CIÊNCIAS SOCIALMENTE APLICÁVEIS:

INTEGRANDO SABERES E ABRINDO CAMINHOS

DAVID GARCÍA MARTUL
(Organizador)

VOL II

EDITORA ARTEMIS
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PRÓLOGO – VOLUME II

La redacción de un prólogo nunca es una tarea fácil, más aún cuando se trata de la presentación de un libro de temática interdisciplinar y transdiciplinar en el campo de las ciencias sociales aplicadas. Es interdisciplinar porque los trabajos que aquí se presentan utilizan un amplio abanico de técnicas de investigación para investigar su objeto de estudio especializado. Así es común encontrar trabajos que por la técnica empleada podríamos pensar son propios de la Antropología y la Sociología. Sin embargo, por el objeto de estudio tratado nos ha parecido más pertinente situarlo en el campo de la Comunicación. Por tanto, hemos dado relevancia al objeto de estudio frente a la metodología investigadora para determinar el campo temático de cada trabajo.

También consideramos que **Ciências Socialmente Aplicáveis: Integrando Saberes e Abrindo Caminhos** es un libro transdisciplinar porque los resultados de las investigaciones son aplicables a muy distintos campos del conocimiento; es decir, una investigación sobre alfabetización mediática puede muy bien ser aplicada tanto al campo de la Educación como a los campos de la Comunicación y la Sociología.

Sin embargo, previa labor de preparación de este prólogo hemos llevado a cabo una labor de análisis de contenido temático de cada uno de los trabajos aquí presentados. Su resultado ha sido un índice desarrollado por un metódico trabajo de selección de los descriptores más acordes a la temática y objeto de estudio de cada capítulo. Para la selección de los descriptores hemos seguido una herramienta, consensuada por la comunidad internacional, como es el Tesauro de la UNESCO; pues en él, se presenta de forma homogénea y normalizada la manera de designar cada uno de los campos del conocimiento. Y si bien debemos considerar toda herramienta de descripción como condicionada por el contexto ideológico, plasmado por sus sesgos y matices socioculturales, de la institución que lo edita pero que aporta un instrumento de navegación por las distintas materias que conforman el mapa de conocimiento de nuestro libro.

Es pues con ello que hemos procurado, de forma estructurada y sistemática, facultar al lector para introducirse en los heterogéneos contenidos del libro de una manera progresiva, armónica y lógica.

En este **Volumen II** se incluyen trabajos en las áreas de Políticas Públicas-Gestión de Conflictos, Empresa-Marketing y Turismo. Se ha optado por el criterio de reunir materias relacionadas con el estudio del desarrollo de estrategias ligadas con actividades económicas.

En el campo de Políticas Públicas-Gestión de Conflictos incluimos ocho trabajos de investigación que tratan desde aspectos ligados con la aplicación de políticas de gobernanza hasta aspectos más específicos acerca de la aplicación de la gestión política en situaciones de riesgo y conflictos.

El segundo bloque de materias en este volumen es el referido a trabajos relacionados más estrictamente con las iniciativas económicas y empresariales. En este bloque vemos cómo las políticas y estrategias empleadas en la gestión del ámbito de lo público pueden ser aplicadas en iniciativas empresariales y de marketing para la creación de una plusvalía en el sector privado. En este campo contamos con un primer grupo de trabajos ligados a la gestión corporativa. En un segundo grupo veremos herramientas empleadas en la aplicación de políticas corporativas y conductas del consumidor que pueden ser de interés para la más eficaz gestión de políticas corporativas, así como algunos casos prácticos de análisis en este sentido. Finalmente incluimos trabajos acerca del marketing como producto efectivo de las políticas de gestión corporativa.

Finalmente afrontamos un tercer y último bloque de seis trabajos en el campo del Turismo como actividad económica específica, con prácticas eminentemente empresariales sin menoscabo de las implicaciones que sobre la sociedad ejerce.

Esperamos que el presente volumen de **Ciências Socialmente Aplicáveis: Integrando Saberes e Abrindo Caminhos** les resulten de interés pues busca proporcionar una foto fija del estado de la investigación a través de un grupo heterogéneo de trabajos aplicados y previamente evaluados sobre distintos temas comprendidos en este campo. Con ello procuramos al mismo tiempo sugerir futuras líneas de investigación a desarrollar a partir de los textos aquí publicados para todas aquellas personas ligadas a la actividad académica.

