DETERMINANTS OF PRODUCTIVITY IN THE QUATERNARY SECTOR

(WORKING PAPER)

AUTHORED BY:
PAULO MATOS
PEDRO NEVES

NEC CONNECTING ECONOMICS

- JUNE 2019 -

In partnership with:
Gabinete de Estratégia e Estudos
MINISTÉRIO DA ECONOMIA

Nova Economics Club is the Economics club at Nova School of Busines and Economics. Since 2012, its focus is to create a bridge between the theory learnt in classes with the work performed by economists on a daily basis.

e-mail: novaeconomicsclub@novasbe.pt
website: www.novaseconomicsclub.pt

Title: *Determinants of Productivity in the Quaternary Sector*
Authors: *Paulo Matos, Pedro Neves*
Partner: GEE - Gabinete de Estratégia e Estudos do Ministério da Economia
Date: *June 2019*

Contents

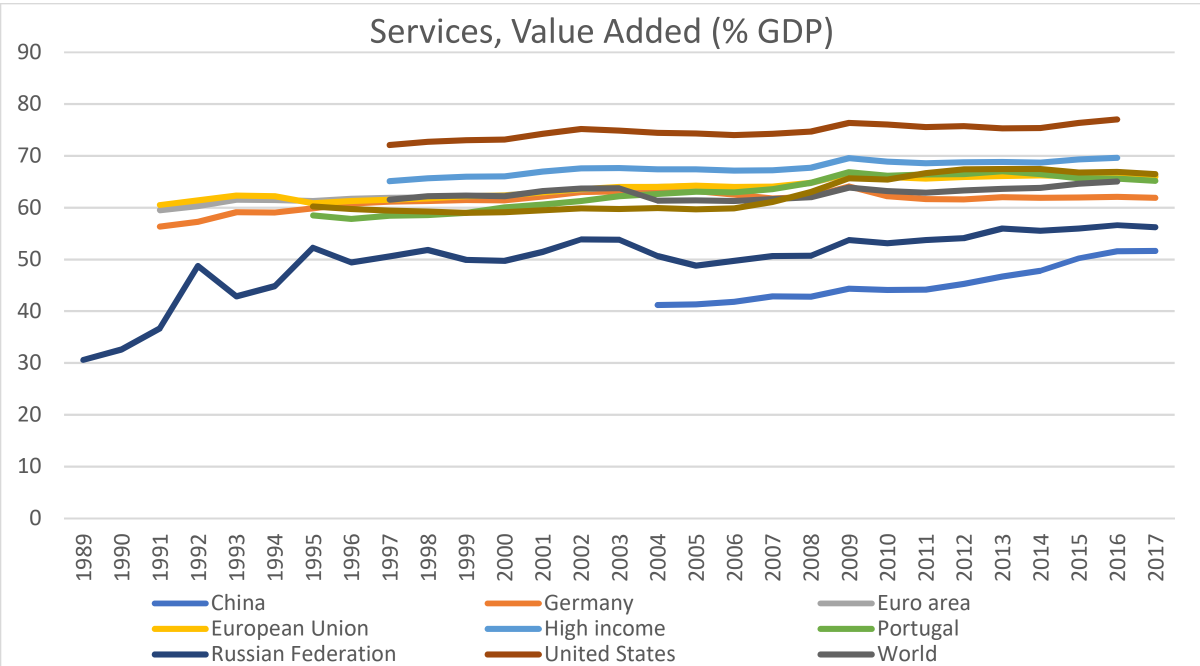
1. Motivation

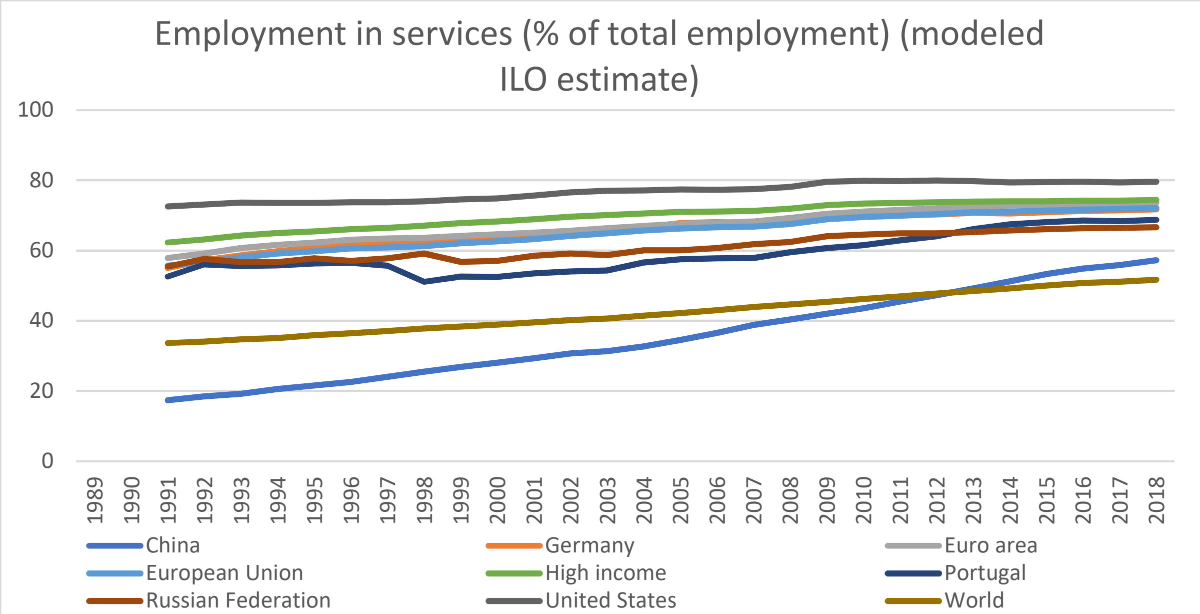
We can date back to the 17th and 18th centuries, to Sir William Petty and Francois Quenay, the first attempts at dividing economic sectors, its within relations and evaluating the impact of shifts among economic sectors. It is important to separate an economy into sectors to have more in-depth insights and logical comparisons across and within sectors. Ever since, we have often used Colin Clark and Jean Fourastié's separation into three sectors, which be generally described as:

- Primary Sector: extraction and/or modification of raw materials;
- Secondary Sector: transformation of raw materials into consumption products or industrial machinery;
- Tertiary Sector: Goods' retailing and Services providing.

But for the sectorial study, we should make sure that they "are sufficiently different from each other to permit their separation and comparative analysis" and "that the overall growth rate and the efficiency performance of the economy are influenced by changes in the relative importance, contribution, and input-output relationships of these … main sectors." (Kenessey, 1987).

