quad (7)$$

The set of independent variables $(x_{i,t})$ explaining the dependent variable $y_{i,t}$ (productivity level expressed in logarithm) includes, in addition to competition level, those commonly used in the scientific literature[39], namely:

- Firm size (Crépon *et al.*, 1998). Firm size was divided in four categories (micro, small, medium and large-sized firms) taking into account the criteria number of employees, as reported in the Commission Recommendation 2003/361**;**
- Qualification of human resources (Crépon *et al.*, 1998), which in this model is measured by the labour cost per employee, expressed in logarithm form;
- Stock of patent applications per employee (Crépon *et al.*, 1998), lagged one period;
- Physical capital per employee (Crépon *et al.*, 1998), measured by tangible fixed assets per employee expressed in logarithm form and lagged one period;
- Access to public support (Sissoko, 2011), measured through R&D tax incentive, R&D grants, subsidized loans and grants for innovation.

All monetary variables include in equation (6) and (7) are expressed in thousands of euro and constant price (base = 2007).

[37] See also Table A1 in Appendix A.
[38] For more details about patent stock estimation see Appendix B1.
[39] See also Table A1 in Appendix A.

4. RESULTS AND DISCUSSION

4.1. Data description

The database covers 654 firms, between 2007 and 2015, divided into 208 NACE 4-digits sectors and more aggregated 16 sectors. The panel is unbalanced because information for some explanatory variables is missing for some years.

The sample is mainly composed of small and medium-sized enterprises (SME) and by firms more than 10 years old (Table B1 – Appendix B). Firms assessed are mostly concentrated in the NUTS 2 level regions of Norte (41.3%), Centro (30%) and Lisboa (24.6%), where firm density is also higher. The average number of patent applications between 2007 and 2015 was 0.48 per year, with a minimum of zero and a maximum of 134.

Despite the study covering a vast range of economic activity, firms operating in manufacturing industry represent more than 66% of the sample, followed by specialized, scientific and technical activities accounting for around 15% of the total (Table 2). These two sections also register the highest proportion of patent applications (86.5% of the total).

TABLE 2. PATENT VERSUS COMPETITION LEVEL, BY MAIN ECONOMIC ACTIVITY

SECTION	N. Firms		N° Patent		Patent by firm		Competition level	
	Total	% Total	Total	% Total	Average	Ranking	Average	Ranking
C. Manufacturing industry	429	65.6%	1 902	67.3%	4.4	3	0.9374	2
F. Construction	22	3.4%	41	1.5%	1.9	7	0.9337	3
G. Trade, repair of automobiles and motorcycles	26	4.0%	80	2.8%	3.1	4	0.9470	1
J. Information and communication	41	6.3%	112	4.0%	2.7	5	0.9043	5
M. Specialized, scientific and technical activities	96	14.7%	543	19.2%	5.7	1	0.8868	6
N. Administrative and support services activities	18	2.8%	97	3.4%	5.4	2	0.9117	4
Other sectors	22	3.4%	52	1.8%	2.4	6	0.8554	7
TOTAL	654		2827		4.3			

Source: Authors' own elaboration based on AMADEUS database.

Note: Other sectors included firms in the following sections: A. Agriculture, Forestry and Fishing; B. Extractive industries; D. Production and distribution of electricity, gas, steam and air conditioning; E. Production and distribution of water, sanitation, waste management and depollution; H. Transport and storage; I. Accommodation and restoration; K. Financial and insurance activities; L. Real estate activities; P. Teaching and; Q. Human health and social action.

As regards the competition level indicator, the lowest average value reported in Table 2 is found in the "others" sectors, which included a group of firms operating in sectors with the lowest competition or the highest concentration of market power. This group also reports lower innovation performance (average patents *per* firm). On the other hand, "Specialized, scientific and technical activities" also report low competition, but show the highest innovation performance. In turn, manufacturing industry records a high degree of competition and relatively high innovation performance. This interpretation could suggest a positive or negative relationship depending on the economic activity.

Concerning the productivity level of the sample, Table 3 reports the average value per firm-year for both measures, TFP and Labour Productivity (LP). A first interesting conclusion is that some economic activities do not rank equally in performance depending on the indicator used. For example, manufacturing industry and construction activities showed a higher relative performance when measured by TFP than by LP, whereas for specialized, scientific and technical activities (section M) and administrative and support services activities (section N) higher relative performance is shown with LP.

TABLE 3. PRODUCTIVITY *VERSUS* COMPETITION, BY MAIN ECONOMIC ACTIVITY

SECTION	Competition level		TFP		Labour Productivity	
	Average firm-year	Ranking	Average firm-year	Ranking	Average firm-year	Ranking
C. Manufacturing industry	0.9374	2	7.14	3	37	6
F. Construction	0.9337	3	7.00	4	33	7
G. Trade, repair of automobiles and motorcycles	0.9470	1	7.29	2	200	2
J. Information and communication	0.9043	5	6.24	5	38	5
M. Specialized, scientific and technical activities	0.8868	6	5.45	7	99	3
N. Administrative and support services activities	0.9117	4	5.98	6	45	4
Other sectors	0.8554	7	8.77	1	759	1

Source: Authors' own elaboration based on AMADEUS database.
Note: Other sectors included firms in the following sections: A. Agriculture, Forestry and Fishing; B. Extractive industries; D. Production and distribution of electricity, gas, steam and air conditioning; E. Production and distribution of water, sanitation, waste management and depollution; H. Transport and storage; I. Accommodation and restoration; K. Financial and insurance activities; L. Real estate activities; P. Teaching and; Q. Human health and social action
TFP = Total Factor Productivity. Labour productivity = valued added by employee.

Table 3 also reveals different behaviours as regards the relationship between competition and productivity:

- Sector with a low level of competition shows a higher performance (others sector);
- Sectors with a high level of competition are associated with high (section G) or modest (section J) performance;
- Sectors with a high level of competition have high performance in TFP and a low performance in LP (section C and F);
- Sectors with low (section M) or modest (section N) competition are linked with low performance in TFP and modest performance in LP.

So once again, the relationship between competition and productivity seems to depend on the sector and the variable used in the analysis.

4.2. Results of patent model

Starting with a simple Poisson regression estimation, with competition level and fixed effects for year, economic activity and NUTS 2 regional level, the results reported in Table D1 (Appendix D) show a negative, non-linear, U-shaped relationship between competition level and innovation, as predicted by Boone (2001). Nevertheless, when the effect of competition is assessed taking into account its growth rate, a positive relationship is found. These findings mean that, in the short-term, the direct effect of competition is negative, but in the medium-long term it becomes dynamic since, faced with increased competition in the market, firms are forced to innovate to overcome competition pressure. Furthermore, these conclusions are seen to be robust since when adding a control variable to the previous baseline model they remain the same, using either a random-effects or a conditional fixed-effects estimator (Table 4).

TABLE 4. RESULTS OF POISSON REGRESSION – N° OF PATENT APPLICATIONS, ALL SECTORS

Variables	Random Effects	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Competition level	-85.19***	-93.61***	-87.14**	-96.33***	-	-
	(32.48)	(32.04)	(33.88)	(34.38)	-	-
Competition level (squared)	49.31***	55.22***	50.37**	56.74***	-	-
	(18.71)	(18.66)	(19.80)	(20.26)	-	-
Δ Competition level (growth rate)	-	-	-	-	5.545**	5.958***
	-	-	-	-	(2.156)	(2.072)
Firm size - Log (n° employee)	0.469***	0.998***	0.479***	0.991***	0.467***	0.961***
	(0.113)	(0.248)	(0.117)	(0.257)	(0.106)	(0.243)
Firm age - Log (n° year)	-0.686***	-0.631**	-0.662***	-0.544*	-0.649***	-0.483
	(0.118)	(0.313)	(0.119)	(0.329)	(0.121)	(0.340)
Δ Patent stock per employee	0.494**	0.549**	0.502**	0.555**	0.478**	0.532**
	(0.208)	(0.262)	(0.223)	(0.279)	(0.217)	(0.260)
Log (average salary per employee) - "T-1"	0.379*	0.403	0.364*	0.353	0.342*	0.308
	(0.196)	(0.403)	(0.197)	(0.402)	(0.184)	(0.360)
Received national public support for RDI - "T"	0.415***	0.383***	-	-	-	-
	(0.113)	(0.125)	-	-	-	-
Received national public support for RDI - "T-1"	-	-	0.224**	0.174*	0.234**	0.191**
	-	-	(0.0994)	(0.0944)	(0.0951)	(0.0925)
NACE 2 digits dummy	YES	NO	YES	NO	YES	NO
Region dummy	YES	NO	YES	NO	YES	NO
Year dummy	YES	YES	YES	YES	YES	YES
Constant	35.64***	-	36.46***	-	-0.176	-
	(13.39)	-	(13.81)	-	(0.460)	-
Observations	4,782	2,609	4,782	2,609	4,782	2,609
Number of id	654	361	654	361	654	361
Log pseudolikelihood	-33,917.01	-21,449.18	-3.410,33	-2.161,17	-3.416,00	-2.168,18
H0: All coefficient = 0	0,0000	0.0000	0,0000	0,0000	0,0000	0,0000
LR test of alpha=0	0,0000	-	0,0000	-	0,0000	-
Hausman test - Ho: difference in coefficients not systematic		0,0000		0,0000		0,0000

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. When fixed-effects model is reported it refers to conditional fixed-effects. Results of Wald test and Hausman test refer to p-value.

Table 4 shows the results of the random-effects (RE) and conditional fixed-effects (FE) Poisson regression model. The particularity of the FE estimator when using non-linear models is dropping all observations that are not time varying. For the present study, this implies that when FE estimators are used the number of total observations used for running the regressions falls by almost 50%. So, despite the Hausman test rejecting the hypothesis that individual-level effects are adequately modelled by an RE model, the results of both will be assessed. Comparing the impact and significance of variables between RE and FE, we can see that surprisingly, and despite a significant reduction of the number of observations, the conclusions are very similar.

Firm sized, expressed by the number of employees, and past innovation performance, measured by the growth of patent stock per employee, are revealed to have a positive effect on the number of patent applications, in all models. The average salary paid to employees, a proxy for workers' qualifications, also has a positive impact on the dependent variable, but only a significant effect in the RE models.

Having received any kind of public support for innovation or R&D expenditure increases the likelihood of the number of patent applications and this effect is sustainable, since it can be observed both in t and $t-1$. Firm age has a negative effect on the number of patent applications in almost all models, which means that younger firms are more likely to innovate. One justification for this finding could be that innovation is a way for start-ups to enter the market or get a higher market share, when competition is greater.

Additionally, a similar exercise was performed for firms operating in manufacturing industry. The results in Appendix D1 reveal some differences concerning the impact of competition on firms' innovation behaviour. First, there is a linear and positive correlation between both variables, which is in line with the findings of Correa and Ornaghi (2014) for US manufacturing industry. Secondly, a robust effect of competition growth rate was not found, which means that the effect of competition on innovation in this sector only happens in the short-term.

4.3. Results of productivity model

Now, turning to assessment of competition's effect on productivity, a preliminary analysis based on a simple panel regression with only these two variables (Appendix E) reveals some evidence of a negative effect on labour productivity and a positive one on TFP. Indeed, competition only has a significant and positive effect on TFP when expressed in growth rate and lagged one year, which means the effect is not immediate (it takes at least one year) and firms react only when competition pressure increases. In turn, the negative effect of competition on labour productivity occurs in both ways, through a direct and immediate impact of the degree of competition and by increased competition. Once again, to assess the robustness of these results, control variables were added and the conclusions about the significance and direction of the effects are the same. Table 5 reports the results of a log-log fixed-effects regression, since the Hausman test rejected the hypothesis that individual-level effects are adequately modelled by an RE model.

Concerning the effect on TFP, since this indicator is linked with technological progress, and the development and implementation of new technology takes time, it is not surprising that its impact was not immediate and was the result of a dynamic process. As regards the negative effect on labour productivity, several factors could explain this result. First, as highlighted by Boone (2001), in the presence of a low level of competition, less efficient firms are active and the incentive to innovate is low, which is also in line with the negative effect found for patent application in the short-term. Secondly, product innovation usually has no effect on labour productivity. In fact, it is process innovation that has a positive effect. In the case of new product development and commercialization, the effect on labour productivity could even be inverse, i.e. negative, because employees need time to adapt their skills for efficient production of the new goods, and during this process productivity can even fall. This justification is also in line with the interpretation of patent stock per employee, as an increase here in the previous period generates a decrease in TFP in the current period.

TABLE 5. RESULTS OF LOG-LOG FIXED-EFFECT REGRESSION – TFP AND LP, ALL SECTORS

	Log (TFP)	Log (TFP)	Log (LP)	Log (LP)
VARIABLES	Model 7	Model 8	Model 9	Model 10
Δ Log (competition level) in "T"	-	-	-1.361**	-1.388**
	-	-	(0.598)	(0.597)
Δ Log (competition level) in "T-1"	0.114***	0.118***	-	
	(0.0405)	(0.0409)	-	
Micro sized-firm	-0.300***	-0.298***	0.430***	0.415***
	(0.0282)	(0.0283)	(0.136)	(0.136)
Small sized-firm	-0.147***	-0.146***	0.126	0.118
	(0.0221)	(0.0223)	(0.0992)	(0.100)
Medium sized-firm	-0.0735***	-0.0731***	0.0771	0.0715
	(0.0160)	(0.0161)	(0.0713)	(0.0718)
Log (average salary per employee) in "T"	-0.0119	-0.0120	0.673***	0.676***
	(0.0168)	(0.0168)	(0.136)	(0.137)
Received national public support for RDI in "T"	0.00584**	-	0.0573***	
	(0.00271)	-	(0.0188)	
Received national public support for RDI in "T-1"	-	0.00798***	-	-0.00648
	-	(0.00249)	-	(0.0174)
Patent stock per employee in "T-1"	-0.0170***	-0.0169***	0.0308	0.0316
	(0.00485)	(0.00487)	(0.0971)	(0.0976)
Log (physical capital per employee) in "T-1"	0.0189***	0.0189***	0.0412	0.0409
	(0.00429)	(0.00430)	(0.0265)	(0.0265)
NACE 2 digits dummy	NO	NO	NO	NO
Region dummy	NO	NO	NO	NO
Year dummy	YES	YES	YES	YES
Constant	2.034***	2.034***	1.214***	1.224***
	(0.0725)	(0.0729)	(0.416)	(0.421)
Observations	4,211	4,211	4,379	4,379
Number of id	651	651	613	613
R-squared (within)	0.290	0.291	0.176	0.175
R-squared (between)	0,8516	0,8521	0,3679	0,3676
R-squared (overall)	0,8205	0,8205	0,3869	0,3851
Wald test - H0: All coefficient = 0	0.000	0.000	0.000	0.000
Hausman test - Ho: difference in coefficients not systematic	0.000	0.000	0.000	0.000

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. When fixed-effects model is reported it refers to conditional fixed-effects. Results of Wald test and Hausman test refer to p-value. Reference category for firm size is large firm.

