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SIZE-BASED CORPORATE TAX INCENTIVES: THE WAY UP OR A LOCK-UP?

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Abstract

Preferential tax schemes for Small and Medium-Sized Enterprises (SMEs) constitute a policy instrument present in multiple OECD nations, aiming to foster the expansion of firms, which takes special relevance in Portugal, where these struggle to grow and SMEs dominate. Nevertheless, these incentives are found, by some authors, to hampering it, since SMEs seek to keep eligible for them. Consequently, this work project assesses how such tax incentives influence Portuguese firms' ability to grow. In sum, the effect of an increase in them on the Portuguese official firm-size variables reveals heterogeneous (positive on net turnover, negative on number of employees).

Keywords: public finance; economics of taxation; size-based corporate income tax incentive; effective marginal tax rate; tax threshold; firm growth; lock-in effect; notch problem; small and medium-sized enterprise; economic distortion.

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1. Introduction

Over the past decades, namely since the adoption of the euro, Portuguese GDP growth has been evolving slowly, and its convergence with the EU (European Union) benchmark was only resumed in the recent few years. Amongst the plausible explanations put forward by some authors, there can be pointed out the difficulties faced by Portuguese companies in growing and gaining scale [Oliveira and Fortunato (2006); Cabral (2007)], which has motivated targeted policies to boost SMEs[2] growth, aiming to unlock growth.

In effect, tax systems which adopt preferential tax treatment of SMEs are present in multiple European nations (Bergner, et al. 2017) and OECD member countries (OECD 2015), such as the United States, United Kingdom, Spain, Germany, France, Canada and Portugal (Chen, Lee and Mintz 2002). This type of policy aims at supporting these firms' growth, taking into consideration, on the one hand, their crucial economic contribution (chiefly, to employment, innovation and supply chains), but, on the other hand, the financing issues, high regulatory burden and hurdles which they tend to face in accessing the foreign and domestic markets.

Nonetheless, some authors argue that size-based CIT (Corporate Income Tax) incentives hamper the SMEs' expansion, by incentivising them, indeed, to remain small, in order to ensure the respective eligibility for such tax benefits and, thus, avoid transitioning into the following level of marginal tax rate, as it is suggested, in the literature, by the segmentation of companies into small entities, in addition to the possibility of them benefiting inefficient firms and, on the other hand, disregarding the efficient small ones (which end up not being eligible for those, owing to the non-positive earnings before taxes recorded by some of the latter).

Thus, this induces a lock-in effect which generates economic inefficiencies and yields an unintended effect – that is, distorts firms' growth and induces a lower Total Factor Productivity

[2] In Portugal, "SME" (Small and Medium-Sized Enterprise) refers to firms which employ less than 250 workers and whose yearly net turnover does not exceed € 50,000,000, or whose annual total balance sheet does not total more than € 43,000,000, according to the Decree-Law 372/2007 of 6 November 2017 (Statistics Portugal 2021).

(TFP) –, which takes a particular relevance in Portugal, where, as previously mentioned, firms denote difficulties in growing, taking into account that the SMEs dominate the respective universe of firms, approximately representing a constant share of 99.9% of total companies from 2008 to 2019, namely micro-firms, which, in turn, accounted for 88.3% of the universe of companies between 2006 and 2019. Additionally, in the latter period, the fraction of firms which have upgraded the respective status (micro, small, medium, large), from years $t-1$ to t, never exceeded 2% of operating firms, except very slightly in 2007 ($\approx 2.1\%$) (Graph 1[3]).

Consequently, the research question which this dissertation sheds light on consists of finding out whether size-based CIT incentives yield a pernicious effect on the firms' growth perspectives in Portugal, disincentivising it. More specifically, it aims to assess to what extent the companies' economic performance is impacted on by a preferential tax treatment (based on reduced CIT rates targeted at SMEs), considering their net turnover, number of employees, TFP, value-added and total assets. For this purpose, resorting to data on *Informação Empresarial Simplificada* (IES) for the population of Portuguese non-financial corporations, supplied by the Bank of Portugal, it is econometrically examined whether those tax advantages give rise to a negative effect on the aforementioned variables.

This analysis resorts, namely, to one of the two essential concepts presented by the Devereux/Griffith model, corresponding to the Effective Marginal Tax Rate (EMTR), which differs from the legally established "statutory CIT rate" ("headline rate") by providing an overarching indicator of the heterogenous effective tax burden that each investment project is subject to, that is, reflecting the impact of tax liabilities, as well as of incentives (tax credits/deductions and capital/depreciation allowances). Thus, the EMTR constitutes a suitable measure for assessing the tax competitiveness (Department of Finance Canada 2019).

[3] See Appendix 1, page 31.

In sum, it is found that such size-based CIT incentives induce an increase in the Portuguese firms' net turnover by 8.8 p.p., notwithstanding a negative impact on the respective number of employees, gross value-added (-5.8 p.p. and -3.87 p.p., respectively) and TFP (down to -4.4 p.p.). The combination of these results hints at a possible artificial effect on the tax base (as proxied by net turnover), related to lower evasion. Furthermore, such incentives reveal to be more effective for firms operating in the manufacturing industry, in contrast to the case of older enterprises and those located in the interior of Portugal (except, in the latter case, in terms of their number of employees).

This dissertation is structured as follows: firstly, a summary of the Portuguese context respecting how the tax system addresses SMEs, from the viewpoint of the respective dimension, is elaborated; secondly, a literature review focused on the topic under analysis is presented; thirdly, we describe the data used in the performed empirical strategy; fourthly, the methodology followed is detailed; afterwards, one proceeds to the discussion of the obtained results; lastly, there are presented the concluding remarks, proposed solutions, identified limitations, as well as the main directions for future research.

2. The SMEs within the framework of the Portuguese tax system

The Portuguese tax system contains a broad set of tax incentives which SMEs are granted. Indeed, in what regards their dimension, these are subject to a reduced CIT rate (of 17%) up to the first € 25,000 of the respective taxable profits, after which threshold they return to the normal tax rate, corresponding to 21% (value which came into effect in 2015, having been 23%, in 2014, and 25%, in the remaining previous years). This policy instrument was introduced in 2014, within the reform of the Portuguese code of *Imposto sobre as Pessoas Coletivas* (*IRC*) (intending to foster the tax competitiveness of the Portuguese economy, within the euro area, and prior to which such a tax scheme – based on an intermediate rate – was generalised to all existing firms, specifically until 2011), and the aforementioned threshold

already reflects the increase it was subject to by 2020 (which had, previously, corresponded to € 15,000) (Law no. 2 2014).

Additionally, the SMEs whose main economic activity is inserted in the manufacturing, commercial, agricultural or service-rendering fields, and takes place in the interior districts of Portugal, are provided with a reduced IRC rate of 12,5% (which targets at the initial € 25,000 of taxable profits), being that, in case the SMEs undertake particular investment projects in the those geographical areas, the maximum value of tax deduction which they can benefit from increases by 20% (Autoridade Tributária e Aduaneira 2020). To access it, SMEs are required to not having outstanding wages, as well as not having resulted from firm split-ups, during the two previous years.

Analogously to Malta and France, in Portugal, the young SMEs receive specific tax reliefs, in line with what the literature about the substance and effects yielded by the preferential tax schemes for SMEs documents, concerning the economic inefficiency potentially induced by the conventional size-based CIT incentives – which tend not to take into consideration the evidence that merely a small fraction of SMEs constitutes, indeed, relevant sources of employment, innovation and value-added, namely the young firms (Bergner, et al. 2017).

3. Literature review

SME-targeted policies, aiming to spur the respective growth and investment, reveal to be a common policy instrument across nations, chiefly the size-based CIT incentives. Indeed, a set of fundamentals is invoked to support the existence of the latter. On the one hand, SMEs present a pivotal economic contribution, not only due to their representativeness within the universe of firms operating on the several markets, but, also, by constituting a vital source of innovation and due to the respective performance in job creation, relative to large companies. Nevertheless, according to the opponents of the preferential tax schemes for SMEs, the latter characteristic reveals non-consistent, exhibiting considerable fluctuations over time and tending to display a

temporary/short-run pattern, as well as an appreciable correlation with the business cycle's phase in which they are at each moment, as documented by James Medoff and David Birch, quoted by Guenther (2009).