Just by looking at data from the worldbank we can see the consistent growth of the share of GDP services take on the 20th century. Out of the sample we considered, we can see that the trend is steeper on developing countries rather than in developed countries (in which the upwards trend actually looks to be stabilizing). This trend is also noticeable in employment in services as percentage of total employment.





More recently economists point to a new sectorial division, in which a Quaternary Sector (Knowledge Oriented Economies) should be included. Kenessey shows a higher growth of the Quaternary Sector from 1947 to 1985, thus indicating we should be considering the Quaternary Sector separately.

Productivity is a crucial component to output creation. This variable is not entirely explained by the combination of intermediate inputs, labour and capital. The remainder share of output is explained by a residual said to be a measurement of technical efficiency. Such measure corresponds to the Total Factor Productivity, an indicator that accounts for differences in cross-firm and cross-country analysis. As argued in Branco and Domingues (2018), when studying TFP a sectoral approach is convenient, as it consists on an analysis of a residual over time. Considering these authors work on the services sector and the work of Gonçalves et al (2016) on the manufacturing sector; this paper will focus on the quaternary sector to complement the analysis of the Portuguese economy. The main objective consists in analysing what are the main determinants of the TFP of the mentioned industry; to what extent they impact firms' productivity; and what conclusions and policy recommendations that should firms consider to boost their performances.