Regarding the effect of other explanatory variables on productivity, Table 5 reveals some differences depending on the measure used for productivity. Firm size has a positive effect on TFP and a negative one on LP. This conclusion is in line with sample firms' characteristics, as large firms record a lower LP than SMEs but a higher TFP. As regards the difference in LP, since this indicator is the ratio between firm output and input, we can see in Table C3 (Appendix C) that large firms have increased their input more than their output, both measured by growth rate.

A higher average salary per employee, a proxy of workers' qualifications, has a positive effect but only on LP, while, physical capital per employee, measured by firm investment in the previous period, has only a positive impact on TFP. These conclusions are in line with the definition of both

productivity indicators. TFP is linked with technological progress, and is associated with investment, while LP is the result of human capital skills, and is influenced by their performance.

Public support for R&D and innovation has a positive and direct effect on both TFP and LP, but while the effect on LP only happens in the short term, for TFP the impact of this policy tool started even in the previous period and remained one year after. This finding showed some evidence that government support is more sustainable in leveraging technological progress than in increasing human capital performance.

Finally, a similar analysis was made for firms operating in manufacturing industry, but as the results did not show differences they are not reported in the present paper. Nevertheless, they are available on request.

5. Conclusion

The present paper assesses the impact of competition on innovation and productivity, based on 654 Portuguese firms, in the period 2007-2015. Innovation is measured by the number of patent applications and productivity by labour productivity and Total Factor Productivity. Competition is estimated using a profitability index, based on the framework of Aghion et al. (2005).

The study reveals that the level of competition in the Portuguese economy is higher in trade and manufacturing industry and lower in specialized, scientific and technical activities. Specialized services are also those showing the best innovative performance, measured by the average number of patents by firm-year, despite low to moderate productivity performance.

On average, competition was revealed to have a negative, U-shaped effect on innovation in the short term, and a positive effect in the medium-long run. However, firms operating in manufacturing industry seem to react more quickly to competitive pressure compared to the average. Indeed, a linear and positive correlation was found between competition and innovation in this sector, which is in line with the findings of Correa and Ornaghi for US manufacturing industry. Nevertheless, the inverted U-shaped relationship of Aghion et al. (2015) is not confirmed in any case, perhaps due to the different characteristics of the firms studied.

Concerning the effect of competition on productivity, a positive effect on Total Factor Productivity emerged from the analysis, while on labour productivity a negative one prevails.

Bigger and younger firms, as well as those with more qualified personnel and higher innovation performance in the past, are more likely to increase the number of patent applications. Public support for R&D and innovation seems to be effective in leveraging both innovation and productivity.

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APPENDIX

Appendix A. Benchmarking studies: competition, innovation and productivity

TABLE A1. STUDIES' CHARACTERISTICS AND MAIN CONCLUSION: COMPETITION, INNOVATION AND PRODUCTIVITY

Authors	Country, period, sector, data and methodology	Measuring competition	Dependent variable	Explanatory variable	Main conclusion
Carlin et al. (2004)	▪ 24 transition countries ▪ 1999 ▪ Agriculture, industry and services sector ▪ Business Environment and Enterprise Performance Survey (BEEP) ▪ Structural equations, OLS and GMM	▪ Market structure: entrepreneur self-perception about the number of competitors in the market for its main product ▪ Market power: entrepreneur self-perception about customer behaviour faced with a 10% increase of product price (switch to rival suppliers' vs continue to buy in similar quantities as previously)	▪ Innovation (Equation 1) ▪ Sales growth per employee (Equation 2)	▪ Equation 1: competition, market growth, access to resources, managerial incentives, firm size ▪ Equation 2: growth of employment, innovation, competition, access to resources, managerial incentives ▪ Industry fixed effects, location (agglomeration fixed effects) and country fixed effects	▪ Results show an inverted U-shaped relationship between competition, measured by the number of competitors, and firm performance, whereas market power reveals a positive effect on productivity growth. ▪ The number of competitors is a weak determinant of the decision to innovate for old firms despite showing the inverted-U form. For new firms, the number of competitors is negatively associated with innovation. ▪ The ability to raise prices (market power) has a positive effect on the decision to innovate.
Aghion et al. (2005)	▪ UK ▪ 1973 – 1994 ▪ All industry sector – 17 two-digit SIC codes ▪ Datastream and NBER patents database ▪ Poisson and linear regression	▪ Lerner index (or price cost margin) = operating profit net of depreciation, provisions and financial cost of capital divided by sales	▪ N° of citation-weighted patents ▪ Technology gap using Total Factor Productivity	▪ Competition ▪ Policy changes and reforms (instrument for competition) ▪ Year and industry fixed effects	▪ Inverted-U shaped impact of competition on innovation (patent) ▪ Technology gap increases with competition ▪ Competition increases the incremental profit from innovation (escape-competition effect) and reduces innovation incentives for laggards (Schumpeterian effect)
Okada (2005)	▪ Japan ▪ 1994 – 2000 ▪ Manufacturing sector (59 industry codes) ▪ Basic Survey of Business Structure and Activities ▪ Dynamic panel estimation (Difference GMM)	▪ Product market competition = price-cost margin = (sales - cost of sales + depreciation - cost of capital) / sales ▪ Market share and diversity index = sales of firm i for its product k in the industry segment or market k ▪ Product market competition = 1 − Industry-averaged price–cost margin	▪ Growth of output (real sales) using production function	▪ R&D stock ▪ technology transaction turnovers divided by sales ▪ Herfindahl index of R&D expenditure ▪ Debt-asset ratio (=financial constraint variable) ▪ Growth rates of both industrial sales and import penetration	▪ Product market competition has a positive effect on productivity growth, whereas the, R&D concentration index has a negative effect (=> spreading R&D expenditure among firms has a positive impact on productivity growth) ▪ Market power has no significant effect on competition in the model with the whole sample and a negative one on those with only R&D performance
Tang (2006)	▪ Canada ▪ 1997 - 1999 ▪ Manufacturing sector with 3-digit NAICS ▪ Statistics Canada Survey of	Entrepreneur self-perception about competitive environment: ▪ Easy substitution of	▪ innovation input (R&D) ▪ innovation output (product and/or process)	▪ Competition perception: i) easy substitution of products; ii) constant arrival of competing products; iii) quick obsolescence of	▪ The relationship between competition and innovation activities can be positive or negative, depending on specific competition perception and innovation activities

	Innovation ▪ Logit and Multinomial logit	products ▪ Constant arrival of competing products ▪ Quick obsolescence of products ▪ Rapid change of production technologies	products; iv) rapid change of production technologies ▪ Public support for R&D (tax credits, grants and venture capital) ▪ Firm size ▪ Industry and firm fixed effect	▪ Easy product substitution is negatively correlated with R&D or product innovation, whereas, constant arrival of competing products and their quick obsolescence shows a positive correlation.

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TABLE A1. STUDIES' CHARACTERISTICS AND MAIN CONCLUSION: COMPETITION, INNOVATION AND PRODUCTIVITY

Authors	Country, period, sector, data and methodology	Measuring competition	Dependent variable	Explanatory variable	Main conclusion
Kato (2009)	▪ India ▪ 1991/92 – 2001/02 ▪ 8 Manufacturing industries sector ▪ Annual Survey of Industries ▪ Fixed effect model and Dynamic panel estimation (Difference GMM)	▪ Index of competition variables composed of the Herfindahl index (HHI), the import ratio of the product market and market share of each firm, where the first two indicators are common to all the firms in the same product market, while the last one is specific to individual firms	▪ Growth rates of total factor productivity	▪ Competition (HHI, import ratio of the product market and market share) ▪ Firm size and age	▪ Product market competition enhances productivity growth rates, since a firm with a smaller market share in a less concentrated market (when competitive pressure is high) is likely to have higher TFP growth rates ▪ Import ratios of product market have a negative effect on the growth rates of TFP, whereas the Herfindahl index has a positive one
Soames et al. (2011)	▪ Australia ▪ 2006-2007 ▪ Manufacturing and services sector (17 division) ▪ Australian Bureau of Statistics Business Characteristics Survey ▪ Binary, Multivariate and Ordered probit models	Entrepreneur self-perception about competitive environment: ▪ Price-cost margin (a measure of mark-up over cost) ▪ Market share ▪ Number of competitors ▪ Being hampered by competition	▪ To have innovation activities (product, process, organizational or marketing) ▪ Degree of novelty and n° of innovations introduced	▪ Competition: market share, n° of competitors and price cost margin and being hampered by competition ▪ Firm characteristics: size, age, export status, export intensity and ownership ▪ Intellectual Property indicator only for ordered probit model ▪ Industry fixed effect	▪ Higher market share, higher n° of competitors and a lower price-cost margin are associated with a higher propensity to innovate ▪ Being hampered by competition has a positive effect on innovation and price cost margin a negative one, suggesting that firms facing profit pressures due to competition and with smaller margins are more likely to innovate ▪ The number of innovation types and the degree of novelty are less sensitive to competition. Only being hampered by competition is statistically significant in both models. Price cost margin is negatively significant but only for the n° of innovations and large market share is only positively significant for the degree of novelty.
Inui et al. (2012)	▪ Japan ▪ 1997 – 2003 ▪ Manufacturing sector ▪ Basic Survey of Business Activities of Enterprises ▪ Fixed effect models with instrumental variables	▪ Lerner index = operating profit less financial costs divided by sales ▪ Herfindahl Index= share of the sales of firm i in industry j at time t in percentage terms	▪ Growth of Total Factor Productivity ▪ Firms' distance from TFP in each industry	▪ Competition ▪ Firm size and age ▪ Foreign ownership ▪ Regulation index, Import ratio and N° of firms (instrument for competition) ▪ Firm, industry and time dummy	▪ Competition has an inverted-U relationship with productivity improvement, but only for firms engaged in R&D activities ▪ Market competition widens the technological gap across firms
Correa and Ornaghi (2014)	▪ US ▪ 1974–2001 ▪ Manufacturing industry - four-digit SIC code industries ▪ NBER patents	▪ Profitability = operating profits less capital cost divided by sales	▪ N° of patents (or citation-weighted patents) ▪ Total Factor Productivity (TFP) or	▪ Competition ▪ Technological progress in France and Germany (instrument for competition) = Growth of TFP or	▪ Patent counts (simple or weighted by citations) and productivity (TFP or LP) increases with more competition ▪ Some doubts exist about an inverted-U relationship

	database and U.S. Bureau of Labor Statistics ▪ Negative binomial regression	Labour productivity (LP)	LP in France and Germany at industry-level ▪ Tariff rate in Canada and Mexico (instrument for competition) ▪ China importation growth (instrument for competition) ▪ Industry and time dummies	between competition and innovation in markets with well-defined intellectual property rights

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TABLE A1. STUDIES' CHARACTERISTICS AND MAIN CONCLUSION: COMPETITION, INNOVATION AND PRODUCTIVITY (continuation)

Authors	Country, period, sector, data and methodology	Measuring competition	Dependent variable	Explanatory variable	Main conclusion
Amin (2015)	▪ India ▪ 2006 ▪ Retail stores ▪ World Bank's Enterprise Surveys ▪ OLS and IV regressions	▪ Entrepreneur self-perception about the pressure/influence of domestic competitors on influencing product prices. The answer is on a scale 1–4 where (1) means not at all important and (4) important.	▪ Labour productivity (sales per employee)	▪ Competition ▪ Firm size and age ▪ Using computer for management ▪ Inventory system ▪ Owner gender ▪ City and store-type fixed effects ▪ Institutional environment	▪ Positive impact of competition on the level of labour productivity ▪ Competition reveals endogeneity depending on citizen and retail characteristics
Friesenbichler and Peneder (2016)	▪ Eastern Europe and Central Asia ▪ 2012/2013 ▪ All industry sector - NACE two-digit industries ▪ World Bank's Enterprise Surveys ▪ Three-stage least-square estimations (3SLS)	▪ Entrepreneur self-perception about the number of competitors for the principal product/service in the main market.	▪ R&D expenditure ▪ Innovation outcome (product or process) ▪ Competition ▪ Productivity (sales per employee, Value added per employee and Multi factor productivity)	▪ Technological regime ▪ Firm size and age ▪ Export status ▪ Employee's level of education ▪ Ownership ▪ Political instability	▪ Inverted-U shaped impact of competition on R&D ▪ The amount of R&D expenditure increases the probability of successful innovation ▪ Successful innovations consistently reduce the perceived number of competitors ▪ Competition and innovation have a positive impact on productivity
Crowley and Jordan (2017)	▪ 30 countries in Central and East Europe and East Asia ▪ 2011 - 2014 ▪ Low, medium and high technology industry ▪ Business Environment and Enterprise Performance Survey (BEEP) ▪ Multivariate probit	▪ Entrepreneur self-perception about the number of competitors in the market for its main product	▪ To be engaged in one of four types of innovation	▪ Level of competition (= n° of competitors) ▪ Having invested in R&D or in fixed assets ▪ Receiving public support ▪ Firm characteristics: size, age, domestic or foreign ownership, local or non-local market orientation, size of urban area where implemented ▪ Technological sector and country fixed effect	▪ One average, greater levels of competition are associated with greater innovation. However, this relationship is not linear, pointing to an inverted U-Shaped type. ▪ Dividing the degree of competition in categories (low, medium and high), results show that lower competition levels are not associated with less likelihood of innovation but higher levels of competition can reduce it.
Dhanora et al. (2017)	▪ India ▪ 2006-2013 ▪ Pharmaceutical sector ▪ Indian patent office and government financial database ▪ Fixed and random effects estimation techniques	▪ Lerner index = Ratio of sales less labour cost, electricity cost and raw material cost to total sales ▪ Profitability (robustness check) = Ratio of operational profit to total sales.	▪ Market power (competition)	▪ Patent intensity = ratio of granted patents (total, product or process) to lagged R&D expenditure ▪ Foreign ownership ▪ Firm specific characteristics (advertising, imports of raw materials and disembodied	▪ Total patent intensity, as well as product or process patent intensity have an inverted U-shaped relationship with market power, measured by Lerner index or profitability

	technology and assets

Source: Authors' own elaboration based on Carlin et al. (2004), Aghion et al. (2005), Okada (2005), Tang (2006), Kato (2009), Soames et al. (2011), Inui et al. (2012), Correa and Ornaghi (2014), Amin (2015), Friesenbichler and Peneder (2016), Crowley and Jordan (2017), Dhanora et al. (2017).