Nonetheless, in fact, according to Birch and Medoff (1994), quoted by Rugy (2005), solely a small fraction of SMEs stands out in terms of employment, innovation and high growth rates, which is, precisely, composed of those firms that most face uncertainty and hurdles regarding their financing (termed "gazelle companies"), and, thus, those that should, indeed, be tax-incentivised. However, by virtue of the difficulty underlying to the respective identification, such SMEs end up excluded from the tax incentives under analysis, due to their frequently non-positive earnings before taxes.

An example of size-based CIT incentives corresponds to the "SME Basic Act", implemented in Japan and for which firms' eligibility is determined by the respective capital stock, or, alternatively, equity. Concerning this program's outcomes, it has been observed that firms are less likely to increase K, thereby retaining the SME status and, thus, keeping meet the established threshold for accessing the reduced tax rate [OECD (2016), quoted by Tsuruta (2020)].

Since companies' size and K are positively correlated, the aforementioned criterion translates, in effect, into a relevant constraint on corporate growth, distorting their size and hindering their growth, with those tending to remain small, as what has been evidenced by this "SME Basic Act" reform – which has materialised in less strict requirements for accessing the tax incentive –, notwithstanding, in manufacturing industries, firms' assets having presented a higher growth after it (Tsuruta 2020).

On the other hand, within the scope of a study focused on Belgium, France, Spain and the United Kingdom, Benedek, et al. (2017) concluded that the companies which are granted more size-related tax incentives tend to experience a relatively inferior TFP growth.

In public finance, this phenomenon describes the "notch problem", consisting, in sum, of a cost implied by the class of tax schemes under analysis, which disincentivises ventures from achieving their optimal size and, therefore, from benefiting from scale economies (Mansell, et al. 2012). Indeed, there are two different natures of thresholds ("notches" and "kinks"), which constitute discontinuity points in the level and slope of choice sets, respectively.

Whilst "kinks" represent the points at which the marginal tax rate rises (to the following level) within a progressive tax system, in accordance with certain schedules, "notches", on the other hand, correspond to the critical limits at which a preferential tax incentive (i.e., specifically targeted) ceases to apply, after which the average and marginal tax rates transition to a higher value. By and large, "notches" imply a change in these two rates, thereby being relatively more distortionary.

In fact, corporate growth rates decline as firms transition out of the SMEs category, since the cost of growth (which also comprises the opportunity cost of being granted these tax incentives) incurred by them increases as they approach the established threshold. Nevertheless, as stated by Baumol (1962), quoted by Tsuruta (2020), this behavioural relationship is not linear, insofar as, once firms graduate from "SMEs", the respective optimal growth rate raises, as that cost no longer reflects the aforementioned opportunity cost. Thus, size-based CIT incentives may not always be considered as a hurdle to corporate growth, depending, in effect, upon that opportunity cost, as long as the other SME-targeted policies (focused on further aspects) can accomplish a meaningful reduction in it, thereby yielding a compensatory effect.

In light of the conventional economic theory, SME policies should be, exclusively, adopted in the presence of a market friction/failure [Storey (1994), quoted by Tsuruta (2020)] – which prevents markets from achieving optimal outcomes and may induce underinvestment in small firms –, such as the asymmetric information in financial markets, which compromises the SMEs financing [Berger and Udell (1998), quoted by Tsuruta (2020)]. The latter problem stems, in

sum, from the difficulty of investors in assessing the profit perspectives and risk inherent to SMEs, which leads them to face credit rationing/restricted access to financing, with higher costs of loan servicing. Taking into consideration that size-related CIT incentives affect tax neutrality, the way they are designed by governments pursues, therefore, two objectives: efficiency and equity.

On the one hand, the first one addresses the fact that the small enterprises are more susceptible of undergoing market failures. Thus, such tax incentives intend to compensate them for the relatively higher administrative, regulatory (by virtue of them tending to operate in scale diseconomies) and compliance costs they incur, which handicap the respective growth. Furthermore, there are equally taken into account the SMEs' issues within the framework of market competition, the increased difficulties in accessing both the domestic and foreign capital markets (which restrict their financing options), as well as the liquidity scarcity (considering the SMEs' relatively higher risk of default, given the higher cost at which they can service the respective issued debt) faced by them. On the other hand, the second goal ("equity") consists of supporting SMEs, taking into consideration their lower net income, in comparison to larger firms.

A study held in China allows one to conclude that the behaviour exhibited by firms' growth rates, indeed, depends upon the specific type of threshold considered. Thus, size-based CIT incentives do not strictly discourage firm growth, having companies' fixed asset growth not exhibited any decline as they were converging to the established taxable income threshold, in contrast to the scenario in which firms' growth is being analysed (assuming, in this case, a total assets threshold), as reported by Cui, et al. (2021). Thus, one can contend that a taxable profits-based threshold – as commonly adopted in most OECD member countries – is predicted to induce a lower distortion to corporate growth, contrariwise to that grounded on firm total assets, as observed in the case of Japan (Cui, et al.2021).

An additional empirical study, which has taken place in Nairobi City County (located in Kenya), shows that the employment rates, duration of SMEs' activity period (lifespan), as well as the diversification of the markets in which they operate, have significantly been reinforced after the introduction of a preferential tax treatment for SMEs, which has, therefore, revealed positive in terms of the respective growth.

Nevertheless, besides the possibility of hindering firms' growth [Hendricks, Amit and Whistler (1997), quoted by Chen, Lee and Mintz (2002)], the preferential tax treatment of SMEs may elicit the fragmentation of firms into multiple small segments, in order to hold their eligibility for the tax savings underlying to it. This phenomenon has been observed, for example, in Canada, where it was pointed out as one of the main responsible factors for this economy's lower productivity, relative to that of the United States (Chen and Mintz 2011).

Therefore, it is relevant to stress that the type of SME policies under discussion (size-based) solely applies to the specific group of profitable firms, thereby not being totally effective in enabling the former to cope with the aforementioned structural challenges faced by SMEs. Indeed, the young SMEs are found not to benefit from such tax reliefs, since they are only slightly influenced by corporate taxation [Arnold et al. (2011), quoted by Cui, et al. (2021)]. Additionally, size-related CIT incentives may not be a suitable policy tool, insofar as corporate taxation does not appear to more negatively impact on small businesses' investment decisions than on those of large firms, according to a study carried out by OECD [quoted by Chen and Mintz (2011)].

Within the scope of the impact of taxation on the corporate investment decisions, the neoclassical Devereux/Griffith model allows for the determination of the (forward-looking) effective average (EATR) and marginal (EMTR) tax rates.

On the one hand, the EATR supports firms' decision about whether to invest (extensive margin), and which project and location are more attractive from the standpoint of taxation,

assessing the tax burden that is levied, on average, on an inframarginal (discrete) investment, that is, whose economic rents are positive, given a higher post-tax expected rate of return than the cost of capital (i.e., the minimum pre-tax real rate of return for an investment to break even, thus required for a company to undertake it) (Hajkova, et al. 2006), being that, the higher such post-tax profits are, the closer the EATR is to the "statutory CIT rate", that is, the less expressive tax incentives are in firms' effective tax burden (Overesch 2005).

Indeed, the EATR corresponds to the change in Net Present Value (i.e., between the pre- and post-tax NPV), discounted by the pre-tax real rate of return – which describes how taxation impacts on NPV –, or, equivalently, the fraction of tax liabilities' NPV which a firm pays throughout a particular project's time horizon in the NPV of the respective return (McKenzie and Smart 2019; Tax Policies in the European Union: 2020 Survey 2020). Additionally, it can be stated that $EATR \in [EMTR; \text{statutory CIT rate}]$ as the economic rents resulting from the investment grow, being $EATR = EMTR$ in what respects a marginal investment (i.e., whose economic rents are null) – considering that both are related as $EATR = \frac{\tilde{p}}{p} EMTR + \frac{p-\tilde{p}}{p} \tau$ (0).