2. Literature Review

2.1. Definition of the Quaternary Sector

The constant technological innovations that our world has been subject to have a strong impact on all industries, enabling the appearance of new market opportunities, services and overall consumer necessities. This way, a fourth sector, the quaternary one, is said to be emerging in economic activity in the last decades, based on the creation of value through the application of scientific/technical knowledge. It was founded on the base of the technological boost of the 70´s, it is led by developed countries and big companies. As such, not only is research and capital intensive, but it uses a high share of skilled labour when compared to other industries.

A conceptual pillar of this work relies on the technical definition of the Quaternary Sector, and this raises a big challenge of ours. The Quaternary Sector has been given little attention, with economists more often studying the Services Sector as a whole, or by studying sub-sectors within the

Quaternary alone. Gottmann (1961) includes in the Quaternary Sector “services that require research, analysis, judgement, in brief, brainwork and responsibility”. Abler, Adams and Gould (1977) rather call the sector information activities, and explicitly exclude public administration from it. Selstad (1990) includes in it specifically R&D, Higher education and consultancy. Kenessey (1987) using the SIC economic activity codes includes Finance, insurance and real estate, Services and Public Administration Major Groups. Křístková (2012) defines the quaternary sector including “education, health care, research and development and governmental service”, thus excluding consultancy and including the government activities. Turečková (2015) using NACE’s Economic Activities codes Information and communication, Financial and insurance activities, Professional, scientific and technical activities, Administrative and support service activities, Education and Human health and social work activities. Kenessey (1987) also shows that the Quaternary Sector is sufficiently different from the remainder, and calls out to the need of studying it separately.
We have decided, similarly to Kenessey (1987), to show that the Quaternary Sector is sufficiently different from the remainder. But instead of showing this for a predefined sectorial aggregation, we decided to study separately per CAE 2-digit code, and constructing our Quaternary Sector.

The four criteria used in Zeoltan Kenessey (1987) are:

- Sectorial Share in GDP growth
- Employment Share growth
- Input-Output Relations Among the Four Sectors
- Value Added and Intermediate Inputs Share

Zeoltan Kenessey (1987) argues the rise of the Quaternary Sector was in the 1970’s, and as such with our dataset it will be impossible to show the sharp increase observed on the Sectorial and Employment Share growth. Thus, although computing all criteria with the available data, our conclusions should focus the latter two.

2.2. Determinants of Productivity on the Quaternary Sector

Literature on productivity is vast. However, most of the studies regarding its components are focused on the manufacturing and services sector. The main reason being that the quaternary sector emerged recently and there are some not consensual doubts regarding the type of firms it includes. The main determinants of TFP ought to remain relevant independently from the studied sector, as the impact of each determinant is expected to vary according to the industry.

2.2.1. Knowledge Creation

Innovation activities are said to be one of the main determinants of productivity growth. Neoclassical models used to account for productivity as an exogenous variable, determined outside of the model (Solow, 1957). More recently, modern economic growth models (Romer, 1986, 1990) aim to explain technological development by accounting for knowledge creation as its main driver, enabling the possibility of perpetual economic growth.

Romer (1993) and Prescott (1998) argued that differences in technology among countries (partly explained by the knowledge component) explain inequalities in output growth between countries. As stated in Isaksson (2007), knowledge is not a measurable variable, as it must be accurately proxied by a quantifiable indicator. For instance, Hall (2011) uses R&D expenses and patent counts as measures for innovation activity. He argues that the former has the advantage of being denominated in a currency and “represents a (costly) decision variable on the part of the firm about its appropriate level of innovative activity". However, being an input variable to innovation, it tells nothing about innovation success. Patent counts, on the other hand, are said to be a measure of innovation output, partially linked to innovation success. Abdih and Joutz (2005) used time series data for the U.S to conclude on a long run relationship between TFP and the stock of knowledge, proxied by patent counts. Also, Guellec and van Pottelsberghe de la Potterie (2001) studied the impact of R&D on TPF growth with three different measures of R&D for the purpose: foreign sourced R&D, domestic business research and public research, all of which successfully explained TFP growth with foreign research having the most notable effect. Pianta and Vaona (2007) and Hall (2011) stressed the importance of product and process innovation on productivity, finding that product innovation has a substantial impact on TFP while process innovation impact is ambiguous. Other literature suggests ICT investment as a proxy for Innovation and as a crucial component for productivity growth. Spiezia (2012) studied the impact of three different categories of ICT investment – computer, software and communication- in 18 different OECD countries during 1995 to 2007, across 26 industries. He found an heterogeneous effect of these three components across countries but an overall contribution to their productivity levels. Seo and Lee (2006) also analysed the relationship between ICT investment and the evolution of productivity growth path. Apart from the positive contribution to TFP growth, they pointed to the existence of ICT externalities (knowledge spillovers) towards developing countries.