APPENDIX B. METHODOLOGICAL APPROACH

B1. Estimating Patent Stock

Patent stocks are estimated using the Perpetual Inventory method (PIM). This approach (7) assumes that the patent stock (PS) in t is equal to the number of patent applications (P) in t plus the patent stock in $t-1$, updated to period t by a depreciation rate of capital (δ). We used a depreciation rate for patent application of 15%, the same as normally used for R&D expenditure[40].

$$PS_{it} = PS_{i,t-1}(1 - \delta) + P_{it} \quad (7)$$

Nevertheless, estimation of the starting point is needed, when the net patent stock value in t-1 for the first year of observation is unknown. In the present study, the first year for which we have information is 2007. So, in year t = 1 (= 2007) the pre-sample accumulation stock is estimated as expressed in equation (8), taking into account the growth rate (g) of patents, as well as the depreciation rate (δ).

$$C_{i,1} = \frac{I_{i,1}}{g+\delta} \quad (8)$$

B2. Estimating Total Factor Productivity

Total Factor Productivity was estimated using a Cobb and Douglas (1928) production function as expressed in equation (9), where i corresponds to the firm and t period of time. Y refers to firms' production output, measured by the value added (GDP). K and L refer to the inputs, representing respectively physical capital stock and labour stock. A expresses the technology used for producing Y and e the error term, which includes unmeasured factors. α, β, and γ correspond to the parameter of interest. Labour stock is measured by the number of employees and physical capital stock by the net value of fixed assets.

$$Y_{it} = A_t K_{it}^{\alpha} L_{it}^{\beta} e^{u_{it}} \quad (9)$$

To estimate equation (9), the logarithm form was taken in order to obtain a linear regression (10). The lower-case letters correspond to the logarithms of each variable. The equation (10) also includes NUTS 2 region fixed effect (φ_i), activity sector fixed effect (γ_i) and time fixed effect (τ_t) to measure technological progress.

$$y_{it} = c + \alpha k_{it} + \beta l_{it} + \varphi_i + \gamma_i + \tau_t + u_{it} \quad (10)$$

The results of the Cobb and Douglas (1928) production function, reported in Table B1, showed as expected a coefficient for labour inputs close to 0.7 and close to 0.3 for capital inputs, revealing that the model correctly predicts the value of technological progress or Total Factor Productivity.

[40] Traditionally, authors (e.g. Hall and Mairesse, 1995) used the value of 15% for the depreciation rate of R&D capital stock.

TABLE B1. RESULTS OF COBB -DOUGLAS PRODUCTION

Variables	Y = Log (added value)
	Model D1
Log (fixed assets)	0.225***
	(0.0200)
Log (n° employees)	0.823***
	(0.0317)
Sector dummy	YES
Region NUTS 2 level	YES
Year dummy	YES
Constant	3.275***
	(0.461)
Observations	5,509
R-squared	0.877
Wald test - H0: All coefficient = 0	192.66 (0.0000)

Source: Authors' own elaboration.
Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

APPENDIX C. DESCRIPTIVE STATISTICS

TABLE C1. MEAN, STANDARD DEVIATION, MINIMUM AND MAXIMUM

Variables	Obs.	Mean	Std. Dev.	Min	Max
N° of patent applications	5,886	0.480	3.253	0	134
Patent stock per employee	5,499	0.210	1.220	0	31.43
Competition level	5,886	0.924	0.040	0.543	1
N° of employees	5,499	155.60	499.67	1	9 724
Micro-sized firm	5,499	0.237	0.426	0	1
Small-sized firm	5,499	0.334	0.472	0	1
Medium-sized firm	5,499	0.309	0.462	0	1
Large-sized firm	5,499	0.119	0.324	0	1
Age (n° of years)	5,656	25.48	19.89	0	122
Start-up (0 - 2 years)	5,656	0.059	0.235	0	1
Young firm (3 - 5 years)	5,656	0.074	0.262	0	1
Mature firm (6 - 10 years)	5,656	0.123	0.328	0	1
Old firm (> 10 years)	5,656	0.745	0.436	0	1
Tangible fixed assets per employee (x €1.000)	5,499	283.21	2923.44	0	93,699.82
Salary and wages per employee (x €1.000)	5,475	39.12	896.30	0.014	47,529.70
Total Factor Productivity	5,460	7.015	1.909	1.714	14.362
Labour Productivity (x €1.000)	5,151	70.06	1,668.92	-18,906.5	82,381.66
Receiving national public support for RDI	6,540	0.284	0.451	0	1
Region NUTS 2 level – Norte	6,540	0.413	0.492	0	1
Region NUTS 2 level – Algarve	6,540	0.009	0.095	0	1
Region NUTS 2 level – Centro	6,540	0.300	0.458	0	1
Region NUTS 2 level – Lisboa	6,540	0.246	0.431	0	1
Region NUTS 2 level – Alentejo	6,540	0.018	0.134	0	1
Region NUTS 2 level - Madeira and Açores	6,540	0.014	0.117	0	1

Source: Authors' own elaboration.
Note: All monetary variables are expressed on thousands of euro and constant price (base=2007).

TABLE C2. COLLINEARITY DIAGNOSTICS AND CORRELATION MATRIX

#	Variables	VIF	Correlation matrix						
			1	2	3	4	5	6	7
1	Competition level	1.05	1						
2	N° of employees	1.03	-0.0039	1					
3	Age (N° of years)	1.07	0.1758	0.1419	1				
4	Patent stock per employee	1.21	-0.1000	-0.0488	-0.1131	1			
5	Tangible fixed assets per employee	1.42	-0.1373	0.0017	-0.0238	0.3747	1		
6	Salary and wages per employee	1.21	-0.0176	-0.0040	0.0134	-0.0004	0.3799	1	
7	Receiving national public support for RDI	1.01	-0.0203	0.0427	-0.0529	-0.0272	-0.0190	0.0373	1

Source: Authors' own elaboration.

TABLE C3. LABOUR PRODUCTIVITY BY FIRM SIZE

	All sample	SMEs	No-SMEs
Growth rate of LP	53,65%	91,39%	-209,21%
Growth rate of value added	7,66%	36,73%	-181,20%
Growth rate of Log (value added)	0,80%	0,88%	0,31%
Growth rate of employees	48,72%	9,41%	341,32%
Growth rate of Log (employees)	2,03%	2,27%	0,32%

Source: Authors' own elaboration.

APPENDIX D. PRELIMINARY ANALYSIS: PATENT FUNCTION

TABLE D1. RESULTS OF POISSON REGRESSION – N° OF PATENT APPLICATIONS, ALL SECTORS AND MANUFACTURING INDUSTRY

Variables	Random effects	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects
	ALL SECTORS					
	Model D1	Model D2	Model D3	Model D4	Model D5	Model D6
Competition level	1.493	1.916	-	-	-56.70**	-58.69**
	(3.093)	(3.349)	-	-	(25.83)	(26.25)
Competition level (squared)	-	-	-	-	33.25**	34.65**
	-	-	-	-	(14.89)	(15.13)
Δ Competition level	-	-	5.397**	5.476**	-	-
(Growth rate)	-	-	(2.355)	(2.375)	-	-
Year dummy	YES	YES	YES	YES	YES	YES
NACE 2 digits dummy	YES	NO	YES	NO	YES	NO
Region dummy	YES	NO	YES	NO	YES	NO
Constant	-2.674	-	-1.141***	-	22.14**	-
	(2.564)	-	(0.188)	-	(10.70)	-
Observations	5,886	3,672	5,232	3,048	5,886	3,672
Number of id	654	408	654	381	654	408
Log pseudolikelihood	-4 664.47	-3 276.79	-4 078.84	-2 763.90	-4 656.24	-3 268.09
H0: All coefficient = 0	0.000	0.003	0.000	0.001	0.000	0.0015
LR test of alpha=0	0.000	-	0.000	-	-	-

Variables	Random effects	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects
	MANUFACTURING INDUSTRY					
	Model D7	Model D8	Model D9	Model D10	Model D11	Model D12
Competition level	9.725**	9.999**	-	-	66.62	55.63
	(4.426)	(4.575)	-	-	(161.0)	(164.0)
Competition level (squared)	-	-	-	-	-30.70	-24.63
	-	-	-	-	(87.16)	(88.75)
Δ Competition level	-	-	5.867+	6.012+	-	-
(Growth rate)	-	-	(3.884)	(3.919)	-	-
Year dummy	YES	YES	YES	YES	YES	YES
NACE 2 digits dummy	YES	NO	YES	NO	YES	NO
Region dummy	YES	NO	YES	NO	YES	NO
Constant	-8.980**	-	0.412		-35.33	-
	(3.675)	-	(0.803)		(74.48)	-
Observations	3,861	2,286	3,432	1,864	3,861	2,286
Number of id	429	254	429	233	429	254
Log pseudolikelihood	-2 899.36	-2 009.45	-2 508.80	-1 671.80	-2 899.00	-2 009.23
H0: All coefficient = 0	0.000	0.0022	0.000	0.0039	0.000	0.0058
LR test of alpha=0	0.000	-	0.000	-	-	-

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: +p<0.15,*** p<0.01, ** p<0.05, * p<0.1. When fixed-effects model is reported it refers to conditional fixed-effects.

APPENDIX E. PRELIMINARY ANALYSIS: PRODUCTIVITY FUNCTION

TABLE E1. RESULTS OF PANEL REGRESSION MODEL – PRODUCTIVITY FUNCTION (LOG TFP), ALL SECTORS

	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects
Variables	Model E1	Model E2	Model E3	Model E4	Model E5	Model E6	Model E7	Model E8
Log (Competition level)	-0.0442	-0.0475	-	-	-	-	-0.202	-0.202
	(0.122)	(0.123)	-	-	-	-	(0.181)	(0.180)
Log (Competition level - squared)	-	-	-	-	-	-	-0.423	-0.413
	-	-	-	-	-	-	(0.530)	(0.531)
Δ Log (Competition level) in "T"	-	-	0.0831	0.0850	-	-	-	-
	-	-	(0.0677)	(0.0671)	-	-	-	-
Δ Log (Competition level) in "T-1"	-	-	-	-	0.228**	0.229***	-	-
	-	-	-	-	(0.0891)	(0.0884)	-	-
Year dummy	YES	YES	YES	YES	YES	YES	YES	YES
NACE 2 digits dummy	YES	NO	YES	NO	YES	NO	YES	NO
Region dummy	YES	NO	YES	NO	YES	NO	YES	NO
Constant	1.583***	1.894***	1.587***	1.904***	1.535***	1.899***	1.576***	1.885***
	(0.0300)	(0.0114)	(0.00518)	(0.00381)	(0.00401)	(0.00353)	(0.0258)	(0.0126)
Observations	5,460	5,460	4,909	4,909	4,344	4,344	5,460	5,460
Number of id	651	651	651	651	651	651	651	651
R-squared (within)	0.013	0.013	0.0145	0.015	0.022	0.022	0.0136	0.014

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

TABLE E2. RESULTS OF PANEL REGRESSION MODEL – PRODUCTIVITY FUNCTION (LOG LP), ALL SECTORS

	Random Effects	Random Effects	Random Effects	Fixed Effects	Fixed Effects	Fixed Effects
Variables	Model E9	Model E10	Model E11	Model E12	Model E13	Model E14
Log (Competition level)	-3.147***	-	-	-3.092***	-	-
	(0.804)	-	-	(0.840)	-	-
Δ Log (Competition level) in "T"	-	-1.432**	-	-	-1.511**	-
	-	(0.590)	-	-	(0.595)	-
Δ Log (Competition level) in "T-1"	-	-	-0.475	-	-	-0.456
	-	-	(0.332)	-	-	(0.328)
Year dummy	YES	YES	YES	YES	YES	YES
NACE 2 digits dummy	YES	YES	YES	NO	NO	NO
Region dummy	YES	YES	YES	NO	NO	NO
Constant	2.506***	3.338***	3.687***	3.256***	3.510***	3.496***
	(0.193)	(0.0370)	(0.0207)	(0.0696)	(0.0197)	(0.0191)
Observations	4,987	4,466	3,939	4,987	4,466	3,939
Number of id	618	616	615	618	616	615
R-squared (within)	0.0263	0.0138	0.009	0.026	0.014	0.009

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

TABLE E3. RESULTS OF PANEL REGRESSION MODEL – PRODUCTIVITY FUNCTION (LOG TFP), MANUFACTURING INDUSTRY

	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects	Random Effects	Fixed Effects
Variables	Model E15	Model E16	Model E17	Model E18	Model E19	Model E20	Model E21	Model E22
Log (Competition level)	-0.0317	-0.0293	-	-	-	-	0.0275	8.84e-05
	(0.115)	(0.114)	-	-	-	-	(0.250)	(0.246)
Log (Competition level - squared)	-	-	-	-	-	-	0.310	0.154
	-	-	-	-	-	-	(1.051)	(1.026)
Δ Log (Competition level) in "T"	-	-	0.0601	0.0623	-	-	-	-
	-	-	(0.0672)	(0.0658)	-	-	-	-
Δ Log (Competition level) in "T-1"	-	-	-	-	0.186	0.188	-	-
	-	-	-	-	(0.147)	(0.145)	-	-
Year dummy	YES	YES	YES	YES	YES	YES	YES	YES
NACE 2 digits dummy	YES	NO	YES	NO	YES	NO	YES	NO
Region dummy	YES	NO	YES	NO	YES	NO	YES	NO
Constant	2.168***	1.944***	2.162***	1.956***	2.157***	1.949***	2.171***	1.945***
	(0.0736)	(0.00943)	(0.0353)	(0.00358)	(0.0357)	(0.00286)	(0.0747)	(0.0132)
Observations	3,691	3,691	3,298	3,298	2,906	2,906	3,691	3,691
Number of id	429	429	429	429	429	429	429	429
R-squared (within)	0.0159	0.016	0.0239	0.024	0.0276	0.028	0.0159	0.016

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

TABLE E4. RESULTS OF PANEL REGRESSION MODEL – PRODUCTIVITY FUNCTION (LOG LP), MANUFACTURING INDUSTRY

	Random Effects	Random Effects	Random Effects	Fixed Effects	Fixed Effects	Fixed Effects
Variables	Model E23	Model E24	Model E25	Model E26	Model E27	Model E28
Log (Competition level)	-3.302***	-3.092***	-	-	-	-
	(0.572)	(0.840)	-	-	-	-
Δ Log (Competition level) in "T"	-	-	-1.032**	-1.511**	-	-
	-	-	(0.404)	(0.595)	-	-
Δ Log (Competition level) in "T-1"	-	-	-	-	-0.349	-0.456
	-	-	-	-	(0.353)	(0.328)
Year dummy	YES	YES	YES	YES	YES	YES
NACE 2 digits dummy	YES	YES	YES	NO	NO	NO
Region dummy	YES	YES	YES	NO	NO	NO
Constant	3.523***	3.256***	3.748***	3.510***	3.448***	3.496***
	(0.172)	(0.0696)	(0.182)	(0.0197)	(0.107)	(0.0191)
Observations	3,506	4,987	3,127	4,466	2,749	3,939
Number of id	416	618	415	616	415	615
R-squared (within)	0.0399	0.026	0.0291	0.014	0.0235	0.009

Source: Authors' own elaboration.

Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

APPENDIX F. PRODUCTIVITY FUNCTION – RANDOM EFFECTS

TABLE F1. RESULTS OF LOG-LOG RANDOM-EFFECT REGRESSION – TFP AND LP, ALL SECTORS

	Log (TFP)	Log (TFP)	Log (LP)	Log (LP)
Variables	Model F1	Model F2	Model F3	Model F4
Δ Log (competition level) in "T"	-	-	-1.218**	-1.253**
	-	-	(0.576)	(0.576)
Δ Log (competition level) in "T-1"	0.111**	0.116**	-	-
	(0.0453)	(0.0459)	-	-
Micro sized-firm	-0.526***	-0.526***	0.150*	0.132
	(0.0242)	(0.0243)	(0.0811)	(0.0806)
Small sized-firm	-0.305***	-0.304***	-0.0726	-0.0828
	(0.0202)	(0.0202)	(0.0574)	(0.0577)
Medium sized-firm	-0.154***	-0.154***	-0.0520	-0.0573
	(0.0175)	(0.0175)	(0.0457)	(0.0459)
Log (average salary per employee) in "T"	0.0106	0.0105	0.745***	0.748***
	(0.0135)	(0.0135)	(0.101)	(0.103)
Received national public support for RDI in "T"	0.0108***	-	0.0753***	-
	(0.00283)	-	(0.0179)	-
Received national public support for RDI in "T-1"	-	0.0109***	-	0.0112
	-	(0.00260)	-	(0.0169)
Patent stock per employee in "T-1"	-0.0122***	-0.0120***	0.0902*	0.0913*
	(0.00402)	(0.00399)	(0.0503)	(0.0504)
Log (physical capital per employee) in "T-1"	0.0285***	0.0284***	0.0878***	0.0877***
	(0.00359)	(0.00360)	(0.0195)	(0.0195)
NACE 2 digits dummy	YES	YES	YES	YES
Region dummy	YES	YES	YES	YES
Year dummy	YES	YES	YES	YES
Constant	1.744***	1.745***	2.171***	2.177***
	(0.0440)	(0.0442)	(0.161)	(0.161)
Observations	4,211	4,211	4,379	4,379
Number of id	651	651	613	613
R-squared (within)	0,2741	0,275	0,1695	0,1676
R-squared (between)	0,8852	0,885	0,6328	0,6292
R-squared (overall)	0,8539	0,8537	0,5144	0,5108
Wald test - H0: All coefficient = 0	0.000	0.000	0.000	0.000

Source: Authors' own elaboration.
Note: Robust standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1.
Results of Wald test and Hausman test refer to p-value. Reference category for firm size is large firm.

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Is deregulation of product and labour markets promoting employment and productivity? A difference-in-differences approach[41]

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ABSTRACT

This paper examines the impact of labour and product market reforms on sectoral employment and productivity, following a difference-in-differences approach. Using industry-level data for the period 1997-2013, we show that employment protection deregulation has a positive effect on sectoral employment for industries more exposed to labour market legislation, despite having a non-positive impact on productivity. Upstream product market deregulation also increases sectorial employment for the downstream sectors more dependent on upstream inputs (i.e. more exposed to deregulation upstream). Nevertheless, it has mixed effects on sectorial productivity: while upstream sectors face productivity losses, the downstream sectors more exposed to the deregulated sectors grasp productivity gains.

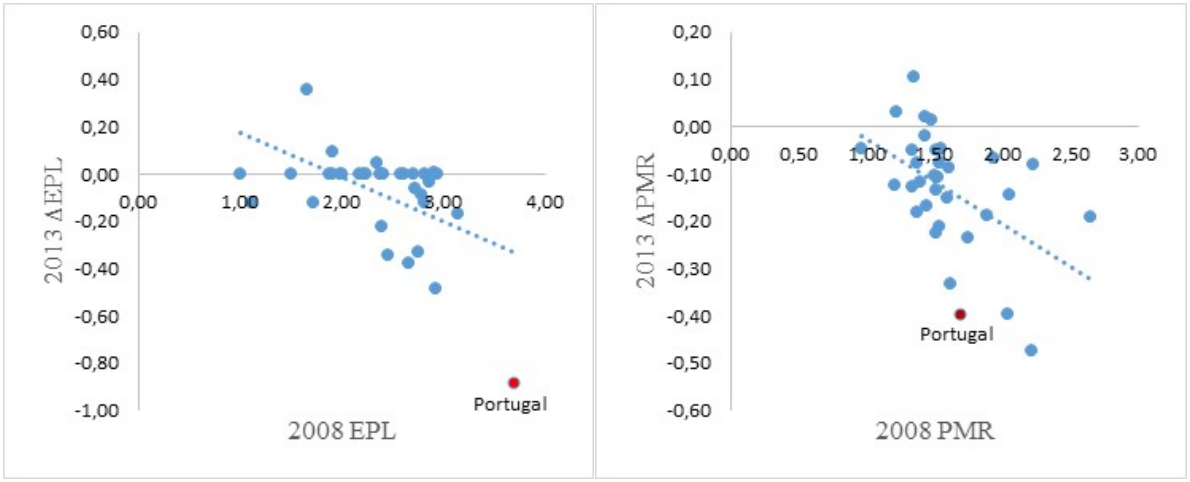
Key words: Labour Market Reforms; Product Market Reforms; Employment; Productivity.
JEL Code: C23; E23; E24; J23; L16; O47

1. INTRODUCTION

In recent years, there has been a surge in the calls for product and labour market reforms, as a growth-promoting tool. Such reforms have been prescribed for Portugal, particularly after the sovereign debt and economic crisis and the adjustment programme that ensued (e.g. European Commission, 2014; OECD, 2014), leading the country to one of the most ambitious plan of structural reforms amongst developed countries in recent years (OECD, 2014; Koske, I. et al., 2015; Figure 1). In the labour market, employment protection legislation reforms included cuts in severance pay, the inclusion of further reasons for dismissal based on inadaptability and performance-based criteria for dismissals in the case of extinction of the work position (OECD, 2017). The product market has also seen significant developments with the liberalization of network sectors and professional services, the enhancement of the competition framework and improvements in the enforcement (European Commission, 2016; OECD, 2013a; 2014). This was achieved in a context of further reforms, namely measures improving framework conditions (e.g. judicial system, business environment, etc.).

[41] The opinions expressed are those of the authors and not necessarily of the institutions.

FIGURE 1: EVOLUTION OF EMPLOYMENT PROTECTION LEGISLATION (EPL) AND UPSTREAM PRODUCT MARKET REGULATION (PMR) IN OECD COUNTRIES



Source: Own calculations, based on OECD Indicators of Employment Protection Legislation and OECD Indicators of Product Market Regulation. These indicators range from 0 to 6, where a lower value reflects a more competition-friendly regulatory stance.

What are the expected impacts of these changes on productivity and employment? The existing literature is not conclusive.

While some authors argue that stringent labour market regulation curbs productivity (OECD, 2007; Bassanini et al., 2009; Cingano et al., 2010), others find productivity gains from employment regulation (Acharya et al., 2013; Gouveia et al., 2017a). Concerning the effect on employment, OECD (2016) provides industry-level evidence of short-run employment losses caused by easing Employment Protection Legislation (EPL), which are then reversed in the long-run. Indeed, most authors find evidence of EPL's negative sectorial effect on employment, namely in labour intensive industries (Ahsan and Pagés, 2009) and in industries that have high job reallocation rates, particularly due to a reduction in the net entry of firms (Pagés and Micco, 2007). There are also cross-country studies, with aggregate-level data, establishing a link between regulation and higher unemployment (Scarpetta, 1996; La Porta et al., 2004).

Turning to the product market, upstream product market deregulation has been found to foster aggregate and sectorial-level long-run employment for those downstream industries more dependent on the intermediate inputs provided by upstream sectors (OECD, 2016). This effect is explained by a competition channel which decreases downstream input prices, increases its quality, and eliminates the regulatory-induced competitive disadvantage of downstream sectors when negotiating contracts and prices with upstream ones (Bourlès et al., 2010). Product market deregulation has also been linked with positive aggregate employment effects that strengthen over time (Fiori et al., 2012). Bassanini (2015) finds evidence of reversible employment losses in upstream sectors in the short-run, mainly through competitive pressures that lead incumbents to downsize.

On the impact of product market regulation on productivity, several papers establish a positive link between pro-competitive upstream product market reforms and downstream productivity, using both firm-level (Arnold et al., 2011; Forlani, 2012; Gal and Hijzen, 2016; Topalova and Lanau, 2016) and sectorial-level data (Bourlès et. al., 2010, 2013; Barone and Cingano, 2011). On the contrary, Amable et al. (2016) argue that deregulation curbs innovation in upstream sectors, which trickles down to downstream sectors, hindering productivity growth. Also, there is evidence of important heterogeneous effects across firms. Indeed, while some authors argue that reforms have greater returns the closer an economy is to the technological frontier (Arnold et al., 2008; Acemoglu et al., 2003, 2006; Vandenbussche et al., 2006), others show that gains increase with the distance to the frontier (Nicoletti and Scarpetta, 2003; Monteiro et al., 2017; Gouveia et al, 2017a). Bourlès et al. (2013) also find evidence of heterogeneous effects, showing that deregulation boosts the returns to innovation for the most productive firms but reduces the innovation incentives for the least productive. This heterogeneity renders a sectoral assessment particularly relevant.

We take advantage of sectorial level national accounts data to assess the effect of product and labour market deregulation on employment and productivity outcomes in Portugal. This strategy allows us to obtain the marginal effect of regulation on the Portuguese economy, taking into account the idiosyncratic conditions of the country, thereby overcoming the limitation of cross-country studies where the estimated parameters are assumed to be the same throughout the panel of countries, in spite of important asymmetries in national economic structures.[42] Industry-level analysis also has advantages vis-à-vis (non-weighted) firm-level analysis, since the impact of a reform on the average firm does not necessarily carry over to the overall impact on the corresponding sector.[43]

Following a difference-in-differences approach, we show that employment protection deregulation has a positive effect on employment for industries more exposed to labour market legislation, despite having a non-positive impact on productivity. In addition, product market deregulation in network sectors (energy, transport and communication) promotes employment growth downstream for the industries more exposed to the deregulated sectors. Concerning productivity, whilst the deregulated upstream sectors suffer losses, the downstream sectors – i.e. those using the inputs produced by the deregulated sectors - grasp productivity gains.

The remainder of the paper is organized as follows: Section 2 presents the methodology, and Section 3 describes the datasets and the variables used. The results are presented in Section 4 and, finally, Section 5 provides the conclusion and lays the foundations for future work.

2. METHODOLOGY

Our baseline regression evaluates the effect of product and labour market regulatoryindicators on two outcomes – employment and productivity – by comparing industries with different exposures to regulation. The fundamental reasoning behind this specification is that the intrinsic nature of an industry makes it more or less affected by regulation. In other words, the degree whereby a sector is exposed to regulation determines how binding regulation is for that sector, thus allowing us to perform a difference-in-differences analysis.

Following the literature, we consider that sectors with higher natural layoff rates are more exposed to labour market regulation (e.g. Bassanini et al., 2009), while those that are more dependent on upstream-sector inputs are more exposed to product market regulation affecting those upstream sectors (e.g. Bourlès et al., 2010).

We thus implement the difference-in-differences specification of Bassanini et al. (2009), who specify the expected pairwise-difference between any two sectors (k and h) as:

$$\mathrm{E}\left(\Delta \log \mathrm{Outcome}_{k,t} - \Delta \log \mathrm{Outcome}_{h,t}\right) = (\mathrm{f}(\mathrm{Exp}_k) - \mathrm{f}(\mathrm{Exp}_h))\mathrm{g}(\mathrm{Reg}_{t-1}, \Delta \mathrm{Reg}_t) \qquad [1]$$

where $\mathrm{f}(.)$ is a non-negative and non-decreasing function.

Letting $\mathrm{g}(.)$ be linear, and $\mathrm{f}(.)$ the identity function, we can re-write [1] as:

$$\mathrm{E}\left(\Delta \log \mathrm{Outcome}_{k,t}\right) - \mathrm{E}\left(\Delta \log \mathrm{Outcome}_{h,t}\right) = \beta \mathrm{Reg}_{t-1}(\mathrm{Exp}_k - \mathrm{Exp}_h) + \delta \Delta \mathrm{Reg}_t(\mathrm{Exp}_k - \mathrm{Exp}_h) + (\gamma_k - \gamma_h) \qquad [2]$$

Hence, for industry j, the expected growth of the outcome variable can be expressed as:

$$\mathrm{E}(\Delta \mathrm{Outcome}_{j,t}) = \beta \mathrm{Exp}_j \mathrm{Reg}_{t-1} + \delta \mathrm{Exp}_j \Delta \mathrm{Reg}_t + \gamma_j + \mu_t \qquad [3]$$

where μ_t captures sector-invariant effects. In this setting, our baseline regression can be written as:

[42] It is worth noting the existence of a trade-off. Cross-country sectoral data necessarily increase the sample variation in opposition to exclusively considering national sectoral data.

[43] Indeed, there are a number of studies looking at the firm-level impact of structural reforms implemented in Portugal, which are particularly useful to understand heterogeneous effects across firms. See, for instance, Gouveia et al. (2017a) and Monteiro et al. (2017).

$$\Delta \text{Outcome}_{j,t} = \beta \text{Exp}_j \, \text{Reg}_{t-1} + \delta \text{Exp}_j \, \Delta \text{Reg}_t + \theta_j + \theta_t + \varepsilon_{jt} \quad [4]$$

$\text{Outcome}_{j,t}$ stands for productivity or employment variables of industry j in year t (depending on the specification), Exp_j denotes the exposure to the regulatory variable for industry j, and Reg_t stands for product or labour market regulation at time t (depending on the specification). Furthermore, θ_j and θ_t are industry and time fixed effects, respectively.

The intuition for the difference-in-differences approach can be easily seen by focusing on a particular case of equation [4], whereby the treatment is defined by an indicator variable which identifies industries as being entirely regulation-binding (treatment group), if their exposure is greater than a certain threshold.[44] In this binary setting, the estimated coefficients provide us with the difference between treatment and control groups. In the continuous case that we follow, β and δ give us the impact of "treatment" intensity. Indeed, as pointed out by Bassanini et al., (2009), it is more plausible that the extent to which an industry is affected by regulation depends on a continuous variable (such as our exposure variables).

In equation [4], β measures the growth-effect, i.e. the permanent impact of the regulatory variable on the growth rate of the outcome variable while δ captures the level-effect i.e. the permanent level-impact of deregulation. Nevertheless, some level-effects may not be captured by δ if they take too much time to materialize; additionally, a level effect which only materializes in the very long-term may be taken, in our model, by a permanent growth effect.

3. DATA

We use annual sectorial-level data from the Portuguese National Accounts (ESA2010), compiled by INE – *Instituto Nacional de Estatística* (Statistics Portugal). The time frame considered is restricted by the available regulatory indicator variables of choice – sourced from OECD - which cover the 1997-2013 period. The sectors included in the analysis are those whereby, for the relevant timeframe, a suitable matching could be performed between the 2-digit ISIC Rev.3 aggregation (followed by OECD regulatory indexes) and the 2-digit CAE Rev.3 (followed by the Portuguese National Accounts).[45] These procedures decrease the sectorial dataset from 306 to 288 observations in the employment protection analysis, and from 612 to 57, for the product market regulation case.