On the other hand, the EMTR allows one to select the investment's scale [intensive margin (Holt, Skali and Thomson 2021)], by quantifying the tax implied by an additional unit of a marginal investment (Tax Policies in the European Union: 2020 Survey 2020)], and, thus, how taxation increases the reservation pre-tax rate of return (termed "hurdle rate"). In effect, the EMTR is given by the proportion of the wedge between the cost of capital ($\tilde{p}$) and real market interest rate (r) – i.e., the post-tax rate of return –, in $\tilde{p}$.

Indeed, the more positive the EMTR is, the more discouraged (thus, less attractive) a particular project is by the tax system, whereas a negative value for it translates into the latter being subsidised (Abramovsky, Klemm and Phillips 2014; Alm and Khan 2017), and, if null, no tax revenue is obtained at the margin (i.e., it is neutral) from it. In conclusion, despite a high statutory tax rate, the EMTR may be low or negative (Giannini and Maggiulli 2002).

4. Empirical strategy

4.1. Methodology

In order to examine the impact exerted by preferential tax schemes (for SMEs) on the expansion of Portuguese firms' size, firstly, there have been regressed the logarithms of firm-level net turnover, number of employees and total assets (proxy variables for firm size – from which the first two constitute the official criteria adopted, in Portugal, in firm classification, according to the respective dimension) on the covariate size-based CIT incentive and the interaction terms, $incent\_district$, $incent\_industry$ and $incent\_age$ (i.e., the product of the tax incentive and the dummy variables $interior$, $manufacturing\_industry$ and age, respectively), intending, in effect, to study how the magnitude of the impact of such a tax incentive on each of those dependent variables is influenced by whether a company is located in the interior of Portugal (where, as previously mentioned, a reduced CIT rate is applied, 12.5%), whether it operates in the manufacturing industry (i.e., in case the respective CAE[4] is comprised between codes 10110 and 33200), as well as by firm age.

In order to derive the values for size-based CIT incentive, there have been computed the values for real interest rates as $r = \frac{i-\pi}{1+\pi}$ (1), in which i has been extracted from *BPstat* (proxied by the "interest rate of loans and deposits (new business) for non-financial corporations"), seeking to more accurately reflect the specific reality of the Portuguese economy, that is, to capture the financing conditions that are effectively faced at the corporate level.

Afterwards, one has proceeded to the estimation of the Effective Marginal Tax Rate as $EMTR = \frac{\tilde{p}-r}{\tilde{p}}$ (2), with $\tilde{p}$ denoting the cost of capital, which is determined as $\tilde{p} = \frac{1-A}{(1-\tau)(1+\pi)}[\rho + \delta(1+\pi) - \pi] - \frac{F(1+\rho)}{(1-\tau)(1+\pi)} - \delta$ (3) [where, in turn, $F = 1 - \frac{1+i}{1+\rho} + \frac{i\tau}{1+\rho} =$

[4] *Classificação Portuguesa das Atividades Económicas* (Statistics Portugal 2007).

$\frac{\rho - i(1-\tau)}{1+\rho}$ (4)]. In parallel to this, there have been derived both δ_f (firm-specific economic rate of depreciation) and A [NPV of "tax depreciation allowances per unit of investment, discounted by the shareholders' nominal discount rate (ρ)" – where $\rho = i$, thereby allowing one to neglect personal taxation in this context, that is, assuming that capital and income are taxed at a homogeneous rate] [inspired by Benedek, et al. (2017)].

In detail, A has been computed according to the straight-line depreciation scheme [which is used, in Portugal, as the standard accounting method in asset depreciation for tax (*IRC*) purposes (Regulatory Decree no. 25/2009)], $A = \frac{\tau\varphi(1+\rho)}{1+\rho}$ (5), where φ (capital allowance[5]) corresponds to the mean of capital allowances for industrial buildings, machinery and intangibles, $\varphi = \frac{0.05+0.3571+0.1}{3} \approx 0.169$ (6) [which three values were reported by Spengel, et al. (2020)], and τ stands for the CIT rate.

In what regards parameter δ_f, its determination has been inspired on the methodological procedure proposed in Egger, et al. (2009). Indeed, there have, initially, been decomposed firm f's total assets into the intangible (IFA_f) and tangible fixed segments (TFA_f), that is, calculated the respective share, in total assets, as $\Theta_f^T = \frac{TFA_t}{total\ assets}$ and $\Theta_f^I = \frac{IFA_t}{total\ assets}$ (7).

Afterwards, Θ_f^T has been disaggregated into the buildings and machinery components, $\Theta_f^b = \Theta_f^T \theta_f^b$ (8) and $\Theta_f^m = \Theta_f^T \theta_f^m$ (9), where, in this work project, θ_f^b and θ_f^m denote, respectively, the firm-specific weight of buildings and machinery in fixed tangible assets – respecting which the available data for the Portuguese firms are, nevertheless, not harmonised, since they cover two distinct accounting periods: *i)* 2006-2009 (*POC* – Official Chart of Accounts), for which we have deducted the amortizations from gross asset to obtain the net asset; *ii)* 2010-2019 (*SNC* – Accounting Standards System). Thus, $\delta_f = \delta^I \Theta_f^I + \delta^b \Theta_f^b + \delta^m \Theta_f^m = 0.15\Theta_f^I +$

[5] Defined as the "rate at which capital expenditure can be offset against tax" (Benedek, et al. 2017).

$0.0361\Theta_f^b + 0.1225\Theta_f^m$ (10), in which δ_f we opted for parameterising[6] according to those followed both by Egger, et al. (2009) and Benedek, et al. (2017).

The determination of $EMTR$ has been performed from two different perspectives. In the first one (i.e., $EMTR$ at the standard CIT rate), there have been considered the values for the normal CIT rate in Portugal, $\tau = \begin{cases} 0.25\ if\ 2006 \leq year \leq 2013 \\ 0.23\ if\ year = 2014 \\ 0.21\ if\ 2015 \leq year \leq 2019 \end{cases}$ (11), whilst, in the second (i.e., $EMTR$ at the reduced CIT rate), those for the special tax rate for SMEs, $\tau = \begin{cases} 0.25\ if\ 2006 \leq year \leq 2013 \\ 0.17\ if\ 2014 \leq year \leq 2019 \end{cases}$ (12). Then, it has been derived the size-based CIT incentive as the difference between both EMTRs, which, thus, consists of a simulation based on comparing two scenarios, in which SMEs would be subject, in the first one, to the normal CIT (*IRC*) rate that is, at each time period, in force in Portugal and, in the second one, to the (preferential) SME-targeted CIT (*IRC*) rate, so as to render it viable to study how Portuguese firms react in the presence of such SME incentives (i.e., when the CIT rate switches).

Secondly, one has proceeded to the estimation of the regression model $Y_{it} = \beta \text{size-based CIT incentive}_{it} + \delta firm\_turnover_i PMR_t + \gamma X_{it} + \alpha_t + \alpha_i + \varepsilon_{it}$ (13) [inspired by Benedek, et al. (2017)], in which, in year t: Y_{it} represents firm i's $\ln TFP$ and $\ln valueadded$; $\text{size-based CIT incentive}_{it}$, a simulation of firm i's size-related tax incentive that, therefore, accrues from the existing differential in EMTRs between large and non-large corporations, seeking to analyse how they react under such different scenarios; PMR_t, the OECD Product Market Regulation index for Portugal, capturing the degree of stringency presented by product market policies ("legal and administrative barriers to entrepreneurship", "state control of business enterprises" and "barriers to international trade and investment") and which is comprised between 0 and 6 – i.e., from the most to the least incentivising ones of

[6] On this step, we opt for not considering land and inventories, given that the corresponding δ_f are null (i.e., they are not tax depreciable).

market competition) (Anderton, Lupidio and Jarmulska 2019); $firm\_turnover_i$ ("business churn"), the sum of firm birth and death rates (respectively, the share of companies which are founded/closed at t, relative to total firms), which enables one to assess how heterogeneous the exposure of each firm to the impact of the regulatory framework on market competition is (Anderton, Lupidio and Jarmulska 2019); and X_{it}, a vector of control variables – debt-to-assets (share of total liabilities in total assets), $innovation$ (fraction of intangible in total assets), firm $size$ (proxied, this time, alternatively by the lagged value-added) and firm age.