David García Martul

Universidad Rey Juan Carlos

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ECONOMIAS À ESCALA E A IMPORTÂNCIA DO CAPITAL HUMANO NO SECTOR DE MOLDES EM PORTUGAL: UMA ABORDAGEM MICRO COM DADOS EM PAINEL

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RESUMO: O sector português de moldes para plásticos caracteriza-se pelo seu elevado grau de especialização tecnológica, inovação, modernidade e vocação fortemente exportadora. É um sector de sucesso que se posiciona no topo da cena internacional. O principal objectivo deste estudo é explicar esse sucesso, identificando os principais factores que determinam a dinâmica da estrutura de produção deste sector e a sua transformação ao longo do tempo. O estudo incide sobre múltiplos aspectos do capital humano, tais como a experiência profissional, tendências de *learning by doing*, inovação, difusão do conhecimento e cooperação entre empresas, que geram externalidades positivas no processo de produção. Todos estes factores contribuem de forma significativa para explicar o sucesso que este sector tem alcançado ao longo das últimas décadas. É utilizada uma função de produção, em linha com a abordagem neoclássica, em que o capital humano é o motor do crescimento, tal como foi postulado pela teoria do crescimento endógeno. A função de produção é estimada utilizando dados em painel não balanceado e aplicada a uma amostra de empresas do sector, para o período 1987-2012. Os resultados obtidos sugerem que, factores tais como o capital físico (que incorpora tecnologia de ponta, incluindo *software* específico) e factores, tanto quantitativos como qualitativos, associados ao capital humano, são os factores-chave que explicam as dinâmicas da produção do sector português de moldes. São também identificadas, como características especiais deste sector, a presença de rendimentos à escala crescentes e a existência de externalidades do capital humano.

PALAVRAS-CHAVE: Função de produção. Economias à escala. Externalidades do capital humano. Dados em painel. Sector de moldes.

ECONOMIES TO SCALE AND THE IMPORTANCE OF HUMAN CAPITAL IN THE MOULDS INDUSTRY IN PORTUGAL: A MICRO PANEL DATA APPROACH

ABSTRACT: The mould for plastics industry in Portugal is highly technological, innovative and modern, with a clear focus on exports. It is one

of the most successful sectors in this country with high reputation in the world markets. The main aim of this study is to explain this success by detecting the main factors which determine the dynamic production structure of this industry and its transformation over time. Focus is given on the multiple aspects of human capital, such as work experience, learning by doing tendencies, innovation, dissemination of knowledge and business cooperation between companies that generate positive externalities in the production process. All these factors contribute significantly to explain the success this industry has achieved over the recent decades. A production function framework is employed in line with the neoclassical approach where human capital is the engine of growth as has been postulated by the endogenous growth theory. The production function is estimated by using unbalanced panel data and applied to a sample of firms operating in this industry, over the period 1987-2012. Our empirical evidence suggests that factors such as physical capital (cutting edge technology, including specific software) and quantitative as well as qualitative factors associated with human capital are the key factors explaining the production dynamics of the moulds industry in Portugal. Increasing returns to scale and human capital externalities are also identified as special characteristics in this sector.
KEYWORDS: Production function. Economies to scale. Human capital externalities. Panel data. Moulds industry.

1 INTRODUCTION

The Portuguese moulds for plastics sector is a branch of the metal industry characterized mainly by its high precision in engineering design. A mould is a steel prototype of cube or parallelepiped shape, formed by layers which serve exclusively to produce the plastic piece for which the mould is designed. Every mould that is ordered by customers is unique and has to be carefully constructed in order to produce the plastic part with the desired shape, hardness and size. A mould consists of two halves and its internal surface has indentations and reliefs (moulding area) which will mould the plastic part into the desired shape. The weight of moulds can vary from hundreds of kilos (production of small plastic parts for the electronics industry) to several tonnes (bumpers and dashboards for cars, etc.). Moulds are made by customer´s order and are built to be placed on a suitable machine, which will inject the plastic material into the mould (injection machine).

It is a highly specialised and innovative sector. It uses cutting edge technology which requires a high degree of precision and accuracy and it is mostly export orientated. Portugal is among a set of countries producing the most technologically advanced mould products with high penetration in international markets. The sector enhances around 450 small and medium enterprises (SMEs) specialising in the design, development and construction of moulds heavily concentrated in locations like *Marinha Grande*[1] (Leiria

[1] About 60% of companies in this sector are located in this region.

District) and, to a lesser extent, in *Oliveira de Azeméis* (Aveiro district). The sector employs approximately 9,000 workers. In 2016, this sector exported more than 85% of its total production, the main markets being Spain, Germany, France, Poland, Czech Republic, Mexico, the United Kingdom and the United States of America, ranking by this order, in a total of more than 90 countries. Production is allocated to leading international brands, especially the automobile sector (more than 70%), but also in many other sectors, such as aeronautics, home appliances, electronics, packaging, renewable energies and the medical-pharmaceutical sector. In 2016, Portugal has consolidated its position as the third largest European producer of plastic injection moulds, ranking eighth worldwide (OLIVEIRA, 2017).