2.2.2. Trade Openess

Trade openness and easiness is also seen as a crucial determinant of productivity growth, mainly as it is considered as mean of exchange of knowledge. Coe and Helpman (1995) and Coe et al (1997) promote trade as a measure of technological transfer. According to these authors, productivity patterns ought to increase if firms import from countries that have strong stocks of knowledge and advanced technology. Isaksson (2007) highlights the contribution of Mayer (2001) work to Coe et al (1997) approach, by combining it with the human capital factor. According to the author, this component is vital, as qualified labour ensures the implementation of foreign technology. Topalova and Khandelwal (2011) exploited the 1991 liberalization episode in India - massive reduction of tariffs on inputs and final goods - to determine the effects of trade reform on firm's productivity. They found that this reform had a positive contribution to productivity. Not only lower tariffs on final products caused firms to be more efficiency, but also the fact that the reduction on inputs tariffs leaded to a raise on its imports, enabling firms to access cheaper and more sophisticated inputs. Similar results regarding trade liberalization and firms TFP are concluded in Nkijam and Cockburn (2011), with evidence from Cameroon. Also, some authors argue about the existence of learn-by-exporting effects, i.e firms become more productive by their participation in the exports market, due to the gains they have by getting access to new knowledge and resources (Arvas and Uyar, 2014; Fernandes and Isgut, 2008).

2.2.3. Human Capital and Training

The adoption of advanced technology and knowledge; being it through investment in R&D and ICT, or by the adoption of foreign skills; is highlighted in the literature as being one of the most important determinants of productivity growth. However, skilled human capital is essential for the embracement of such elements. Romer (1990) defends the importance of skilled labour as a crucial determinant of innovation and implementation of foreign technology. Jajri (2007) analyses the TFP of Malaysia during 1971-2004 and argues regarding its determinants. He finds that the number of skilled workers highly contributes to productivity by managing to operate sophisticated technology and knowledge. Such results are in line with Fernandes (2008). While neoclassical models tended to account for the accumulation of physical capital, more recent models already account for human capital and knowledge accumulation to explain differences between countries (Jones 2008). Fuente (2011); even pointing to this upgrade in recent models; recalls that empirical evidence regarding this relationship is ambiguous, as several studies in the second half of the twentieth century did not find robust results of educational variables on growth and even negative relationships were deducted (Pritchett, 2001). Fuente (2011) argues that such results might arise due to the difficulty of measuring human capital correctly. He finds evidence that investment in education (human capital) are not only positive but higher than those in physical capital for most European countries.

2.2.4. Financial Wealth and Capital Structure

Financial structure is also approached in the literature as a relevant component for its productivity, as it might determine a firm´s ability to invest in R&D, sophisticated technology and knowledge. The role of capital structure on the TFP at the firm level has been studied through the years and several conflicting conclusions were taken. Nickell and Nicolitsas (1995) covered this relationship empirically using a sample of U.K firms. Their results and argumentation were in line with Jensen (1986), who proposed a positive connection between a firm´s leverage and its productivity, arguing that high debt levels increase managers productivity due the pressure of bankruptcy caused by such leverage. This way, financial pressure ends up having a positive impact in productivity growth. Other studies point towards a different correlation between these two variables. Nucci et al (2005) concludes on a non-linear negative relationship among productivity and leverage. Using data from Italian companies, they find their results coherent with theory of firms' financial structure, mainly based on (i) bankruptcy costs, (ii) conflicts of interest between equityholders and debtholders and (iii) control rights. Ghosh (2009) finds similar results using similar argumentation for the Indian case. The easiness of a firm to get internal (or external) finance is also approached in the literature as a crucial factor. The availability of internal funds access of credit in credit markets help promoting investment in productivity-enhancement projects (Fazzari et al, 1988). The European Commission (2014) also stressed the importance of internal funding on productivity growth.