The aforementioned model has been estimated based on fixed-effects, aiming to capture unobserved time-invariant firm-specific characteristics, thereby controlling for exogenous factors that may influence corporate TFP and value-added, such that solely the net effect of predictors on dependent variables is studied, that is, minimising the noise which these are subject to. In order to prevent a potential violation of the Gauss-Markov theorem's homoskedasticity assumption from producing inefficient estimators, it has been applied a correction for possible heteroskedasticity (through the use of robust standard errors).

Regarding the firm-level logarithm of TFP, there have been adopted three avenues to determine it. According to the first one, $\ln TFP_{\text{OLS-based}}$ corresponds to the residual of Cobb-Douglas production function (Output 3)[7]'s logarithmic version, $\ln y_{it} = \beta_0 + \beta_1 \ln k_{it} + \beta_2 \ln l_{it} + \beta_3 \ln m_{it} + \mu$ (14), estimated by Ordinary Least Squares (OLS), where y_{it}, k_{it}, l_{it} and m_{it} stand for "net sales and services rendered", "fixed tangible assets", "employee expenses" and "supplies and external services", respectively. The second one, on the other hand, defines $\ln TFP_{\text{W-based}}$ as the residual of the production function's log-form estimated according to the Wooldridge (2009) estimator[8]. Lastly, the third one measures $\ln TFP_{\text{index-based}}$ as the logarithm of the index $\frac{\Delta \text{Net sales and services rendered}_t}{\Delta(\text{Fixed tangible assets} + \text{Employee expenses} + \text{Supplies and external services})_t}$,

[7] See Appendix 1, page 35.
[8] The Wooldridge (2009) estimation (see Appendix 2, page 35) has been performed through the STATA software command by Rovigatti and Mollisi (n.d.).

inspired on European Commission (2016).

Afterwards, there have been computed $PMR = \begin{cases} 2.12 \; if \; year < 2008 \\ 1.69 \; if \; 2008 \leq year \leq 2012 \\ 1.29 \; if \; 2013 \leq year \leq 2017 \\ 1.34 \; if \; year \geq 2018 \end{cases}$ (15)

(values obtained from *OECD.Stat*), $regulation$ as the product of PMR and $firm\_turnover_i$, and gross value-added as (net sales and services rendered + variation in production + capitalized production + supplementary revenues + operating subsidies) – (cost of goods sold and material consumed + supplies and external services + indirect taxes).

In sum, this second model under analysis has been estimated by regressing the vector of dependent variables y = [$\ln TFP_{\textbf{OLS}\text{-based}}$ $\ln TFP_{\textbf{W}\text{-based}}$ $\ln TFP_{\textbf{index}\text{-based}}$ $\ln valueadded$] on size-based CIT incentive, debt-to-assets, $innovation$, $size$, $regulation$, five dummy variables (for firm age being, this time, comprised between 2.5-5, 5-10, 10-15, 15-20, or greater than 20 years), time dummies and, additionally, the interaction term between size-based CIT incentive and $innovation$ [given by $incent\_it$ = size-based CIT incentive × $innovation$ (16)].

4.2. Data

For the development of this dissertation, one has resorted to *Banco de Portugal Microdata Research Laboratory* (BPLIM)'s "Central Balance Sheet Harmonized Panel Data" firm panel (longitudinal) dataset, respecting the time horizon 2006-2019 and containing the information collected by means of *Informação Empresarial Simplificada* – a procedure which firms are, in Portugal, obliged to, whereby accounting, tax and financial information concerning them is reported to *Autoridade Tributária e Aduaneira*.

The respective observations present an annual frequency, taking all Portuguese non-financial corporations into consideration and in a time-consistent basis, insofar as they were not impacted on by the transition from POC to SNC, held in Portugal, in 2009/2010, or, alternatively, it has

been possible to harmonise them, thereby rendering it viable to cope with the resulting structural change, that is, not jeopardising the comparability of variables over time. This dataset is composed of 5,485,164 observations and reflects economic and financial (income statement and balance sheet), employment, trade and general information on the non-financial corporations operating in Portugal (BPLIM 2021). Nevertheless, a limitation that can be pointed out consists of it being an unbalanced panel, inasmuch as there are not always available data for all firms, over all the considered years.

The descriptive statistics (Table 1) respecting the analysed variables allow one to identify relevant characteristics that define the latter. Indeed, the economic rate of depreciation – rate at which a particular asset's economic (productive) value declines throughout time, under the influence of economic factors that disturb the respective market value, but not according to any specific lifetime-based depreciation schedule (as what occurs in "accounting depreciation") – is, on average, particularly low (1.7%), analogously to the innovation-based CIT tax incentive ($incent\_it$) (nearly null), $innovation$, $regulation$ and size-based CIT incentive (2.6%).

On the other hand, the Effective Marginal Tax Rate (EMTR) – determined either considering the standard CIT rate or that targeted at SMEs – is, on average, negative (-34% and -37%, respectively), which translates into firms being encouraged/subsidised by the Portuguese tax system [according to Policy Framework For Investment User's Toolkit (2013)], possibly due to the effect of investment tax incentives and interest deductibility (Coelho and Aslam 2021), as well as of substantial "allowances for corporate equity" that allow for deductions against the respective taxable income (Pomerleau 2021). Indeed, this reveals that, in Portugal, corporate taxation leads investors to require a relatively lower pre-tax rate of return for breaking even (OECD 2021), that is, promotes an increase in the investments' return (Norrman and McLure 1997).

Conversely, the particularly expressive value that debt-to-assets ratio takes on average

(181.1) denotes that the Portuguese firms finance a large fraction of the respective total assets on debt issuance, thereby suggesting a vulnerable situation of those, under financial distress – more specifically, highly leveraged, with difficulties in complying with their financial commitments and risky for lending to or investing in, given a considerable default risk. This, hence, potentially represents a hurdle to the perspectives for their future growth and competitiveness in the markets which they are inserted in.

Furthermore, between 2006 and 2019, the substantial annual growth rates for Portuguese firm-specific $TFP_{\mathbf{OLS}\text{-based}}$ and $TFP_{\mathbf{W}\text{-based}}$ indicate, on average, that the fraction of companies' output which is not explained by the inputs employed in the respective production processes roughly doubled from years $t-1$ to t over this period, which may, in effect, suggest that the efficiency in the combination of productive factors in those was being incremented throughout time, notwithstanding the respective particularly high standard deviation.

On average, each observed firm ages 10 years and employs 6 workers, which reflects the non-sustainable/volatile nature of the respective growth and the pattern of corporate size distribution in Portugal, with the majority of the observed Portuguese firms consisting of micro (which account for 88.32% of total firms), followed by small entities (Table 2)[9].

Variables		Mean	Std. dev.	p25	p50	p75
economic rate of depreciation	decimals	0.017	0.069	0.001	0.008	0.025
EMTR, at the:		–	–	–	–	–
– standard CIT rate		-0.343	0.370	-0.474	-0.257	-0.088
– CIT rate for SMEs		-0.370	0.360	-0.488	-0.257	-0.133
size-based CIT incentive		0.026	0.030	0.000	0.045	0.051
innovation		0.014	0.099	0.000	0.000	0.000
regulation		0.161	0.042	0.148	0.161	0.193
incent_it		0.000	0.020	0.000	0.000	0.000
debt-to-assets		181.1	59907.4	0.382	0.745	1.026
growth rate of $TFP_{\mathbf{OLS}\text{-based}}$	%	94.95	36112.47	-13.9	-0.671	14.129
growth rate of $TFP_{\mathbf{W}\text{-based}}$	%	134.26	49950.71	-14.1	0.41	17.24
value-added	€	197668	4222691	0.000	19985	73463
age	years	10.070	11.358	3.000	6.000	13.000
Proxy variables for firm size:	–	–	–	–	–	–
– net_turnover ("net sales and services rendered")	€	836784	20900000	9463	65925	229685

[9] See Appendix 1, page 31.