One of the most interesting characteristics of this sector is undoubtedly the great dynamism and spirit of cooperation[2] among its entrepreneurs facilitating the geographical agglomeration of this activity. One of the greatest expressions of this cooperation was the creation of *CEFAMOL* (National Mould Industry Association), in 1969, on the initiative of seven companies manufacturing moulds for the plastics industry (CEFAMOL, 2017). This Association has enhanced the sector's dynamism and has played a relevant role in improving cooperation and promoting the cohesion for which this sector is currently known in the international market. *CEFAMOL* was the point of origin and the driving force behind *CENTIMFE* (Technological Centre for the Moulds, Special Tools and Plastics Industry) founded in January 1991. *CENTIMFE* has also played an extremely important role in technological development and technical support for this sector. It has been the driving force behind the Competitiveness and Technology Hub which, developing the banner of *Engineering & Tooling from Portugal*, aims to be a collective brand under which the Portuguese companies can manifest their skills to a highly competitive international market. The brand seeks to promote the Portuguese industry of *Engineering & Tooling* on a national and international level (CENTIMFE, 2017).

These are the singular characteristics which make the analysis of this sector particularly interesting, namely the importance of human capital in all its aspects: the qualifications and high degree of personal and professional skills required of the labour force, the constant innovation and dissemination of knowledge, team work and cooperation established among companies.

The main objective of this study is to identify the main factors which explain the production performance of the moulds sector in Portugal considered as one of the most dynamic sector with a great reputation in external markets. Our analysis is concentrated

[2] This cooperation is rooted in the fact that the founders were schoolmates and/or workmates and thus, even though they were competitors, they were united by their companionship and strategic vision for this industry.

on the importance of human capital employed in this sector that could be responsible for the presence of externalities and the presence of increasing returns to scale. Human capital in this study is viewed in a broad manner, so as to encompass all dimensions associated with the intrinsic value of labour in organisations as well as the implicit value of their network relations.

The empirical analysis employed in this study tries to reconcile the main macroeconomic fundamentals of the growth theory and adapt them to a microeconomic study applied to a specific sector, namely the moulds for plastic sector in a specific country, Portugal. Focus is given to the role of human capital in explaining the successful dynamic performance of this sector and its export-led orientation. Panel data at the firms´ level is used to estimate the production function in this sector and measure the presence of economies of scale. To our knowledge there are few studies that try to apply macroeconomic fundamentals to micro-firm based data, and there is no study focusing on the moulds industry in Portugal using this methodology.

The study is structured as follows: Besides the introductory section, parts 2 and 3 make a brief reference to the literature on the production function and growth models and the role of human capital as a productive factor. In particular, section 3 clarifies the important issue of human capital externalities and its implications on the production and growth processes. Section 4 explains the model to be estimated based on the production function where human capital is considered as the engine of growth in line with the endogenous growth approach. Section 5 explains the micro-data at a firm´s level and the variables used to estimate the production function in the moulds sector. Section 6, reports the empirical results from the Panel data estimation approach and the obtained evidence are discussed. The last section summarizes the main findings.

2 THE IMPORTANCE OF HUMAN CAPITAL AS A PRODUCTIVE FACTOR

The issues of the importance of human capital, externalities, dissemination of knowledge, innovation, entrepreneurship, cooperation, productivity, competitiveness and their contribution to economic development have been the subject of growing interest since ever, at both, the macro and micro economic analysis.

Conventional economic theory linked to the neoclassical approach, only recognised that physical capital (gross fixed capital formation), labour (number of workers or number of hours worked) and land (natural resources) were the main input factors in the production function. Capital and labour are considered as the production factors *par excellence* and deemed to be mutually interchangeable. Economic development resulted in the awareness that this dualist vision was too limiting and far away from the reality. The reallocation of labour and capital was only possible by accumulating technical and scientific knowledge, therefore technical progress is the driving force of production.

Neoclassical theory based on the SOLOW (1957) model, early assumed that technology is an important productive factor, exogenously determined and given as a residual in the production function. Solow was the first author to distinguish between "*embodied*" and "*disembodied*" technology in capital. The "*embodied"* technology was derived from new investments (incorporating new technology), which results in an improvement in the quality of capital. "*Disembodied*" technology is independent of the accumulation of capital and is reflected in aspects such as more efficient management or improvement in worker capabilities through professional training or *R&D* activities. According to this line of thought, growth of output is supply orientated and input factors (including technology) are exogenous in the production process with diminishing (or constant) returns to scale properties. In contrast to this vein of thought, the demand driven approach linked to the Keynesian tradition attributes an endogenous role to technology and to other input factors, all depending on the strength of demand. Technology is responsible for improving the productivity of other factors of production, enhancing increasing returns to scale properties in the long-term. Therefore, production is demand-led and not supply-led as the neo-classical theory assumes, subject to increasing returns to scales emanated from technology that compensate the diminishing returns of capital.