The outcome variables, derived from national accounts, are worked hours (HoursWorked), as a baseline for employment, with the number of employees (Employees) being used for robustness checks. The measure of productivity is labour productivity, determined by the ratio of gross value added (GVA) to worked hours (HoursWorked). Output is used instead of gross value added, for assessing the robustness of the results.

Turning now to the regulatory variables, the regulatory stringency of the labour market is measured through the OECD indicator of Employment Protection Legislation, a measure of the incurred costs and procedures associated with the dismissal and hiring of employees. This measure is partitioned into three sub-indicators: EPR, an index of regulatory strictness concerning individual dismissal of workers on regular contracts; EPT, which measures the degree of regulation for temporary contracts; and EPRC, comprising a weighted sum of both individual and collective dismissal sub-indicators.[46] These regulatory indicators range from 0 (no regulation) to 6 (maximum stringency). We follow Bassanini et al. (2009) and Jain-Chandra and Zhang (2014), and use the layoff rate for the United States for the period 2001-03 as a measure of exposure to labour market regulation. These rates were computed by Bassanini et al. (2009) and are based on the 2004 Displaced Workers Supplement data. The rationale is that industries which are more prone to adjust to shocks in demand and supply through layoffs are more affected by regulation governing layoffs. The US is the OECD country with the lowest level of employment protection legislation, thus serving as a *de facto* proxy that captures any given industry's "natural" layoff rate in the absence of regulation. By using the US layoff rate, we

[44] See Bassanini et al (2009), Appendix 2, p.16, for a derivation of the discrete case.
[45] See Box 1 in the Appendix for a breakdown of the different sectors considered for the EPL and PMR analysis, respectively.
[46] EPRC attributes a weight of 2/7 for additional provisions for collective dismissals and 5/7 to individual dismissals (regular contracts). For additional details on these indicators please refer to chapter 2 of OECD (2013d).

avoid endogeneity issues related with using the Portuguese rate, as the national value is determined by the prevailing level of regulation in the labour market.

For the effect of upstream product market deregulation on downstream industries, we rely on the regulatory impact indicator (Regimpact), computed by the OECD.[47] This indicator, developed by Égert and Wanner (2016) building on Conway and Nicoletti (2006), follows the same methodological approach just described for the labour market: it incorporates the OECD regulatory indices for network sectors (ranging from 0 to 6, where 6 is maximum regulation), which are then weighted by an industry-specific exposure variable. The exposure variable is computed using the input-output matrices, ascertaining the relevance of upstream sector industries on the input usage of the different sectors (relying on the inverse of the Leontief matrix, kept constant for the entire period). The intuition is that a sector which uses a higher amount of inputs from the upstream industries is more vulnerable to regulation in those sectors. Similarly to the layoff rate, and following the identification strategy of Rajan and Zingales (1998), we rely on the input-output data from the correspondent US industry, to avoid endogeneity issues. Table 1 presents the descriptive statistics for the variables used in the different specifications.

TABLE 1: DESCRIPTIVE STATISTICS

Variables - PMR (612 Observations)	Unit	Mean	Std Dev	Min.	Max.
Narrow Indicator (US)	unit	0.58	1.00	0.11	6.53
Wide Indicator (US)	unit	1.25	1.23	0.23	6.76
Gross Value Added	10^6 €	4,160.00	4,832.00	191.00	22,220.00
Total Output	10^6 €	9,008.00	8,513.00	311.00	43,830.00
Hours Worked	10^6	204.00	255.00	3.00	1,313.00
Employees	10^3	133.00	169.00	2.00	757.00
Variables - EPL (306 Observations)	**Unit**	**Mean**	**Std Dev**	**Min.**	**Max.**
US Layoff Rate	unit	5.18	1.35	2.83	8.12
EPR - Regular Contracts	unit	4.33	0.38	3.18	4.58
EPT - Temporary Contracts	unit	2.44	0.40	1.81	2.81
EPRC - Individual and Collective Dismissals	unit	3.79	0.39	2.81	4.10
Gross Value Added	10^6 €	3,946.0	5,019.0	191.0	22,220.0
Total Output	10^6 €	10,814.0	10,287.0	651.0	43,830.0
Hours Worked	10^6	242.00	313.00	3.00	1,313.00
Employees	10^3	140.00	184.00	2.00	757.00

Source: Own computations using Statistics Portugal (INE), OECD data (both ranging from 1997-2013) and Displaced Workers Supplement data (2004).

4. EMPIRICAL RESULTS

This section presents the estimation results for specification [4], adapting it in accordance with the outcomes and regulatory indicators of choice.

Labour Market Regulation

The results, presented in Table 2, provide evidence of a negative link between employment protection legislation and the number of hours worked, in industries that are "naturally" more affected by such legislation. A likely explanation is that industries more prone to adjust to market

[47] A wider version including also retail distribution and professional services is also used for robustness checks. However, given that only the networks regulatory indices have an annual frequency (the others are available every 4 years), the narrow version only covering networks is better suited for time series analysis. For additional details please refer to Égert and Wanner (2016).

shocks through hirings and layoffs have a higher latent labour demand than the one displayed under tight regulation. Therefore, if regulation hinders their ability to adjust, they are cautious to hire due to uncertainty, implying less efficient production outcomes, as they are less responsive to market changes. With deregulatory reform, these sectors are able to increase net hirings, with net benefits arising from increased flexibility. The result is robust to the usage of the variation in the number of employees as a measure of employment growth and is visible for all three measures of employment regulation.

Concerning the effects on productivity, the results presented in Table 3 suggest a non-positive response of productivity to a reduction of employment protection. Indeed, results are, in general, non-significant,; there are only two significant effects, for the indicators of temporary contracts (EPT) and of stringency ruling individual and collective dismissals (EPRC) – supporting the result of losses from deregulation, but that fail to be robust to changes in the outcome variable of labour productivity.

TABLE 2: IMPACT OF EMPLOYMENT PROTECTION LEGISLATION ON SECTOR-LEVEL EMPLOYMENT

Variables	ΔHoursWorked	ΔEmployees	ΔHoursWorked	ΔEmployees	ΔHoursWorked	ΔEmployees
EPR_{t-1}	-0.02**	-0.02**	-	-	-	-
ΔEPR	-0.01	0.00	-	-	-	-
EPT_{t-1}	-	-	-0.02**	-0.01**	-	-
ΔEPT	-	-	-0.01	-0.01	-	-
$EPRC_{t-1}$	-	-	-	-	-0.02**	-0.02**
ΔEPRC	-	-	-	-	-0.01	-0.01
Time Fixed Effects	YES	YES	YES	YES	YES	YES
N	288	288	288	288	270	270
Overall R^2	5%	5%	9%	10%	5%	6%

Notes: Variations in the number of observations are due to data availability. Results were estimated using robust standard errors. ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.

Source: Own computations, using INE and OECD data for the years 1997-2013

TABLE 3: IMPACT OF EMPLOYMENT PROTECTION LEGISLATION ON SECTOR-LEVEL PRODUCTIVITY

Variable	Δ LP = GVA/Employees	Δ LP = Output/Employees	Δ LP = GVA/Employees	Δ LP = Output/Employees	Δ LP = GVA/Employees	Δ LP = Output/Employees
EPR_{t-1}	0.06	0.02	-	-	-	-
ΔEPR	-0.04	0.01	-	-	-	-
EPT_{t-1}	-	-	0.02	0.02**	-	-
ΔEPT	-	-	-0.00	0.00	-	-
$EPRC_{t-1}$	-	-	-	-	0.05*	0.02
ΔEPRC	-	-	-	-	-0.06	0.00
Time Fixed Effects	YES	YES	YES	YES	YES	YES
N	288.00	288.00	288.00	288.00	270.00	270.00
Overall R^2	0.00	0.00	0.02	0.02	0.00	0.10

Notes: Variations in the number of observations are due to data availability. Results were estimated using robust standard errors. ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.

Source: Own computations, using INE and OECD data for the years 1997-2013.

Product Market Regulation

Competitive-enhancing reforms of network sectors are estimated to have a positive impact on employment growth for industries that depend relatively more on those upstream intermediate inputs, and are consequently more affected by upstream product market regulation (Table 4). One expects that lower upstream regulation pressures upstream sectors to reduce prices and to increase the quality of their services, via increased competition and reduced negotiation-edge vis-à-vis downstream clients, which fosters downstream growth (both at the extensive and intensive margin) and allows downstream sectors to channel resources towards further hirings. The results are robust to using the number of employees as employment variable and to the use of the wide version of the regulatory index.

The direct effect on upstream industries employment is unclear. Whilst competition may lead to a downsizing of incumbents, firm entry is promoted by deregulation. Since the regulatory impact indicator is also capturing the effect that upstream deregulation has on the upstream sectors (direct effect of deregulation), we exclude the upstream industries from our sample and re-estimate the regression, in order to exclusively capture the indirect effects of upstream deregulation (on downstream sectors). While for the case of the narrow indicator (i.e. excluding networks) there are no significant changes between the estimated coefficients, they turn out to be stronger when looking at the wide indicator (i.e. excluding networks, retail and professional services from the sample), showing that the effect on upstream sectors is necessarily lower or even negative (Table 5) [48]

Turning to the impact on productivity, we find that an upstream deregulatory process dampens labour productivity growth (Table 6). This result is robust to the usage of the wide indicator and to the usage of Output, instead of the baseline variables.

Table 7 clarifies this outcome. Indeed, we find that there are productivity gains for downstream industries. This means that the productivity losses in Table 6 are driven by effects on upstream sectors, which are harmed by increased competition and lower incentives to innovation (due to reduced mark-ups). The downstream sectors are likely to see their input costs going down and to gain better access to upstream services, thus allowing them to increase the efficiency of their production process and to channel resources towards productivity-enhancing technology.

TABLE 4: IMPACT OF UPSTREAM PRODUCT MARKET REGULATION ON SECTOR-LEVEL EMPLOYMENT

Variable	ΔHoursWorked	ΔEmployees	ΔHoursWorked	ΔEmployees
$Regimpact_{t-1}$ (narrow)	-0.01***	-0.01***	-	-
ΔRegimpact(narrow)	-0.02	-0.01	-	-
$Regimpact_{t-1}$ (wide)	-	-	-0.01***	-0.01***
ΔRegimpact(wide)	-	-	-0.01	-0.01
Time Fixed Effects	YES	YES	YES	YES
N	576	576	576	576
Overall R^2	11%	10%	7%	6%

Notes: Results were estimated using robust standard errors. ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.

Source: Own computations, using INE and OECD data for the years 1997-2013.

[48] Please note that due to reduced number of upstream sectors, a regression cannot be performed solely for those sectors. Our analysis shows that the effects on upstream sectors are lower than in downstream but nothing can be said about the sign: the effect may still be positive (but lower than in downstream industries) or it can be negative.

TABLE 5: IMPACT OF UPSTREAM PRODUCT MARKET REGULATION ON DOWNSTREAM SECTOR-LEVEL EMPLOYMENT

Variable	ΔHoursWorked	ΔEmployees	ΔHoursWorked	ΔEmployees
$Regimpact_{t-1}$ (narrow)	-0.01***	-0.01***	-	-
ΔRegimpact(narrow)	-0.01	-0.01	-	-
$Regimpact_{t-1}$ (wide)	-	-	-0.02	-0.05**
ΔRegimpact(wide)	-	-	-0.07**	-0.08**
Time Fixed Effects	YES	YES	YES	YES
N	560	560	496	496
Overall R^2	10%	9%	11%	6%

Notes: Variations in the number of observations are due to data availability. Results were estimated using robust standard errors. ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.

Source: Own computations, using INE and OECD data for the years 1997-2013.

TABLE 6 - IMPACT OF UPSTREAM PRODUCT MARKET REGULATION ON SECTOR-LEVEL PRODUCTIVITY

Variable	Δ LP = GVA/HoursWorked	Δ LP = Output/HoursWorked	Δ LP = GVA/HoursWorked	Δ LP = Output/HoursWorked
$Regimpact_{t-1}$ (narrow)	0.02**	0.02*	-	-
ΔRegimpact(narrow)	0.03	-0.01	-	-
$Regimpact_{t-1}$ (wide)	-	-	0.02**	0.02***
ΔRegimpact(wide)	-	-	0.00	-0.01
Time Fixed Effects	YES	YES	YES	YES
N	576	576	576	576
Overall R^2	2%	15%	2%	11%

Notes: Results were estimated using robust standard errors. ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.

Source: Own computations, using INE and OECD data for the years 1997-2013.

TABLE 7: IMPACT OF UPSTREAM PRODUCT MARKET REGULATION ON DOWNSTREAM SECTOR-LEVEL PRODUCTIVITY

Variable	Δ LP = GVA/HoursWorked	Δ LP = Output/HoursWorked	Δ LP = GVA/HoursWorked	Δ LP = Output/HoursWorked
$Regimpact_{t-1}$ (narrow)	0.02	-0.00	-	-
ΔRegimpact(narrow)	-0.07*	-0.10***	-	-
$Regimpact_{t-1}$ (wide)	-	-	-0.07***	-0.03*
ΔRegimpact(wide)	-	-	-0.03	-0.01
Time Fixed Effects	YES	YES	YES	YES
N	560	560	496	496
Overall R^2	3%	16%	1%	13%

Notes: Results were estimated using robust standard errors. ***: significant at 1% level; **: significant at 5% level; *: significant at 10% level.

Source: Own computations, using INE and OECD data for the years 1997-2013.

6. CONCLUSION

Recent years have seen a surge in the demand for product and labour market deregulation alike. Portugal has been in the forefront of reform implementation, having undertaken an ambitious reform programme in the midst of sluggish economic growth and persistent economic imbalances. Empirical evidence on the aggregate sectorial impact of structural reforms, taking into account the specificities of the Portuguese economy, is therefore vital from a policy maker's standpoint, in order to sharpen the design and implementation of such reforms and to complement the existing firm-level and cross-country evidence. Moreover, information is also vital for the ownership of any reform process (Boeri and Tabellini, 2012; Gouveia et al., 2017b).

In this context, we use sectorial-level data for the periods 1997-2013 to evaluate the impact of labour and product market reforms on employment and productivity, following a difference-in-differences approach. Concerning labour market reforms, and in line with the findings of OECD (2016) and Pagés and Micco (2007), our results suggest that decreasing the costs associated with hirings and dismissals fosters employment for industries more exposed to labour market regulations (proxied by the

industry's layoff rate in the absence of regulation). However, as also pointed by Acharya et al. (2013), there is no evidence of a positive impact on productivity.[49]

In respect to product market reforms, upstream deregulation is found to promote employment for the sectors with a relatively high degree of exposure to upstream inputs, matching the findings of OECD (2016). Additionally, our results show that downstream industries grasp productivity gains from upstream product market deregulation, in line with the findings of Barone and Cingano (2011) and Bourlès et al., (2013). Conversely, and as argued by Amable et al. (2016), we find evidence that upstream sectors face productivity losses, possible due to reduced incentives to innovate (via reduced mark-ups).