2.2.5. Firm Size

Internal characteristics of the firm are said to influence its productivity levels. More specifically, the size of the company, usually measured by the number of employees or the amount of total assets, constitute a crucial feature when considering the TFP. However, the relation between these two indicators is far from being consensual in the literature. Satpathy et. al (2017) found a positive association between the size of Indian manufacturing firms and its productivity, proxying size with the (logarithm of) total assets of the firm for that purpose. According to Castany et. Al (2005), such relationship can be explained due to several arguments; (i) scale economies effects, (ii) the scope economies effects, (iii) the experience effects and (iv) organization effects. Leung et. Al (2008) found similar results for manufacturing and non-manufacturing firms in Canada and the U.S. Opposite results were deducted by Fleischer (1990), who concludes that "small firms have higher productivity or efficiency due to their lean organisational structure" (Satpathy et. al, 2017). Brouwer et al. (2005) suggested a non-linear relation among both indicators, pointing to an initial gain in productivity with size until a certain threshold, from where the impact becomes negative.

2.2.6. Firm Age

Such as age, there is a strong debate in the literature regarding the impact of a firm´s age on productivity. Jovanovic and Nyarko (1996) argue about a positive effect, highlighting the learn-by-doing effects. Older firms have more experience and consequently more knowledge, which implies more advanced technology when compared to small firms. However, several authors suggest an inverse U-shaped connection among these two variables (Brouwer, 2005; and Fernandes, 2008).

According to these authors, firms start at relatively low TFP values, as they learn and invest in new opportunities that increase their productivity levels (economies of scale also play a role here). They get to a point where their technology gets outdated as they start having decreasing returns to age.

2.3. Total Factor Productivity Approach

Three main approaches have been taken to estimate Total Factor Productivity (henceforth TFP): Parametric, Non-Parametric and Semiparametric. An overview on nonparametric approaches can be found in OECD Publishing (2001), and as discussed in FQRSUND (1980) and Zamoranol (2001), the main disadvantages of the nonparametric approach is its assumptions, such as the deterministic nature, the constant returns to scale and the sensitivity to extreme values. As discussed in Beveren (2009), parametric approaches will suffer from: Simultaneity, Selection Bias, Omitted Price Bias and Multi-product Firms Bias. The Semiparametric approach presents a new take on the parametric, and corrects for its previously exposed problems. It is as well the most common on recent literature, in particular the Olley-Pakes (henceforth OP) and the Levinsohn-Petrin (henceforth LP).

The OP, introduced in Olley and Pakes (1996), suggests an algorithm where Investment proxies unobserved shocks, and calculates TFP in a two-step algorithm.

Assuming the production function looks like $Y_{it} = A_{it}{K_{it}}^{\beta_k}{L_{it}}^{\beta_l}{M_{it}}^{\beta_m}$, we can take its logarithm form to simply estimation:

$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \varepsilon_{it}$.

Then, taking investment depending on capital and productivity, $i_{it} = i_t(k_{it}, \omega_{it})$, and assuming investment is strictly increasing on productivity, we can invert the investment function into $\omega_{it} = h(k_{it}, i_{it})$. We can then rewrite the production function as:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + h(k_{it}, i_{it}) + {u_{it}}^q$$

or as,

$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \varphi(k_{it}, i_{it}) + {u_{it}}^q$, where $\varphi(k_{it}, i_{it}) = \beta_0 + \beta_k k_{it} + h(k_{it}, i_{it})$

By approximating $\varphi(k_{it}, i_{it})$ to a higher polynomial in i_{it} and k_{it}, usually of forth order, we can get consistent estimates for the coefficients on labour and materials.