– number of (paid and unpaid) employees	units	6.969	82.056	1.000	2.000	4.000
– total_assets	€	1655792	52600000	30455	105343	363110
– lagged value-added		207858	4380031	253	22505	78065

Table 1 – Descriptive statistics of the main variables of interest.
Source: BPLIM (Bank of Portugal)

4.3. Results

In the performed analysis, net turnover and number of firm employees (corresponding to the two statistical criteria which, in Portugal, are used to define firm dimension), as well as TFP and value-added [which is positively correlated with firm size (Tran, Grafton and Kompas 2009)], are considered as proxy variables for firm size – the dependent variable under analysis, in addition to firm total assets (Harford, Mansi and Maxwell 2008). The option for TFP owes to the fact that companies' productivity level is found to tend to increase in the respective size, according to Ruano (2002), quoted by Castany, López-Bazo and Moreno (2005). In short, it is expected that, if the obtained coefficients for the selected regressors are positive in each regression, such dependent variables[10] are expected, on average, to be positively impacted on by an increase in the latter, *ceteris paribus*.

Regarding net turnover and number of employees, a size-based CIT incentive exhibits somewhat conflictual results. Indeed, whilst it positively impacts on the first one, the respective effect on the second one is negative, that is, a unitary increase in this tax incentive (i.e., in the gap between standard and SME-targeted EMTRs) is predicted, on average, to induce a rise ($+8.8$ p.p.) in a non-large firm's net turnover and a reduction (-5.8 p.p.) in the respective number of employees, *ceteris paribus*, whereas its total assets almost double ($+91.7$ p.p.).[11] The negative effect on no. of employees could be justified under the assumption of firms

[10] The performed econometric analysis considers the logarithmic version of net turnover, number of employees, total assets and value-added.
[11] In all these three specifications, there is both global and individual (statistical) significance at $\alpha = 0.05$.

indeed becoming more productive, thereby requiring fewer units of labour, as a result of a hypothetical positive impact of size-based CIT incentive on their value-added (which is, however, not corroborated by the results for the estimation presented later on this dissertation).

On the other hand, in case the impact of a size-related CIT incentive on these three dependent variables takes into account whether the observed firm is located in the interior of Portugal or not (where the CIT rate for SMEs is reduced, 12.5%, for the initial € 25,000 of taxable profits, so as to attract businesses to those areas and, thus, economically foster them[12]), one can conclude that, for a company situated in the interior, the positive impact of size-based CIT incentive on net turnover and total assets is, in its magnitude, predicted, on average, to shrink (by 3.4 p.p. and 73 p.p., respectively), relative to an enterprise operating in other districts. Conversely, the negative effect yielded by size-based CIT incentive on a particular firm's number of employees is expected to slightly be enhanced by 2.54 p.p., in the case of a corporation installed in the interior, *ceteris paribus*.[13]

For each additional age year of a firm, a unitary increase in size-based CIT incentive is predicted, on average, to slightly slow down the growth of the respective net turnover, while amplifying the reduction in its number of employees and total assets (by -4.3 p.p. and -2.38 p.p., respectively), being that, under this regression specification (including the interaction term $incent\_age$), such an incentive also negatively impacts on total assets (besides on the number of employees, as previously mentioned), which translates into the less young firms responding less positively/more negatively to the preferential tax scheme under analysis.[14]

Furthermore, the positive impact of size-based CIT incentive on net turnover and total assets is expected to be particularly strengthened ($+87.7$ p.p. and $+109.6$ p.p., respectively),

[12] Namely, Beja, Bragança, Castelo Branco, Évora, Guarda, Portalegre, Vila Real, and Viseu.
[13] Respecting $incent\_district$, the corresponding estimate is only statistically significant, at $\alpha = 0.05$, when considering $\ln total\_assets$ as dependent variable.
[14] The coefficient for $incent\_age$ is solely statistically significant, at $\alpha = 0.05$, when assuming $\ln no\_employees$ as the dependent variable.

in the case of a firm inserted in the manufacturing industry, being that the respective initially negative effect on the number of employees now becomes positive ($+29.1$ p.p. $= -9.6 + 38.7 \times 1$), which reveals that belonging to this economic industry promotes the effectiveness of such incentives, relative to operating in other sectors.[15] (Output 1[16]).

From a complementary perspective, departing from the estimation of the model $Y_{it} = \beta \text{size-based CIT incentive}_{it} + \delta firm\_turnover_i PMR_t + \gamma X_{it} + \alpha_t + \alpha_i + \varepsilon_{it}$ (13), one can conclude that the size-based CIT incentive is characterised by a slightly negative impact on Portuguese firms' TFP, which holds under all the three selected estimation methods, $TFP_{\textbf{OLS}\text{-based}}$, $TFP_{\textbf{W}\text{-based}}$ and $TFP_{\textbf{index}\text{-based}}$ (which predictably decline by 1.2 p.p., 4.4 p.p. and 3.56 p.p., respectively, as a result of a unitary rise in the tax incentive), as well as on the respective gross value-added (which is found to drop by 3.87 p.p.), *ceteris paribus*.

In parallel to the previously studied effects, it is additionally relevant to briefly examine the information provided by the established control variables in this second model, in order to infer the factors that characterise the Portuguese firms and could, thus, influence the respective response behaviour in the presence of unitary increases in size-based CIT incentive.

Indeed, an expansion in a particular Portuguese firm's innovation activity (represented by $innovation$) presents a negative contribution to firms' TFP [except on $TFP_{\textbf{index}\text{-based}}$ ($+0.82$ p.p.)] and to value-added, whilst, in what concerns $size$, one can conclude that the corporate dimension exerts a nearly null, albeit positive effect on $TFP_{\textbf{OLS}\text{-based}}$, $TFP_{\textbf{W}\text{-based}}$ and $TFP_{\textbf{index}\text{-based}}$, as well as on gross value-added. In fact, these results may translate into Portuguese firms not accomplishing to operate under scale economies (and, thus, to benefit from the cost-efficiency that the latter would render viable and that would potentiate the

[15] For $incent\_industry$, there is individual (statistical) significance in all these three specifications.
[16] See Appendix 1, page 31.

expansion of firms' production), namely taking into consideration that the Portuguese universe of companies is, namely, composed of micro- and SMEs.

Regarding debt-to-assets ratio, it is verified a nearly null impact of it on the different TFP measures and gross value-added, yet with a positive sign (which could result from possible substantial investments on efficiency enhancement undertaken by firms – a hypothetical explanation, however, not investigated within the scope of this dissertation), while the covariate $regulation$, on the other hand, displays, *ceteris paribus*, a negative impact on all the considered dependent variables [that is, the less market competition-favourable the regulatory framework is at each t, the less productive firms tend to be, namely in the years in which they are relatively more exposed to the repercussions of such policies (i.e., their turnover is higher – with more firm entries and exits being recorded – and, since those entrants typically present a small dimension, the regulatory costs they incur tend to be higher)], excluding on $TFP_{\text{OLS-based}}$ ($+10$ p.p.), which could, in this case, owe to the fact that a more intense market competition (this time, assuming a fall in the Product Market Regulation index and, on the other hand, a rise in firm turnover) leads incumbent companies to seek to become more efficient (in order to preserve the respective market power), or, alternatively, to the fact that the less efficient ones leave the markets, as relatively in light of Anderton, Lupidio and Jarmulska (2019).

Respecting firm age, one can, by and large, infer that it negatively contributes to TFP measures, that is, the older a particular company is, the more negative a variation in the respective TFP tends to be, which could possibly stem from that the likely more efficient technologies of production employed in the more recent corporations (as a result of a more intense incorporation of skilled labour, innovation, knowledge and technical progress, as time elapses) outweigh the experience accumulated by the older firms (in what respects optimal decisions about resource allocation) over the respective life, which may become obsolete.