The analysis in this paper could be enlarged in a number of ways. In particular, the assessment of employment outcomes focuses on the quantity of overall employment. It would be interesting to consider the effects on full-time and part-time employment and on permanent and temporary contracts, as changes in regulation are likely to have heterogeneous effects. Also, we do not account for the impact on the quality of employment, which is also a key element for policy assessment. Deregulation may induce less stable employment relations and an erosion of workers' rights, with important equity considerations. Furthermore, we do not account for interactions among reforms or for the initial regulatory stance. The impact of changes in regulation may be non-linear and may depend on the existing level of regulation, which is important for informing the adequate sequencing and packaging of reforms. Finally, we consider that the effects are symmetric, i.e. that loosening and tightening regulation have a comparable (symmetric) effect, which is not necessarily the case.

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APPENDIX – BOX 1

Sectors Considered for the Employment Protection Legislation analysis:

Manufacture of food products, beverages and tobacco products; Manufacture of textiles, wearing apparel and leather products; Manufacture of wood and paper products, and printing; Manufacture of coke, and refined petroleum products; Manufacture of chemicals and chemical products; Manufacture of basic pharmaceutical products and pharmaceutical preparations; Manufacture of rubber and plastics products, and other non-metallic mineral products; Manufacture of basic metals and fabricated metal products, except machinery and equipment; Manufacture of electrical equipment; Manufacture of machinery and equipment n.e.c.; Manufacture of transport equipment; Manufacture of furniture; other manufacturing; repair and installation of machinery and equipment; Water, sewerage, waste management and remediation activities; Construction; Wholesale and retail trade, repair of motor vehicles and motorcycles; Transportation and storage; Accommodation and food service activities; Telecommunications.

Sectors Considered for the Product Market Regulation analysis:

Agriculture, forestry and fishing; Mining and quarrying; Manufacture of food products, beverages and tobacco products; Manufacture of textiles, wearing apparel and leather products; Manufacture of wood and paper products, and printing; Manufacture of coke, and refined petroleum products; Manufacture of chemicals and chemical products; Manufacture of basic pharmaceutical products and pharmaceutical preparations; Manufacture of rubber and plastics products, and other non-metallic mineral products; Manufacture of basic metals and fabricated metal products, except machinery and equipment; Manufacture of computer, electronic and optical products; Manufacture of electrical equipment; Manufacture of machinery and equipment n.e.c.; Manufacture of transport equipment; Manufacture of furniture; other manufacturing; repair and installation of machinery and equipment; Electricity, gas, steam and air-conditioning supply; Water, sewerage, waste management and remediation activities; Construction; Wholesale and retail trade, repair of motor vehicles and motorcycles; Transportation and storage; Accommodation and food service activities; Publishing, audiovisual and broadcasting activities; Telecommunications; Computer programming, consultancy and related activities; information service activities; Financial and insurance activities; Real estate activities; Legal and accounting activities; activities of head offices; management consultancy activities; architecture and engineering activities; technical testing and analysis; Scientific research and development; Advertising and market research; other professional, scientific and technical activities; Veterinary activities; Administrative and support service activities; Public administration and defence; compulsory social security; Education; Human health services; Social work activities; Arts, entertainment and recreation; Other services activities.

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The Determinants of TFP Growth in the Portuguese Manufacturing Sector[50]

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ABSTRACT

Given the linkage between Total Factor Productivity growth and economic growth, it becomes relevant to understand, at the firm level, which are the main determinants of such growth path. We use an extensive panel data covering Portuguese manufacturing firms, between 2010 and 2014, in order to assess which are the main determinants of the Total Factor Productivity. Through a second stage estimation we present a fixed-effects model that captures different dimensions of firm level characteristics that impact TFP growth, suggesting policy recommendations amid the model's results. Our results show that age and debt influence negatively TFP growth, whereas size, exports and training expenses prompt TFP growth.

JEL CLASSIFICATION: D22, D24

KEY-WORDS: Total Factor Productivity, Industry

1. INTRODUCTION

"...Productivity isn't everything, but in the long run it is almost everything"

Krugman (1997)

The solely combination of inputs such as labour, capital and, at some extent, intermediate inputs does not entirely explain output creation. The remaining share of output variation which cannot be explained by such endowment of inputs is a measurement of technical efficiency and provides insights on aggregate economic growth. Assessing the determinants of Total Factor Productivity Growth at the firm-level aware policymakers to which extent they should enhance some policies in order to provide firms an economic and financial environment keen to prompt its performance and achieve higher levels of technological efficiency. In fact, a hand of authors state that a great part of

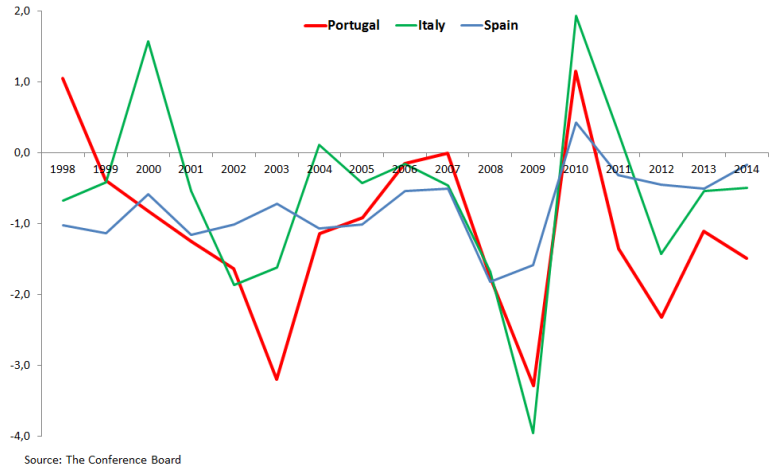
[50] The views are those of the authors and do not necessarily coincide with those of the institution.

growth in income per capital is explained by the residual of production and not by the accumulation of capital and labour[51].

The current global crisis has reinforced concerns on growth prospects, and firms provide an accurate insight not only on how the aggregate economy performs but also on how economic activity can be driven into a sustainable growth path. In general, productivity evolution is being decreasing since the beginning of the current century in the major developed countries, pointing to a linkage between weakness of competitiveness and slowdown of economic activity.

Chart 1 considers TFP Growth for some Southern European Countries according to data from The Conference Board (2015), the productivity of labour and capital together (measured by Total Factor Productivity - TFP), has consistently decreased (with the exception of a slight increase in 2010) since the late nineties.

CHART 1: TFP GROWTH - SOUTHERN EUROPE COUNTRIES



What we propose to do in this paper is, through the study of a microdata database of Portuguese manufacturing companies (in panel, in the period 2010-2014), test the significance of the main determinants suggested by the literature such as innovation variables (namely training and fixed intangible assets), export activity, internal firm characteristics like age and dimension, and debt-to-equity as a proxy to firms financial health.

The paper is organized as following. Section 2 includes a brief literature review on the topic. Section 3 provides Data description and the methodology applied on cleaning the dataset according to the purpose of our research. Next, we explain the chosen method for TFP estimation and provide result comparisons amongst different estimating methods on Section 4. Section 5 approaches the methodological issues concerning second-stage estimations and includes our econometric framework on the robustness of the model. The estimated model and the interpretation of the results with linkage to others from the literature is compiled on Section 5. The paper is concluded with Section 6, on which we suggest policy recommendations according to the results from the estimated model.

2. LITERATURE REVIEW

The assessment of TFP Growth determinants at the firm-level is broadly approached in the literature, providing an extensive result comparison among different countries, sectors and specific industries. Moreover, it is more common to observe researches on specific topics of determinants instead of considering simultaneously different spectrums of determinants.

Innovation and technological progress is considered on the main enhancers of TFP Growth. Romer (1986,1990) endorses the endogenous knowledge creation as a factor for perpetual economic

[51] Recall Abramovitz (1956) and (Solow 1957) for more on the subject.

growth. One of the main challenge of measuring innovation and its effects on TFP Growth is to define accurate proxies for such purpose, namely Research and Development (R&D), patent data or Foreign Direct Investment (FDI). For instance, Castany *et. al* (2005) studied the impact of innovative activity and skilled labour usage on TFP Growth using information from *Encuesta sobre Estrategias Empresariales* on Spanish manufacturing firms. He finds that firm size restricts the effect of R&D and employees' qualification on productivity and that size affects indirectly TFP Growth. Other literature focuses on the notion of knowledge, as the impacts of factors such as Information and Communication Technologies, patents or scientific publications may be interpreted as a function of openness and institutions, and therefore has positive effects on TFP Growth (Chen and Dahlman (2004). Calligaris *et. al* (2016) find that innovation (measured by intangible assets such as R&D, branding, marketing) prompts productivity growth. In the same line, Crass and Peters (2014) used a panel data for German companies covering the period 2006-2010, investigates how intangible assets affect productivity at the firm level and find strong productivity-enhancing effects for R&D and Human Capital (proxied by training expenditure and share of high skilled labour). Innovation may also be linked with firm's age. Dabla-Norris *et. Al* (2010) show that older firms that hold the exporter status and engage on innovation activities present higher productivity levels.

Trade is also pointed as one of the main determinants of TFP Growth at the firm level. Bernard et al. (2003) shows that as there is a decrease in trade costs, then there will be a better reallocation of resources and, consequently, the most productive firms will be favoured. Trade enhances firm-level productivity due to its externalities that may have different forms, such as learning-by-doing effects, import of more innovative products or better managerial practices. Learning-by-doing effects are important as firms may self-select themselves into foreign markets, leading to a higher level of TFP Growth for exporters compared to non-exporters (Arvas and Uyar,2014). Ortega *et. al* (2013) studied the relationship between exports and productivity in Chilean firms via four main theories: Self-selection hypothesis (whereby high productivity generates exports), Learning-by-exporting hypothesis (whereby exports increase productivity), Exporting-by-innovating hypothesis (whereby R&D is a determinant of exports) and Innovating-by-exporting hypothesis (whereby exports promote innovative practices). They find that exports explain productivity rather than productivity influencing exports.

Financial constraints also hold an important role on economic growth, conditioning savings and investment decisions and, consequently, impact TFP Growth. The impact of such variable holds as perfect financial markets stimulate long-term investments on productivity-enhancing projects (Aghion *et. al*, 2007). At a certain level, investments in risky opportunities usually related to R&D investments may be constrained as firms must hold a solid financial performance in order for banks to lend the needed resources (Fazzari *et. al*, 1988). The European Commission (2014) reported that firms' TFP Growth is constrained by the availability of internal funds, and this holds especially for micro firms relatively, suggesting a linkage between productivity growth and internal financing.

Capital structure is also approached in the literature, as it is linked to bankruptcy risks and may constrain a firm on obtaining the needed funds to invest in productivity-enhancing activities. Jensen (1986) shows that higher levels of debt prompts managers' efforts on increasing the firm's performance in order to avoid bankruptcy. Productivity can be enhanced on a firm with high level of debt as workers may work harder on the shadow of bankruptcy possibilities (Nickel and Nicolitsas,1999). Köke (2001) investigated the effect of financial pressure on productivity growth for Germany manufacturing firms and found that financial pressure has a positive impact on productivity growth, and that this effect is larger when the amount of bank debt is high.

Finally, on what concerns the role of wages on determining TFP Growth, Gehringer *et. al* (2013) which examines the development of total factor productivity (TFP) and the drivers of TFP for a panel of 17 EU countries in the period of 1995-2007, find that wages (unit wages, per worker) are the main driver of TFP. They interpret it assuming that more efficient workers are paid higher salaries and so industries employing workers with a higher labour productivity are also more productive (in terms of TFP).

3. DATASET

The firm-level panel dataset we use was constructed from *Informação Empresarial Simplificada* (IES) provided by Banco de Portugal, which consists on a broad collection of accounting and financial data apart from other descriptive data and firm-specific characteristics, such as district, size, number of workers and industry. We have performed a pre-check on the disposable firms, excluding all firms that have less than five workers (following Barbosa and Pinho, 2016). The dataset only considers the period between 2010 and 2014, as the data for 2015 and the previous to 2010 is currently not available. The main disadvantage we point out to our time span is that it starts immediately after the beginning of the financial and economic crisis of 2008, and possibly the results from our model will be downward biased as it is a sensitive period characterized by bankruptcies, merges or even cession of operations, as a consequence from the economic activity slowdown. Nevertheless, we hope that this study may provide fruitful results that may be compared in the future with a dataset with a wider time span. Another limitation is that the database does not provide qualitative information on employees.

Apart from considering all firms with more than five workers (and in this way still considering the micro firms category with plants operating with five to ten workers) we pursuit some specific data cleaning in order to exclude outliers and firms whose values for several variables were not correctly plotted. [52]

Table 1 disposes the number of firms in our dataset per year, as well as the number of companies that fulfill the Exporter Status criteria defined by the Bank of Portugal:

1. At least 50% of annual turnover is from exports of goods and services; or
2. At least 10% of annual turnover due to exports and its value overpasses 150.000€.

TABLE 1. EXPORT DYNAMICS FOR THE 2010-2014 PERIOD

Year	Nr of firms	Nr of exporters	Export participation (%)
2010	20,423	4,251	21%
2011	19,647	4,548	23%
2012	18,455	4,738	26%
2013	17,415	4,682	27%
2014	16,610	4,413	27%

Source: Author's calculations with IES database.

The total number of firms (that sum up to 92,550 observations for all five years) has a decreasing path throughout the sample period, a trend that is not verified in what concerns the export firms. Although the number of exporters decreases in 2012-2014, its weight on total manufacturing firms increases between 2010 and 2014. (In Annex 1 one can observe the firm dynamics by industry considering CAE 2-digit used by the Instituto Nacional de Estatística and in Annex 2 we present our self-made aggregation of the CAE 2-digit nomenclature).

[52] We have dropped all firms with negative values for Gross Revenue, Utilities and Services, Total Number of Worked Hours and Fix Tangible Assets. For convenience, we have not considered firms with negative values for Total Assets, Total Liabilities, Number of Workers and Total Personnel Spending.

4. TOTAL FACTOR PRODUCTIVITY

4.1. Estimating Total Factor Productivity

In order to calculate the total factor productivity (henceforth TFP) at the firm-level and, subsequently, for each of the considered years we have relied on the Levpet algorithm (henceforth LP) introduced by Levinsohn and Petrin (2003).

> **Box 1: Definition of Total Factor Productivity**
>
> TFP represents the part of the output which is not explained by the firm's choice on the amounts of inputs. Its measurement is related to the level of efficiency and intensity of the use of those inputs in the production process (Comin, 2006). On what concerns the TFP growth, is usually measured by the Solow residual. In this way, TFP growth is considered in the literature as being an important determinant of economic growth and it is intrinsically related with differences on per-capita income across countries (Solow, 1957). OECD considers Multi-Product Productivity (a concept similar to TFP) as the total contribution of input factors in output growth.