To proceed to the second step, we must assume productivity follows a first order Markov process, i.e. $\omega_{it} = E(\omega_{it}|\omega_{it-1}) + \xi_{it}$, where ξ_{it} is assumed to be uncorrelated with productivity and capital in year t. We must assume as well that firms might exit the market given that their productivity is too low, i.e. $\chi_{it} = \mathbb{1}(\, \omega_{it} \geq \underline{\omega_{it}})$ where χ_{it} is a survival indicator. At last, taking $E(\omega_{it}|\omega_{it-1}, \chi_{it}) = g(P_{it-1}, \varphi_{it-1} - \beta_k k_{it-1})$ that follows the law of motion for the productivity shocks and $P_{it} = \Pr\{\chi_{it} = 1\}$, to obtain consistent coefficients on capital we can estimate:

$$y_{it} - \beta_l l_{it} - \beta_m m_{it} = \beta_0 + \beta_k k_{it} + g(\hat{P}_{it-1}, \hat{\varphi}_{it-1} - \hat{\beta}_k k_{it-1}) + \xi_{it} + {u_{it}}^q$$

But this method is said to fail in Levinsohn and Petrin (2003), as investment may take negative values, and an intermediate input is proposed instead to proxy unobserved shocks while still taking a similar two-step approach. The difference in estimation will be obtaining the coefficient on materials on the second step only, but the survival indicator is excluded.

3. Bibliography

Solow, R. (1956). A Contribution To The Theory Of Economic Growth. *The Quarterly Journal Of Economics*, 70(1), P.65.Romer (1986):

Romer, P. (1990). Capital, Labor, And Productivity. *Brookings Papers On Economic Activity. Microeconomics*, 1990, P.337.Romer (1993):

Prescott, L. (1998). New Growth Factors Spurt Into Action. *Inpharma Weekly*, &Na;(1122), Pp.12-13.

Isaksson, Anders. "Determinants Of Total Factor Productivity: A Literature Review." *Research And Statistics Branch, Unido*(2007).

Hall, Bronwyn H. *Innovation And Productivity*. No. W17178. National Bureau Of Economic Research, 2011.

Joutz, F. And Abdih, Y. (2005). Relating The Knowledge Production Function To Total Factor Productivity: An Endogenous Growth Puzzle. *Imf Working Papers*, 05(74), P.1.

Guellec, D. And Van Pottelsberghe De La Potterie, B. (2002). R&D And Productivity Growth. *Oecd Economic Studies*, 2001(2), Pp.103-126.

Pianta, Mario, And Andrea Vaona (2007). Innovation And Productivity In European Industries. *Economics Of Innovation And New Technology,* 16.7, Pp.485-499.

Spiezia, V. (2013). Ict Investments And Productivity. *Oecd Journal: Economic Studies*, 2012(1), Pp.199-211.

Seo, Hwan-Joo, Young Soo Lee, And Jeong Hun Oh (2009). Does Ict Investment Widen The Growth Gap?. *Telecommunications Policy,* 33.8, Pp.422-431.

Topalova, P. And Khandelwal, A. (2011). Trade Liberalization And Firm Productivity: The Case Of India. *Review Of Economics And Statistics*, 93(3), Pp.995-1009.Nkijam And Cockburn (2011):

Fernandes, A. And Isgut, A. (2007). Learning-By-Exporting Effects: Are They For Real?. *Ssrn Electronic Journal*.

Arvas, M. Akif, And Burak Uyar (2014). Exports And Firm Productivity In Turkish Manufacturing: An Olley-Pakes Estimation. *International Journal Of Economics And Financial Issues*, 4.2, Pp.243-257.

Jajri, Idris (2007). Determinants Of Total Factor Productivity Growth In Malaysia. *Journal Of Economic Cooperation* 28.3, Pp.41-58.

De La Fuente, Angel (2011). Human Capital And Productivity. *Nordic Economic Policy Review,* 2.2, Pp.103-132.

Jones, Benjamin F. (2008). The Knowledge Trap: Human Capital And Development Reconsidered. *National Bureau Of Economic Research*.

Filmer, Deon, And Lant H. Pritchett (2001). Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application To Educational Enrollments In States Of India. *Demography* 38.1, Pp.115-132.

Nickell, Stephen, Daphne Nicolitsas, And Neil Dryden (1997). "What Makes Firms Perform Well?." *European Economic Review,* 41.3-5, Pp.783-796.