At this point, a possible limitation faced by the statistical inference from size-based CIT incentive lies on the respective statistical non-significance in all the analysed regression specifications for TFP and value-added, which, therefore, suggests a cautious coefficient interpretation and policy evaluation. In contrast, the regressors $size$ and $age\_5/10/15/20$ reveal to be statistically significant across those.

From the standpoint of time dummies, given $t \in [2006,2019]$, indeed, the shock associated with the 2008 economic crisis marked a transition period, in terms of the economic context present in each year, insofar as, from 2010/2011 on, firms' TFP ($TFP_{\textbf{OLS}\text{-based}}$ and $TFP_{\textbf{W}\text{-based}}$) and value-added were subject to an annual negative impact, which exacerbated until 2013, after when this pattern gradually started to invert itself.

This evolution just reflects the economic cycle (among recessive and expansion phases), taking into account the 2007 financial crisis (emerged in the United States, departing from the subprime market and with the collapse of the highly leveraged financial sector), which generated, in 2008, an economic and, subsequently, sovereign debt crisis in the euro area, leading firms of vulnerable economies to face a particularly adverse financial context.

In Portugal, in the aftermath of such an economic recession, when the respective GDP resumed its growth trend, it is possible to conclude, based on the results obtained in the performed regressions, that the negative effects on firms' TFP and value-added may have elicited a 'hysteresis' – shock which lasts beyond the period when the initial disturbance event occurred (Output 2[17]).

Regarding the core fixed effects regression model previously developed, the $corr(u_i, X_b)$ is, overall, considerably low and even negative, thereby supporting the option adopted in this dissertation of resorting to the fixed-effects estimator, insofar as it denotes a correlation between regressors and fixed effects.

[17] See Appendix 1, page 32.

Additionally, the very substantial values obtained for $rho = \frac{\sigma_u^2}{\sigma_u^2+\sigma_\varepsilon^2}$ (where ε denotes the annual variance) mean that a particularly appreciable share (given by rho) of the unexplained error term variance owes to the firm-level fixed effects, with a considerable set of regression specifications presenting a rho higher than 80%.

In conclusion, the values for R^2 (measure of goodness of fit) obtained in the performed estimations are relatively low ($< 5\%$), which means that models in question capture a small fraction of the variance in dependent variables (that is, the explanatory variables poorly reflect differences/fluctuations in the latter), between firms ("between R^2") and within each firm, over time ("within R^2").

4.4. Robustness checks

The implementation of two different regression specifications for each of the dependent variables $\ln TFP_{\text{OLS-based}}$, $\ln TFP_{\text{W-based}}$ and $\ln TFP_{\text{index-based}}$, including, or not, the interaction term $incent\_it$, allows for performing a robustness test, which consists of comparing the conclusions drawn from the coefficients for the critical core variables (specifically, the size-based CIT incentive), prior and after having been added the regressor $incent\_it$, aiming to check whether they hold.

Indeed, in case $incent\_it$ is included in all the aforementioned regression specifications, it is observed that the negative impulse of a size-based CIT incentive [when this is set to take into consideration (in its value) the heterogenous level of investment in innovation undertaken by each firm, thereby seeking to privilege the potentially more economically efficient ones] on $TFP_{\text{OLS-based}}$ and $TFP_{\text{W-based}}$ turns out to be slightly exacerbated (-7.04 p.p. $= -0.0141$-*0.0563* and -12.13 p.p. $= -0.0469$-*0.0744*, respectively, for an 1 p.p. increase in $innovation$).

Conversely, the negative impact of size-based CIT incentive on $TFP_{\text{index-based}}$ becomes positive, in aggregate terms, as the level of a particular firm's innovation activity grows, that is,

on average, a unitary increase in such an incentive predictably expands it by 1.65 p.p. ($= -0.0338 + 0.0503$), *ceteris paribus*, relative to a conventional size-related CIT incentive. The latter inference reveals a convergence with Benedek, et al. (2017), who reported a relatively higher effectiveness of CIT incentives whose value depends on firm innovation.

Thus, it can be concluded that both specifications prove to be robust, that is, structurally valid/plausible. Thus, the performed causal inference suggests to be valid, insofar as, in all the three cases described above, the coefficients of all independent variables reveal not to be elastic to the added predictor $incent\_it$, remaining, approximately, constant (Output 2[18]).

5. Concluding remarks

Arrived at this point, it reveals relevant to recall the question that constitutes this work project's title: "Size-based corporate tax incentives: a way up or a lock-up?". Indeed, the answer to it reveals non-conclusive, within the scope of the Portuguese firms' size, according to the empirical strategy carried out.

As a matter of fact, from this econometric study, size-based CIT incentives are predicted, on average, to positively impact on a firm's net turnover, but negatively on the respective number of employees. On the other hand, the effectiveness of size-based CIT incentives tends to decline in firm age and for companies situated in the interior districts (considering net turnover, while its harmful impact on number of employees is exacerbated, in the first case, and enhanced in the second one), but to improve in the manufacturing industry (for which the responses of both firm-size official defining criteria converge, being that also the number of employees displays an increase).

On the other hand, size-based CIT incentives, in Portugal, are found to (slightly) negatively influence firms' TFP, in line with the conclusions drawn by Benedek, et al. (2017) for Belgium,

[18] See Appendix 1, page 32.

France, Spain, and the United Kingdom. Furthermore, the obtained negative EMTRs for firms allow one to conclude that the Portuguese tax system's design appears to signal a potentially encouraging effect on those.

As policy implications, aiming to support the process of transition of SME status to firms with a higher dimension, in Portugal, there could be replaced the design of the current size-based CIT incentive for one that is time-limited and considers, in its determination, necessary conditions other than the two official size-based firm defining criteria, namely the respective TFP, value-added and R&D/innovation intensity, thereby making the size-based criteria a non-sufficient condition for accessing it, discriminating SMEs according to their heterogeneous characteristics and, indeed, targeting at the most efficient ones.

The main limitations underlying to this work project consist of the statistical non-significance of the coefficients for size-based CIT incentive for TFP, as well as the fact that the production functions (based on which the values for each firm's ln TFP have been obtained) are not specified for each 2-digits *CAE*, which could result in a lower economic explanatory power of it, notwithstanding the individual and global significance in those estimated through OLS and Wooldridge (2009) (p-values $= 0$) and a substantial R-squared ($R^2 = 0.7446$).

For future research, it would be relevant to examine whether the phenomenon of corporate bunching (clustering) occurs in Portugal, which describes a particularly higher density of firm distribution just below the levels of net turnover and employees at which companies transition out of the SME category, and which likely suggests a negative impact on firm growth originated by preferential tax schemes.

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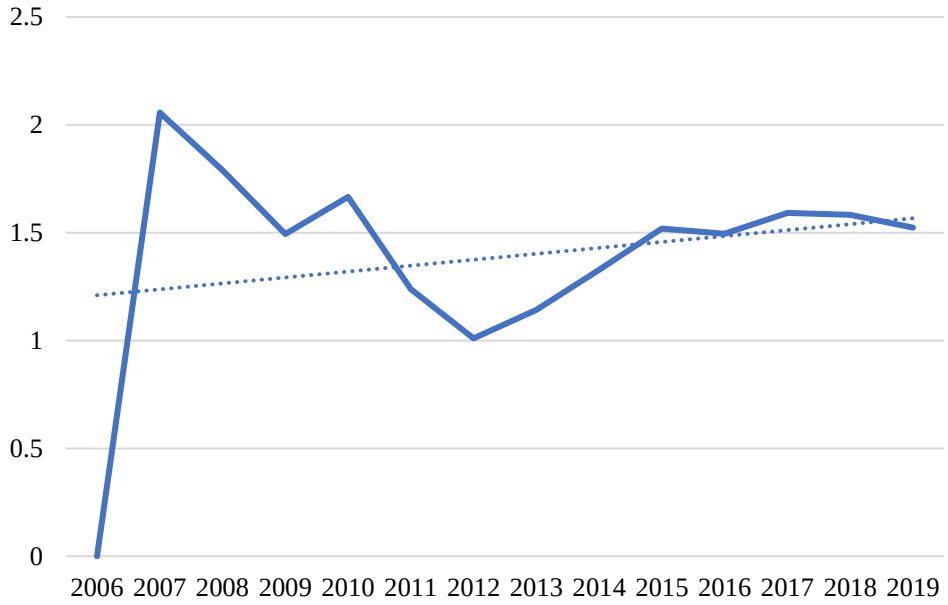
Appendix 1



Graph 1 – Share of growing firms (from $t-1$ to t), expressed in % of total firms, in Portugal, between 2006 and 2019.
Source: BPLIM (Bank of Portugal).