The production technology assumed by the referred authors is the Cobb-Douglas Production Function (1). The consideration of a Cobb-Douglas production function can be devoted to the seminal work of Solow (1957), whose work took into account the separation of growth in factors of production from the increase in efficiency of using these factors (Arvas and Uyar,2014).

$$\boldsymbol{Y_{it} = A_{it} K_{it}^{\beta k} L_{it}^{\beta l} M_{it}^{\beta m}} \qquad \textbf{(1)}$$

where Y_{it} represents the physical output of the firm *i* in the period *t*; K_{it}, L_{it}, M_{it} represent respectively the inputs from capital, labor and intermediate input. A_{it} is the Hicksian neutral efficiency level output of the firm *i* in the period *t*. Table 2 presents the proxy variables and its descriptive statistics.

TABLE 2. DESCRIPTIVE STATISTICS FOR THE MAIN VARIABLES IN PRODUCTION FUNCTION

Variables	*Proxy*	Mean	Standard Deviation	Min.	Max	Observations
Output (Y)	Gross Revenue	3867519	66700000	24.64	9630000000	92,550
Capital (K)	Fixed Tangible Assets	1171367	18000000	.01	2450000000	92,550
Labor (L)	Total Work Hours	53113.41	138667.1	2	6406960	92,542
Material (M)	External Services and Utilities	660280.7	5170006	17.33	497000000	92,550

Source: Author's calculations with IES database.

Given its irregular representation in order to be econometrically estimated, taking the logarithms from (1) derives a linear Cobb-Douglas production function, easily interpretable:

$$\boldsymbol{y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \varepsilon_{it}} \qquad \textbf{(2)}$$

with $\ln(A_{it}) = \beta_0 + \varepsilon_{it}$, where β_0 measures the mean efficiency level across firms and over time and ε_{it} the time and producer specific deviation from that mean, which can be further decomposed into an observable (or at least predictable) and unobservable component (van Beveren, 2007), resulting in the following equation:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + w_{it} + \eta_{it} \quad (3)$$

w_{it} represents the transmitted productivity component, whereas η_{it} denotes an error term uncorrelated with labor, capital and intermediate inputs (Petrin *et. al* ,2004) . The error term represents unexpected deviations from the mean due to measurement error, unexpected delays or other external circumstances (van Beveren, 2007) and further on impacts firm level decisions (Petrin *et. al*, 2004). The transmitted productivity component is related to the firm's decision problem, and thus intrinsically determined both firm selection and input demand decisions (Olley and Pakes, 1996).

In what concerns the transmitted productivity component $\boldsymbol{w_t}$, the algorithm created by Levinsohn and Petrin (2003) assumes productivity as the a result of a first-order Markov process, holding $\boldsymbol{w_t = E[w_t|w_{t-1}] + \xi_t}$. The authors also assume that the demand function for the intermediate input $\boldsymbol{m_t}$ is monotonically increasing in w_t, provided its dependence on the firm's state variables k_t and w_{it}, holding $\boldsymbol{m_t = m_t(k_t, w_t)}$ and thus the inverted intermediate demand function $\boldsymbol{w_t = w_t(k_t, m_t)}$.

Amid the two options of the LP command and data restrictions we have use gross revenue as our dependent variable in the production function instead of value-added. Firstly, production function estimation with value-added as it generally yields biased estimates of returns to scale in the presence of imperfect markets[53]. Secondly, gross revenue estimates allow for intermediate inputs and therefore they provide a more accurate perspective on the production process (Sichel, 2001).

Denoting $\boldsymbol{y_t}$ as the gross revenue in logarithms we estimated Equation (2)[54]. The estimated results from LP are analyzed further on.

4.2. Comparing different methods

Although the scope of our research does not rely on investigating the accuracy of different methodologies for the calculation of TFP, we have performed comparison calculations to ensure that the one from LP would better fit the purpose of our work.

We have calculated the production function under 3 parametric and semi-parametric approaches: Ordinary-Least-Squares (OLS), Least Square Dummy Variable with time fixed-effecst (LSDV) and finally LP. We have not estimated TFP with Olley and Pakes (1996) estimator (henceforth OP) as we did not have available data on investment accurate enough in order to be considered a proxy for unobserved productivity. Given the lack of information concerning investment from most firms, considering intermediate inputs (utilities and services) as proxy for unobservable productivity ensures a bigger dataset, as $\boldsymbol{m_{it}}$ is positive whenever the firm production is positive (Eberhardt and Helmers, 2010). Another advantage of LP over OP is that the latter requires additional depreciation costs over investment spending, as its "non-convexity" violates the monotonicity imposed in OP (Eberhardt and Helmers, 2010).

On what concerns the selection bias[55] in our data set, we have decided to keep all disposable firms instead of creating a balanced panel. Regarding the limitations of the LP method, we cannot omit all firms that enter and exit during the considered sample, as it is possible with the OP algorithm since it includes an additional correction to account the probability of firm's survival (Olley and Pakes, 1996). As this study focus on a very sensible period – right after the start of the 2008 economic and financial crisis - it would be risky to apply self-defined methods to decide which firms should be studied, as new firms that were founded between 2010-2014 were keen to be excluded – moreover, Olley and Pakes highlight the importance of not using artificially balanced panels. In line with Levinsohn and Petrin (2003) we do not focus also on selection issues as Olley and Pakes (1996) show little different

[53] Basu and Fernald(1997) prove the biased returns to scale under value-added production functions and show that the omitted variable in the equation that creates that bias is zero only in the presence of perfect competition (price equals marginal costs) and elasticity between inputs and materials equal to zero. As we consider in our database imperfect competition markets, we relied instead on gross-output. Another branch of the literature studies the problems on value-added production functions, such as Sudit and Finger (1981), Oulton and O'Mahony (1994).

[54] For such purpose we have used the *levpet* command – see Levinhson *et. al* (2003). We consider 50 bootstraps (number of iterations).

[55] The problem of selection bias was firstly approached by Wedervang (1965).

on the TFP estimates between unbalanced and balanced panels. Simply using an unbalanced panel avoids the problem of selection bias (van Beveren, 2007). As a great branch of literature enhances the importance of the entry-exit patterns of firms during a certain period (such as Jovanovic,1982 or Hopenhayn,1992), it would be imprudent to reduce significantly the dataset. Nevertheless, the use of an unbalanced panel does not mean a full overpass of the bias problem if in fact the explicit exit decision is not taken into account, as exit firms have prior knowledge of their productivity level $\boldsymbol{w_{it}}$ before exiting markets (Ackelberg *et. al* , 2007). Moreover, Van Beveren (2010) states that omitting exiting firms in the dataset , even though they tend to be less productive, will induce lower elasticities on the balanced panel firms and higher estimated TFP values (on average).

Table 3 presents a brief summary of methodological issues concerning TFP estimation, as already stated:

TABLE 3: SUMMARY OF METHODOLOGICAL ISSUES ON TFP ESTIMATION

Origin of the bias	Definition	Direction of the Bias	References
Selection Bias (endogeneity of attrition)	Causes correlation between $\boldsymbol{\varepsilon_{it}}$ and the observable inputs	Biased downward	Eberhardt and Helmers (2010) Beveren (2007) Olley and Pakes (1996) Wedervang (1965)
Simultaneity bias (endogeneity of inputs)	Correlation between $\boldsymbol{\varepsilon_{it}}$ and the observable inputs if firms' prior beliefs on $\boldsymbol{\varepsilon_{it}}$ influence its choice of inputs	Biased upward and downward if: $\widehat{\boldsymbol{\beta}}_{\boldsymbol{L}} > \boldsymbol{\beta_L}$ or $\widehat{\boldsymbol{\beta}}_{\boldsymbol{L}} < \boldsymbol{\beta_L}$ Biased upward if: $\widehat{\boldsymbol{\beta}}_{\boldsymbol{M}} > \boldsymbol{\beta_M}$ Biased downward if: $\widehat{\boldsymbol{\beta}}_{\boldsymbol{K}} > \boldsymbol{\beta_K}$	Eberhardt and Helmers (2010) Beveren (2007) De Loecker (2007) Levinsohn & Melitz (2002)

Source: Retrieved from Sulimierska(2014). Does not include other methodological problems concerning input price bias and multiproduct firms (as stressed by Beveren 2007, De Loecker 2007). Major source is Eberhardt and Helmers (2010) and Beveren (2007). ε_{it} is the time and producer specific deviation from the mean of efficient production

Several estimation techniques are suggested to solve problems of endogeneity and simultaneity provided from OLS estimations[56], but as Basu *et. al* (2009) stresses no method can be considered better that another under all possible circumstances. As said before, we have also estimated our production function Least Square Dummy Variable (LSDV) estimation, including time-specific fixed-effects[57]. It assumes that the unobserved productivity $\boldsymbol{w_{it}}$ is time invariant and a plant specific attribute. Arnold (2005) presents some disadvantages from the usage of such method: firstly, the fixed-effect estimator uses only the across time variation (and thus the coefficients will be weakly identified) and secondly the reasonability of the fixed assumption on the plant attribute. Harris(2005) also considers that using LSDV may infer biased coefficients because of incidental parameters problem as the result from the correlation between fixed effects and the explanatory variables, as it also produces sensible and unbiased results (Van Beveren, 2007).

One great advantage of the LP algorithm is that addresses the problem of simultaneity and endogeneity. Marschak and Andrews (1994) approached the contemporaneous and serial correlation between input demands, and proved that OLS estimated production functions may give inconsistent

[56] Several alternative techniques are suggested in the literature. For instance, Harris (2005) indicates within-group fixed effects (WG) least squares models, 2SLS within group fixed effects, frontier models and GMM system model (Blundell and Bond, 1998). The semi-parametric alternative using Olley and Pakes (1996) routines is also broadly used, although we have not applied it as we relied on LP. The author also mentions the extensions from Ackerberg *et. al* (2006).

[57] Introduced by Mundlak(1961) and Hoch(1962). Pavcnik(2002) Levinsohn and Petrin (2003) use also LSDV estimator.

estimates for input coefficients as it ignores the existent correlation between input demands and the productivity term. Estimating the production function with OLS requires that the inputs are exogenous, *i.e.*, determined independently from the firm's efficiency level (Van Beveren, 2007). The existence of simultaneity bias might induce different reactions on the inputs' coefficients, as the profit maximization problem "*implies that the realization of the error term of the production function is expected to influence the choice of factor inputs*" (Arnold, 2005). The degree of correlation between capital and labor inputs biases the capital coefficient (although it is not clear the direction of such bias), whereas the simultaneity bias causes an upward bias on the labor and materials coefficients (De Loecker, 1997). If such correlation exists, the capital coefficient will be biased downwards (Levinsohn and Petrin, 2003), assuming labor as the only variable factor and capital to be a quasi-fixed input (see Table 3 above for a related literature on the subject).

On Table 4 there are presented the estimated coefficients for capital, labor and material inputs for the three different methods OLS, FE and LP. We have a lower coefficient value to the intermediate goods in LP compared to OLS, in line with the results from Muendler (2004), and in both methods there is a significantly gap between the capital coefficient and the material coefficient. The results from Table 3 confirm the ones from Levinhson and Petrin (2003), as the coefficients of all the inputs are higher in OLS estimation when compared to the LP[58].

TABLE 4: COMPARISON AMONG ALTERNATIVE PRODUCTION FUNCTION ESTIMATES

Variables (Dependent Variable "Log of *Gross Revenue*")	**OLS**	**Fixed Effects**	**LP**
Observations (2010-2014)	**92,542**	**92,542**	**92,542**
Total Number of Firms	**25,324**	**25,324**	**25,324**
Capital (K)	0.073	0.042	0.05
	(0.0014)	(0.0029342)	(0.0588408)
Labor (L)	0.302	0.19	0.257
	(0.0049)	(0.0109367)	(0.0062028)
Material (M)	0.658	0.545	0.58
	(0.00294)	(0.0087708)	(0.2310618)
Sum of Elasticities	0.93	0.89	0.9

Source: Authors' calculations with IES database. Robust Standard Errors in brackets (to control for heteroscedasticity and autocorrelation)

In line with the results from Muendler (2004), our estimated coefficients for the intermediate inputs share the same pattern across the three different estimations, as its value is allways the higher and around the double of the elasticity from labor input (in the case of the FE, the coefficient for material input is more than the double of the labor input coefficient). Still in comparison with Muendler (2004), the intermediate inputs coefficient from LP estimation is lower than the one from OLS and FE. Following Van Beveren (2010), we confirm that as the fixed effects estimation allows for simultaneity and selection bias its coefficients for labor and material inputs will be lower than the ones from OLS. Still in line with the results from Van Beveren (2010), we do not have a higher coefficient for capital in LP compared to OLS, nor higher estimates for material and labor elasticities. Nevertheless, we confirm that all estimates for LP present higher values compared to the FE estimation. On what concerns the returns to scale, our three estimates present decreasing returns to scale. We present the same results as Levinsohn and Petrin (2003) on the sum of elasticities: OLS with the highest value, followed by LP and finally by FE.

[58] Following van Beveren (2010), we perfomed all regressions with STATA 14. OLS estimation was computed with command *reg*, FE estimation computed with *xtreg* and LP with *levpet* from Levinhson and Petrin (2003).

5. Estimated Model

5.1. Second-Stage Regressions and its Methodological Issues

Amid the estimation of the TFP values in the first-stage, we proceed to assess which variables are significantly determinants of its growth.

Wang and Schmidt (2002) refer to the problems resulting from second-stage regressions as the omitted variable problem not resolved in the first stage may provide inefficient and downward-biased estimates in the second-stage regression (the model *per si*).

We pursued the same methodology as in Harris *et. al* (2005): firstly we estimated the production function, getting the elasticities for each different input and secondly, we considered the residuals from the estimated production function as being TFP[59]. If we consider the matrix X as being a vector for observed (proxy) variables for the determination of the TFP values, we hold the following equation:

$$\widehat{lnTFP}_{it} = y_{it} - \hat{\alpha}_L l_{it} - \hat{\alpha}_M m_{it} - \hat{\alpha}_K k_{it} = \hat{\alpha}_i - \hat{\alpha}_X X_{it} + \hat{\alpha}_T t + \varepsilon_{it} \quad \textbf{(5)}$$

As Harris and Moffat (2011) remind, in the literature is quite common (and thus we chose such path of analysis) to estimate (5) without accounting for X and include it in ε_{it}. On the second-approach the determinants of TFP are regressed, enlarging the problem of omitted variables that will bias the estimates for the elasticities of output.

For instance, Harris and Li (2009) rely on a system-GMM approach that allows for fixed effects and endogenous inputs, amid several other options.

In fact, several authors confirm the econometric problematic from this issue, although Van Beveren (2010) showed that TFP estimated with different methods still present close results on the second-stage estimation, using the estimated TFP as dependent variable.

On Table 5 we present correlations between the estimated TFP values for each of the three chosen methods. We have found a higher correlation value between FE and OLS (0.84) compared to van Beveren, 2010 (that registered 0.6840). The correlation between FE and LP is also higher in our results (0.5602 compared to 0.3672) and we present a lower, but indeed high, level of correlation between LP and OLS (0.8498 compared to 0.9262).

Table 5: Correlation between different estimated TFP

	Fixed Effects	OLS	LP
Fixed Effects	1		
OLS	0.8498	1	
LP	0.5602	0.5472	1

Source: Author's calculations with IES database.