Jensen, Michael C. (1986). Agency Costs Of Free Cash Flow, Corporate Finance, And Takeovers. *The American Economic Review,* 76.2, Pp.323-329.

Nucci, Francesco, Alberto Pozzolo, And Fabiano Schivardi (2005). "Is Firm's Productivity Related To Its Financial Structure? Evidence From Microeconomic Data." *Rivista Di Politica Economica,* 95. Pp.269-290.

Ghosh, Saibal (2006). Did Financial Liberalization Ease Financing Constraints? Evidence From Indian Firm-Level Data. *Emerging Markets Review,* 7.2, Pp.176-190.

Fazzari, Steven, R. Glenn Hubbard, And Bruce Petersen (1988). Investment, Financing Decisions, And Tax Policy. *The American Economic Review,* 78.2, Pp.200-205.

Commission, E. Et Al. (2014). Helping Firms Grow. European Competitiveness Report.

Satpathy, Lopamudra D., Bani Chatterjee, And Jitendra Mahakud (2017). Firm Characteristics And Total Factor Productivity: Evidence From Indian Manufacturing Firms. *Margin: The Journal Of Applied Economic Research,* 11.1, Pp.77-98.

Castany, Laia, Enrique López-Bazo, And Rosina Moreno (2005). Differences In Total Factor Productivity Across Firm Size-A Distributional Analysis.

Leung, Danny, Césaire Meh, And Yaz Terajima (2008). Firm Size And Productivity. *Bank Of Canada Working Paper*.

Tornatzky, Louis G., Mitchell Fleischer, And A. K. Chakrabarti. "The Processes Of Technological Innovation. Issues In Organization And Management Series." *Lexington Books. Available At Http://Www. Amazon. Com/Processes-Technological-Innovation-Organization/Management/Dp/0669203483. Accessed June* 10 (1990): 2013.

Brouwer, P., J. De Kok, And J. Fris. "Can Firm Age Account For Productivity Differences? Eim Scales-Paper N200421, Zoetermeer, Netherlands." (2005).

Jovanovic, Boyan, And Yaw Nyarko. "How Does Productivity Depends On Past R&D?'." (1996).

Fernandes, Ana M. *Firm Productivity In Bangladesh Manufacturing Industries*. The World Bank, 2006.
Measuring Productivity - Oecd Manual (2001). *Paris: Oecd Publishing*.

Turečková, Kamila, And Stanislav Martinát (2015). Quaternary Sector And Extended Sectoral Structure Of The Economy In The Selected European Countries.

Kenessey, Z. (1987). The Primary, Secondary, Tertiary And Quaternary Sectors Of The Economy. *Review Of Income And Wealth*, 33(4), Pp.359-385.

Křístková, Z. (2012). Impact Of R&D Investment On Economic Growth Of The Czech Republic - A Recursively Dynamic Cge Approach. *Prague Economic Papers*, 21(4), Pp.412-433.

Ray, D., Abler, R., Adams, J. And Gould, P. (1972). Spatial Organization: The Geographer's View Of The World. *Economic Geography*, 48(4), P.447.

Selstad, T. (1990). The Rise Of The Quaternary Sector. The Regional Dimension Of Knowledge-Based Services In Norway, 1970–1985. *Norsk Geografisk Tidsskrift - Norwegian Journal Of Geography*, 44(1), Pp.21-37.

Shaw, F. And Gottmann, J. (1962). Megalopolis: The Urbanized Northeastern Seaboard Of The United States. *Journal Of Educational Sociology*, 36(3), P.143.

Levinsohn, J. And Petrin, A. (2003). Estimating Production Functions Using Inputs To Control For Unobservables. *Review Of Economic Studies*, 70(2), Pp.317-341.

Olley, G. And Pakes, A. (1996). The Dynamics Of Productivity In The Telecommunications Equipment Industry. *Econometrica*, 64(6), P.1263.

Martins, Ana, Tiago Domingues, And Catarina Branco (2018). The Determinants Of Tfp Growth In The Portuguese Service Sector. *Gabinete de Estratégia e Estudos, Ministério da Economia.*

NEC
CONNECTING ECONOMICS

Gabinete de Estratégia e Estudos
MINISTÉRIO DA ECONOMIA