Category of firm size	Share of total firms
Micro	88.32%
Small	9.87%
Medium	1.55%
Large	0.26%

Table 2 – Firm size distribution in Portugal, between 2006 and 2019.
Source: BPLIM (Bank of Portugal).

VARIABLES	ln *net_turnover*	ln *no_employees*	ln *total_assets*	ln *net_turnover*
size-based CIT incentive	0.0881***	-0.0582***	0.917***	0.101***
	(0.0333)	(0.0204)	(0.227)	(0.0324)
incent_district	_	_	_	-0.0339
				(0.0630)
Constant	11.89***	1.308***	12.04***	11.89***
	(0.000868)	(0.000531)	(0.00598)	(0.000764)
Observations	3,158,632	3,029,921	3,486,703	3,158,367
R-squared	0.000	0.000	0.003	0.000

VARIABLES	ln *net_turnover*	ln *net_turnover*	ln *no_employees*	ln *no_employees*
size-based CIT incentive	0.704	0.00381	-0.0681***	-0.303
	(2.687)	(0.0221)	(0.0210)	(0.399)

incent_district	_	_	0.0254 (0.0361)	_
incent_age	-0.0185 (0.110)	_	_	-0.0434** (0.0219)
incent_industry	_	0.877*** (0.0812)	_	_
Constant	10.09*** (0.0537)	11.89*** (0.000566)	1.308*** (0.000489)	0.687*** (0.00746)
Observations	8,468	3,158,541	3,029,652	10,206
R-squared	0.000	0.000	0.000	0.007

VARIABLES	ln $no\_employees$	ln $total\_assets$	ln $total\_assets$	ln $total\_assets$
size-based CIT incentive	-0.0960*** (0.0326)	1.178*** (0.0246)	-1.394*** (0.214)	0.813*** (0.220)
incent_district	_	-0.727** (0.282)	_	_
incent_age	_	_	-0.0238* (0.0137)	_
incent_industry	0.387*** (0.0640)	_	_	1.096*** (0.225)
Constant	1.308*** (0.000766)	12.03*** (0.00106)	10.83*** (0.00446)	12.04*** (0.00513)
Observations	3,029,823	3,486,431	34,900	3,486,572
R-squared	0.000	0.003	0.018	0.003

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Output 1 – Fixed-effects estimation of ln $net\_turnover$, ln $no\_employees$ and ln $total\_assets$ (with and without the interaction terms $incent\_district$, $incent\_age$ and $incent\_industry$). Source: BPLIM (Bank of Portugal).

VARIABLES	ln $TFP_{\mathbf{OLS}}$-based	ln $TFP_{\mathbf{OLS}}$-based (with $incent\_it$; used as robustness checks)	ln $TFP_{\mathbf{W}}$-based	ln $TFP_{\mathbf{W}}$-based (with $incent\_it$, used as robustness checks)
size-based CIT incentive	-0.0122 (0.0183)	-0.0141 (0.0200)	-0.0444 (0.0461)	-0.0469 (0.0485)
incent_it	_	-0.0563*** (0.0156)	_	-0.0744*** (0.0193)
debt_assets	1.76e-08*** (3.14e-09)	1.76e-08*** (3.15e-09)	1.63e-08 (1.16e-08)	1.63e-08 (1.16e-08)
innovation	-0.155*** (0.0168)	-0.163*** (0.0141)	-0.197*** (0.0219)	-0.208*** (0.0185)
size	3.74e-09*** (7.53e-10)	3.74e-09*** (7.53e-10)	1.01e-08*** (1.94e-09)	1.01e-08*** (1.94e-09)
regulation	0.100***	0.100***	-0.209***	-0.209***

	(0.0130)	(0.0130)	(0.0151)	(0.0151)
age_2	-0.177***	-0.177***	-0.708***	-0.708***
	(0.0317)	(0.0317)	(0.0391)	(0.0391)
age_5	-0.182***	-0.182***	-0.757***	-0.757***
	(0.0247)	(0.0247)	(0.0314)	(0.0314)
age_10	-0.222***	-0.222***	-0.716***	-0.716***
	(0.0334)	(0.0334)	(0.0402)	(0.0402)
age_15	-0.209***	-0.209***	-0.752***	-0.752***
	(0.0365)	(0.0365)	(0.0461)	(0.0461)
age_20	-0.332***	-0.332***	-0.812***	-0.812***
	(0.0293)	(0.0293)	(0.0379)	(0.0379)
o.y2006	–	–	–	–
y2007	0.135***	0.135***	0.180***	0.180***
	(0.00281)	(0.00286)	(0.00421)	(0.00431)
y2008	0.0998***	0.0996***	0.124***	0.124***
	(0.00241)	(0.00246)	(0.00376)	(0.00386)
y2009	0.0695***	0.0693***	0.0373***	0.0371***
	(0.00218)	(0.00223)	(0.00349)	(0.00359)
y2010	0.0476***	0.0474***	0.0400***	0.0398***
	(0.00209)	(0.00214)	(0.00341)	(0.00351)
y2011	-0.00572**	-0.00587**	-0.0360***	-0.0362***
	(0.00226)	(0.00231)	(0.00359)	(0.00370)
y2012	-0.0424***	-0.0425***	-0.118***	-0.118***
	(0.00218)	(0.00223)	(0.00350)	(0.00361)
y2013	-0.0183***	-0.0185***	-0.117***	-0.117***
	(0.00190)	(0.00195)	(0.00319)	(0.00329)
y2014	0.000751	0.000796	-0.0885***	-0.0884***
	(0.00150)	(0.00150)	(0.00184)	(0.00185)
y2015	0.00745***	0.00744***	-0.0662***	-0.0662***
	(0.00143)	(0.00143)	(0.00172)	(0.00172)
y2016	0.00201	0.00200	-0.0569***	-0.0569***
	(0.00127)	(0.00127)	(0.00150)	(0.00151)
y2017	0.0109***	0.0109***	-0.0122***	-0.0122***
	(0.00114)	(0.00114)	(0.00130)	(0.00130)
o.y2018	–	–	–	–
o.y2019	–	–	–	–
Constant	-0.0195***	-0.0193***	6.764***	6.764***
	(0.00173)	(0.00175)	(0.00273)	(0.00279)
Observations	2,646,590	2,646,590	2,647,919	2,647,919
R-squared	0.010	0.010	0.026	0.026