5.2. Robustness of the Model

Our estimated model for the TFP determinants consists on a fixed effects model, which allows for the inclusion of group-specific components that are correlated with other covariates in the form of "omitted variable"(Townsend *et. al*, 2013). The referred omitted variables, the so named "fixed effects" are in fact fixed or constant variables common to all sample firms in the dataset, invariant for all the time frame. The fixed effects estimation (or within estimators) do not intend to explain those inner-firm characteristic differences, nor are included in the model since "the demeaning process will cause their value to be zero for all time periods" (Wooldridge, 2002).

[59] Crass and Peters (2014) also rely on a second-stage estimation, having calculated TFP with the LP algorithm as well. Gatti e Love (2006) is also a fair example of second-stage estimation.

Following Hausman (1978) we have performed the Hausman test in order to justify the choice of fixed effects over random effects, rejecting the null hypothesis of consistency that the within estimator and that the individual and time-effects are not correlated with the explanatory variables (Baltagi, 2005), we found a correlation of -0.0040 between the fixed effects and the explanatory variables, showing a week negative correlation.

While analyzing the robustness of our model we have not given strong emphasis on serial correlation of errors, following Wooldridge (2002) as the within estimators yield consistency with large datasets with a small number of periods. As suggested in Wooldridge (2002) and Bertrand *et. al* (2004) we have considered cluster-robust standard errors as the normal standard errors from the within estimator provide inconsistent values in the presence of serial correlation[60]. As autocorrelation and heteroscedasticity are corrected, we overpass the problem concerning biased statistical inference and we are able to pursuit the correct analysis of estimated coefficients (Hoechle, 2007).

5.3. Estimated Model and Results

In Table 6 we present our estimated fixed-effects model, with dependent variable as being the logarithm of TFP estimated with LP with a sort of statistically significant variables as determinants for TFP growth:

$$lnTFP = \beta_0 + \beta_1 Size_{it} + \beta_2 Age_{it} + \beta_3 Wages_{it} + \beta_4 Training_{it} + \beta_5 ExporterStatus_{it} + \beta_6 Debt - to - Equity + \beta_7 Innovation_{it} + \varepsilon_{it}$$

TABLE 6: ESTIMATED MODEL FOR ALL FIRMS AND BIG FIRMS

Variable		*Estimated Coefficient (p-values) All Firms*	*Estimated Coefficient (p-values) Big Firms*	*Description*
Size	2 – Small Size Firm	**0.0345** *(0.000)**	-	Dummy Variable
	3 – Medium Firm	**0.1365** *(0.000)**	-	Reference group is (1) Micro Firm
	4 – Big Firm	**0.298** *(0.000)**	-	
Age		**- 0.008** *(0.000)**	**-0.007** *(0.845)*	
Wages		**0.2084** *(0.000)**	**0.0392** (0.570)	Logarithm of Average Annual Gross Wage per Worker
Training		**0.3644** *(0.005)**	**0.0758** *(0.598)*	Share of Training Expenses on Personnel Global Costs
Exporter Status		**0.059** *(0.000)**	**-0.0074** *(0.827)*	Dummy Variable 1 – Firm has Exporter Status 0 – Firm has not Exporter Status
Debt-to-Equity		**- 0.0244** *(0.000)**	**-0.0189** *(0.128)*	Logarithm of the Ratio Total Liabilities by Equity
Innovation		**0.014** *(0.001)**	**-0.0413** *(0.123)*	Dummy Variable 1 – Firm has the ratio Fix Intangible Assets/Total Assets different from 0 0 – has the ratio Fix Intangible Assets/Total Assets equal to zero
Number of Observations (Number of Firms)		**78,879**$^{+}$ **(12,082)**	**1,369**$^{+}$ **(353)**	-
corr(u_i, Xb)		**-0.0040**	• **0.1680**	Correlation between Fixed Effects and Explanatory Variables
R^2		***88%***$^{++}$	-	-

Source: Author's calculations with IES database.

[60] We rejected the Null Hypothesis of no serial autocorrelation of errors on our model.

*Significant at 5% | Controlled for heteroscedasticity and serial autocorrelation with cluster-robust standard errors
[+]Although the total number of firms in the dataset is 92,550¸only 78,879 had available information on Fix Intangible Assets, reducing the final cleaned dataset to the latter number of observations.
[++]R^2 was calculated with the STATA command *areg*, followed with *absorb* of the variable representing the firm's anonymous identity number.

On what concerns the explanatory variables, we divide its analysis according to four different categories of determinants of TFP growth (descriptive statistics from the variables can be accessed on Annex 2):

1. Internal Firm Characteristics: Dimension and Age;
2. Trade: Export Status;
3. Financial Constraints: Debt-to-Equity;
4. Research & Development, Innovation and Human Capital: Training Expenses, Innovation and Wages.

5.3.1. On Firms Internal Characteristics

On what concerns the effects of firm's age on TFP growth, we have found the existence of a negative effect, indicating that as a firm gets older than less productive it will be (at least a decrease of 0.8% per added year). As stressed in Harris and Moffat (2011), this might be due to the case of not accounting properly for capital obsolescence, leading to an advantage for younger firms to adopt more properly new technologies as older ones face sunk costs[61]**.** These results are in line with the ones from Hill and Kalirajan (1993) but diverge from Biggs *et. al* (1996)**.** Fernandes (2008) suggest the existence of a robust inverse-U shaped relationship between firm age and TFP on which she states that the most productive firms are the ones between 10-20 years old. Van Biesenbroeck (2005a) finds that TFP is higher in younger firms with a dataset of African countries and Jensen *et.al* (2001) finds the same results for a panel of US firms – recall Chart 6, where it is shown that younger firms have higher levels for TFP when compared to older firms. Our results contradict the "learning-by-doing" effects referred in Jovanovic and Nyarko (1996), on which they state that older firms achieve higher levels of productivity. Gatti e Love (2006), contrarily to previous results, also measure the effects of age on TFP growth with a second-stage estimation and found that it is negative.

Considering the effects of firm level dimension, our results contrast the ones from Fernandes (2008) on which she states that Bangladeshi small firms are more productive than bigger firms (although we are aware of the social, economic and cultural differences between Portugal and Bangladesh that may infer different results). Jovanovic (1982) states that bigger firms are more productive, which is line with our results. For instance Biesebroeck (2005a) finds that TFP increases monotonically with size for firms in nine African countries although not indicating on how much large firms were indeed more productive. Although considering a different sizing scale, Lee and Tang (2001) using firm-level data from Canada find that firms with more than 500 employees register more 17% of TFP compared to firms with less than 100 employees. In the same line, our results point to a difference of 30% between big and micro firms and 18.5% between medium and micro firms, suggesting that as size increases the higher is the different in TFP growth considering micro firms as the reference group. This might be due to the usage of more advanced technologies as suggested by Baldwin and Diverty (1995).

5.3.2. On Trade

For the purpose of measuring the marginal impacts of exporting, we have relied on a dummy variable concerning the fulfillment of the Bank of Portugal export status criteria. In this respect, we have found that the exporter status impacts, *ceteris paribus*, the growth rate of TFP 5.9% on average. The dimension of such impact may be due to several reasons, namely the import of technology or attraction of Foreign Direct Investment that offers firm's more innovative production methods (Mayer, 2001). Other reason may be due to the fact that exporters tend to have a higher endowment of capital, which makes them more innovative when compared to other firms that are more

[61] According to Lambson (1991) the sunk cost effect may be more visible on industries were entry firms have to choose between older and newer technologies simultaneously.

orientated to domestic markets (Baldwin and Hanel, 2000). For instance, we might relate the export status with the higher level of efficiency from the exporters firms, as stressed by UNIDO (2007). In the same line, Arvas and Uyar (2014) state that firms may self-select themselves in exporting to foreign markets as they achieve higher levels of efficiency. Greenaway and Kneller (2007) confirm that exporting activities will provide productivity gains only prior, with the so called "learning-by-exporting" effects post-entry.

5.3.3. On R&D, Innovation and Human Capital

Innovation and Research&Development (henceforth R&D) are commonly pointed out in the literature as enhancers of TFP Growth. Endogenous growth theory, explored by Romer (1990) or Grossman and Helpman (1991) among others, enhances the positive linkage between innovation spending and increases in production, prompting a rise in total factor productivity. Unfortunately we could not get any information concerning investments on R&D and therefore we have look into alternative ways of measuring the impacts of this category on TFP growth.

We proxy Research & Development and Innovation with the variables *Innovation* (which is a dummy variable that assumes the value 1 if the company has positive Fix Intangible Assets by Total Assets Ratio), training (which measures the ratio training expenses by total personnel costs) and average annual gross wages (which appears in logarithm in the final model). Unfortunately we could not have access to any data concerning the education from workers, therefore only having human capital variables in the presence of the training ratio.

On what concerns the *Training* variable, we follow the work of Crass and Peters (2014) that consider training expenses as part of Human Capital. Their second-stage estimation using TFP calculated with LP yields a positive coefficient for training expenses in line with our results, as we show that a unit increase on the ratio leads to a TFP growth of around 36%. Dearden *et.* al (2006) also prove that training expenses have a positive impact on productivity, considering a panel of British manufacturing firms. In another perspective, Konings and Vanormelingen (2009) found that the productivity premium of a trained worker is around 23% while analyzing firm-level from Belgian firms.

Next we consider a ratio of Fix Intangible Assets by Total Assets, assessing its effects on TFP growth through a dummy variable on which 1 represents a positive ratio value and 0 for a 0 value[62]. Our results show that a firm with a positive ratio, *ceteris paribus*, sees its TFP grow by more 1.4% than a firm that does not account for Fix Intangible Assets. As differently from several studies from the literature, we do not include Fix Intangible Assets on the production function as part of the capital variable in order to account for its effects on TFP growth. In this way, we avoid endogeneity and bias on the results and enrich the model with a variable broadly used in the literature. In line with our results, Greenhalgh and Longland (2005) used patents and trademark registrations (a component of Fix Intangible Assets) and find positive effects on productivity. On a different perspective, Marrocu *et.al* (2012) show that considering intangible capital assets measured on current expenses has less impact on TFP growth when compared with capitalized intangible capital – a difference that we cannot overcome due to our database.

Finally in this category, we conclude that average annual gross wages growth has a positive impact on TFP growth. We use this variable as a proxy for different schooling levels as we do not have access to more precise data on that. Gehringer *et. al* (2013) show on their model that unit wages are the major driver of TFP growth with a 0.19% growth on TFP as a result of 1% growth on unit wages (we achieve a result of 0.2% growth per 1% growth on average annual growth wages, a quite similar result). The same authors suggest that this variable can be in fact interpreted in two ways: firstly, more efficient employees get higher salaries, which will mean that they achieve higher levels of labor productivity and therefore they are more productive; secondly, the authors consider that industries that pay higher wages will achieve higher levels of TFP.

[62] Fixe Intangible Assets are considered in several works in the literature (Griliches, 1979; Griliches, Hall and Pakes, 1991; Geroski, Van Reenen and Walters, 2002; Bosworth and Rogers, 2001) among others. Kleinknecht (1996) and Hinloopen (2003) consider also innovative non intellectual property fixed intangible assets as proxy for innovation.

5.3.4. On Financial Constraints

In line with a great branch of the literature we considered a financial variable, keen to represent the firm's financial health on the model. We have relied for such purpose on debt-to-equity, although we describe firm-level heterogeneity concerning the variable leverage before on this paper, but did not include it to avoid endogeneity (both ratios include the variable Total Liabilities).

Our results show that an increase in 1% on the debt-to-equity ratio decreases TFP growth on 0.02%. The literature states that in general debt accumulation is a "cumulative result of hierarchical financing decisions overtime" (Shyam-Sunder and Myers,1999), and as a result firms not aim to a target debt ratio while respecting an optimal capital structure (Coricelli *et. al*, 2012). These authors show that debt may have positive impacts on TFP growth under a threshold effect, on which after a certain level of debt reached the firm would see its TFP growth decrease. For instance, Gatti & Love (2008) prove that access to credit prompts TFP growth using a panel with Bulgarian firms, contrarily to Nucci *et. al* (2005) that found a negative impact of debt ratio on productivity while analyzing Italian firms[63]. The authors consider also that firms with higher levels of TFP are likely to generate higher levels of profit (and cash flows) and therefore rely less on debt to finance its activity.

5.3.4. Comparing the all firm's sample with the big firm's sample

We estimated the model for a sample only with manufacturing big firms, having estimated firstly the TFP values with LP as well. On Table 6 it is possible to observe that none of the variables from our model are significant in the big firm's sample, showing that considering such sample individually may need a different effort on assessing the determinants of TFP growth. Going forward, it would be interesting to assess other set of determinants specific for this firm size group.

6. CONCLUDING REMARKS

On the light of our model's results, we propose some intuitive and practical measures keen to be applied by policymakers in order to prompt TFP growth, considering the manufacturing sector. We divide our suggestions in key thematic relating such possible reforms and consider its effects on the variables that are included in our final equation.

This analysis has identified several determinants that have an impact on or are associated with TFP growth. Of these, dimension, age, being an exporter, training, leverage, appropriate internal financing and wages seem to directly affect TFP growth of Portuguese companies in the industry sector. Therefore, according to our results, public incentives to promote Portuguese firms productivity should be targeted at:

Creation of new firms - Younger firms are more dynamic and have a higher probability of engaging in export and innovative activities. To stimulate the creation of new firms policies such as the reduction of entry barriers or the improvement of the access to finance of start-ups should be pursued. Also, bankruptcy legislation and judicial efficiency can encourage experimentation with innovation and new technologies: bankruptcy should not be penalised too severely;

Promotion of exports – Policies that increase the ability of domestic firms to overcome the export-entry barriers should be pursued; Lower bilateral trade costs and lifting barriers to competition in goods markets;

Dimension - Since productivity increases with size, policies that stimulate mergers and acquisitions and the expansion of the activity of companies should be pursued;

Leverage – Given that productivity decreases with the debt-to-equity ratio policies that support the development of complementary sources of debt, such as venture capital markets, should be pursued; also reduce the corporate debt overhang to facilitate resource allocation, policies that encourage equity over debt such as the removal of tax incentives that favour debt over equity and the simplification of equity rules which increase costs of private equity;

[63] The work of Nucci *et. al* (2005) refers also that is important to overpass the endogeneity problem arising from the bond between debt and intangible assets, whose problem we avoid has we do not include intangible assets in the capital structure of the production function and thus is not part of the TFP estimates directly.

Training and Innovation - Policies that develop absorptive capacity are key to ensuring productivity spillovers. Building absorptive capacity includes developing local innovation and enhancing human capital; incentives to collaborate between firms and universities, R&D fiscal incentives and state funding of basic research; Encouraging investment in R&D and human capital; Policies that encourage stronger links between firms and research, educational and training institutions can facilitate knowledge transfer;

Skilled Labour - Facing higher wages as a proxy for higher qualifications (rewarded with higher salaries), policy measures should give incentives to invest in skills, encourage the use of more skilled labour, specialized and efficient work and make a greater use of training.

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