VARIABLES	$\ln TFP_{\textbf{index}\text{-based}}$	$\ln TFP_{\textbf{index}\text{-based}}$ (with $incent\_it$, used as robustness checks)	$\ln valueadded$
size-based CIT inc.	-0.0356	-0.0338	-0.0387
	(0.0319)	(0.0302)	(0.0401)

incent_it	_	0.0503** (0.0220)	_
debt_assets	1.87e-07*** (3.14e-08)	1.87e-07*** (3.14e-08)	1.05e-06*** (1.33e-08)
innovation	0.00823 (0.0286)	0.0166 (0.0313)	-0.232*** (0.0252)
size	3.63e-09*** (1.10e-09)	3.63e-09*** (1.10e-09)	1.84e-08*** (3.52e-09)
regulation	-0.0284 (0.0587)	-0.0285 (0.0587)	-0.829*** (0.0197)
age_2	-0.0822** (0.0356)	-0.0822** (0.0356)	-0.888*** (0.0569)
age_5	-0.173*** (0.0295)	-0.173*** (0.0295)	-1.064*** (0.0504)
age_10	-0.223*** (0.0366)	-0.223*** (0.0366)	-0.966*** (0.0549)
age_15	-0.176*** (0.0464)	-0.176*** (0.0464)	-1.090*** (0.0686)
age_20	-0.267*** (0.0393)	-0.267*** (0.0393)	-1.104*** (0.0544)
o.y2006	_	_	_
y2007	0.0356*** (0.0105)	0.0358*** (0.0104)	0.174*** (0.00490)
y2008	0.0463*** (0.00855)	0.0464*** (0.00853)	0.0954*** (0.00432)
y2009	0.0781*** (0.00736)	0.0783*** (0.00734)	0.00957** (0.00395)
y2010	0.0104 (0.00712)	0.0106 (0.00710)	-0.0227*** (0.00378)
y2011	0.103*** (0.00814)	0.104*** (0.00812)	-0.118*** (0.00400)
y2012	0.0870*** (0.00772)	0.0871*** (0.00770)	-0.287*** (0.00387)
y2013	0.0257*** (0.00641)	0.0258*** (0.00638)	-0.322*** (0.00345)
y2014	0.0350*** (0.00580)	0.0349*** (0.00580)	-0.286*** (0.00247)
y2015	0.0452*** (0.00579)	0.0452*** (0.00579)	-0.203*** (0.00227)
y2016	0.0232*** (0.00537)	0.0232*** (0.00537)	-0.149*** (0.00199)
y2017	0.0248*** (0.00531)	0.0247*** (0.00531)	-0.0517*** (0.00178)
o.y2018	_	_	_
o.y2019	_	_	_

Constant	0.423*** (0.00620)	0.422*** (0.00619)	11.15*** (0.00328)
Observations	2,036,582	2,036,582	2,666,757
R-squared	0.001	0.001	0.046

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Output 2 – Fixed-effects estimation of $\ln TFP_{\mathbf{OLS}}$-based, $\ln TFP_{\mathbf{W}}$-based and $\ln TFP_{\mathbf{index}}$-based (with and without $incent\_it$, for robustness checks effects), and $\ln valueadded$.
Source: BPLIM (Bank of Portugal).

VARIABLES	ln_y	
	estimated through *OLS*	estimated through *Wooldridge (2009)*
ln_k	0.0361*** (0.000276)	0.0752*** (0.000609)
ln_l	0.400*** (0.000642)	0.435*** (0.000701)
ln_m	0.563*** (0.000570)	–
Constant	1.462*** (0.00402)	–
Observations	3,415,135	2,827,875
R-squared	0.745	527,250

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: From the Wooldridge (2009) production function estimation, one can observe that labour corresponds to the production factor that contributes most to output, whereas, by OLS, intermediate inputs are those whose participation is larger. Both OLS and Wooldridge (2009) yield statistically global and individual significance.

Output 3 – Production function estimation through OLS and Wooldridge (2009).
Source: BPLIM (Bank of Portugal).

Appendix 2

Wooldridge (2009) assumes the production function $\ln y_{it} = \alpha + \beta \ln l_{it} + \gamma \ln k_{it} + f\left[g\left(\ln k_{i,t-1}, \ln m_{i,t-1}\right)\right] + a_{it} + e_{it}$, t=1,...,T, where v_{it} and e_{it}, respectively, denote the TFP $[= v_{it} = \boldsymbol{g}(\mathbf{ln}\, \boldsymbol{k_{it}}, \mathbf{ln}\, \boldsymbol{m_{it}})]$ and a sequence of shocks mean-conditionally independent of previous and current inputs, such that $E\left(e_{it} \middle| \ln l_{it}, \ln k_{it}, \ln m_{it}, \ln l_{i,t-1}, \ln k_{i,t-1}, \ln m_{i,t-1}, \ldots, \ln l_{i1}, \ln k_{i1}, \ln m_{i1}\right) = 0 \Rightarrow$

$E(\ln y_{it} \mid \ln l_{it}, \ln k_{it}, \ln m_{it}) = \beta \ln l_{it} + \underset{[= h(\ln k_{it}, \ln m_{it})]}{\alpha + \gamma \ln k_{it} + \boldsymbol{g}(\mathbf{ln}\, \boldsymbol{k_{it}}, \mathbf{ln}\, \boldsymbol{m_{it}})}$. To identify/estimate β and γ, $\boldsymbol{g}(\mathbf{ln}\, \boldsymbol{k_{it}}, \mathbf{ln}\, \boldsymbol{m_{it}})$ contains all polynomials of order $n = 3$, such that $g(\ln k_{it}, \ln m_{it}) = \lambda_0 + \lambda \underset{(a\ vector\ of\ functions)}{c(\ln k_{it}, \ln m_{it})}$.

The TFP (v_{it})'s dynamics are, then, restricted to a 1st Markov chain process, $E(v_{it}|v_{i,t-1}, \dots, v_{i1}) = E(v_{it}|\ln k_{it}, \ln l_{i,t-1} \ln k_{i,t-1}, \ln m_{i,t-1}, \dots, \ln l_{i1}, \ln k_{i1}, \ln m_{i1}) =$ $E(v_{it}|v_{i,t-1}) = f\left[\underset{(= v_{i,t-1})}{g(\ln k_{i,t-1}, \ln m_{i,t-1})}\right]$, t=2,3,...,T, that is, v_{it} is an unknown function, $f(.)$ (as it is also $g(.)$), of its lagged value – in which $f(.)$ is approximated by a polynomial in v, $f(v) = \rho_0 + \rho_1 v + \cdots + \rho_3 v^3$ – and of proxy [intermediate inputs, thereby adopting the Levinsohn and Petrin (2003) approach], free (labour) and state (capital) variables. An additional orthogonality condition assumed corresponds to $E(u_{it}|\ln k_{it}, \ln l_{i,t-1} \ln k_{i,t-1}, \ln m_{i,t-1}, \dots, \ln l_{i1}, \ln k_{i1}, \ln m_{i1}) = 0$, t=2,...,T, where $u_{it} \equiv a_{it} + e_{it}$. Furthermore, $\ln k_{it}$ and a_{it} are uncorrelated with the innovation $a_{it} \equiv v_{it} - E(v_{it}|v_{i,t-1})$ and $(\ln k_{i,t-1}, \ln m_{i,t-1})$, respectively, thereby ensuring consistency.

Thus, the initial production function becomes $\ln y_{it} = \alpha + \beta \ln l_{it} + \gamma \ln k_{it} + \rho_1(\lambda c_{i,t-1}) + \cdots + \rho_3(\lambda c_{i,t-1})^3 + u_{it}$, t=2,...,T, whose residual function is given by $r_{it}(\theta) = \begin{pmatrix} r_{it1}(\theta) \\ r_{it2}(\theta) \end{pmatrix} = \begin{pmatrix} \ln y_{it} - \alpha - \beta \ln l_{it} - \gamma \ln k_{it} - \lambda c_{it} \\ \ln y_{it} - \alpha - \beta \ln l_{it} - \gamma \ln k_{it} - \rho_1(\lambda c_{i,t-1}) - \cdots - \rho_3(\lambda c_{i,t-1})^3 \end{pmatrix}$, t=2,...,T, which, in turn, yields the moment conditions $E[Z_{it} r_{it}(\theta)] = 0$, with the instrumental variables $Z_{it} = \begin{cases} z_{it1} = (1, \ln l_{it}, \ln k_{it}, c_{it}) \\ z_{it2} = (1, \ln l_{i,t-1}, \ln k_{it}, c_{i,t-1}, q_{i,t-1}) \end{cases}$ (where $q_{i,t-1}$ represents nonlinear functions of $c_{i,t-1}$). In sum, this allows the production function's estimation to be held by means of the Generalized Method of Moments (GMM) (Wooldridge 2009).