The concept of "human capital" as an additional factor of production was later formalised by authors like ROMER (1986, 1987, 1990), LUCAS (1988) and BARRO (1991) postulating the so-called "Endogenous Growth Theory", the roots of which are strongly interconnected with the concept of *learning by doing* propounded by ARROW (1962), and the important role that increasing returns play in explaining growth. As ROMER (1986) affirmed, the idea that increasing returns are a fundamental element for explaining long-term growth dates back to Adam Smith and to the concept of division and specialisation of labour, later considered again by YOUNG (1928) and KALDOR (1966). In this sense, ROMER (1987) defends that the greater the level of specialisation or division of labour, the greater the quantity of production is obtained. The main argument of the endogenous growth theory lies on the fact that human capital is considered as an additional productive factor that drives economic growth.

The studies by BARRO (1991) are mainly empirical in nature and have the merit of confirming the hypothesis postulated by Romer and Lucas with regard to the importance of human capital for economic growth. Barro found empirical evidence supporting the idea that the growth rate of real per capita GDP was positively related to the initial human capital level, having used the level of education as a proxy for human capital. Countries with larger initial stocks of human capital undergo faster growth of technological progress, generating new products and new knowledge, and consequently tend to grow faster.

SACHS and WARNER (1997) defended that the accumulation of human capital is a non-linear function in relation to its level: when the initial human capital is low, the accumulation of human capital is also low; when human capital is at an intermediate level, then the growth in the accumulation of human capital is faster; when the level of human capital is already very high, the accumulation of human capital is once again lower. The authors concluded that this fact means that economic growth tends to be higher in countries with an intermediate level of human capital than in countries with very low or very high levels of human capital.

CHEN and DAHLMAN (2004) empirically studied the effects of the various dimensions of knowledge on economic growth. They found that knowledge acts as a main driving force for economic growth, and that the amount of knowledge and the way in which it is used are the key determinants of total factor productivity. In particular, they showed that the stock of human capital (average years of schooling), the national level of innovation and technological adaptations (number of patents), and the level of Information & Communication Technologies (ICT) infrastructure (number of mobile phones per 1,000 people) have significant positive effects on the long-term pace of economic growth.

SOUKIAZIS and CRAVO (2008) - using the average number of years of education for the population aged over 25 to express low levels of human capital, the number of scientific publications and patents registered, as well as the ratio of patents/articles published to express higher levels of human capital, showed that the latter are more important to explain the growth rates of the developed countries while the basic or intermediate levels of schooling better explain differences in growth rates between the less developed countries.

Although these above studies referred to macroeconomic developments, they also reflect the microeconomic reality with respect to business organisations. In this line, ICHIJO and NONAKA (2007, pp. 3-4) affirmed that

> to compete successfully, companies must hire, develop, and retain excellent managers who accumulate valuable knowledge assets. Attracting smart, talented people and raising their level of intellectual capabilities is a core competency. In addition, the unique feature of knowledge as resource is that it can become obsolete in the future. Therefore, new knowledge has to be created continuously.

NONAKA and TOYAMA (2007) also argue that the way knowledge is generated within organisations explains the differences in their performance.

3 HUMAN CAPITAL EXTERNALITIES

An interesting issue of research, which is by no means free of controversy, relates to the concept of "externalities" of human capital. In general, it can be said that economic agents create an external effect when their activity generates utility to others without receiving any monetary compensation. Many authors relate human capital externalities with the educational qualifications of individuals. NELSON and PHELPS (1966) stated that education develops the capacity of people to receive, decode and understand information that farther allows performing many tasks. They also stated that academic training is especially important for those functions which require adaptation to changes due to new technological developments. Well qualified individuals are prone to innovation and, consequently, academic training accelerates the process of technological diffusion. If innovations produce externalities because they pave the way for imitators, then academic training also produces externalities owing to the fact that it stimulates innovation.

ROMER (1986) also refers to human capital externalities. This author developed a model in which technological progress is endogenous and "new knowledge", considered to be a capital asset with growing marginal productivity, obtained by means of investment in technical progress. The increase in knowledge will not remain exclusively in the possession of the company which supported this investment, as it will be freely available to all other competing companies. This spillover of knowledge is, consequently, an "externality", an asset in the public domain for other companies. Thus, in addition to increasing the level of productivity at the promoting company, this new knowledge makes a positive contribution to the levels of productivity of other companies, without additional costs. Consequently, if companies were inclined to invest jointly in new technical progress, they could reap the benefits of these "externalities"[3].

In line with Romer, LUCAS (1988) highlighted the accumulation and specialisation of human capital as one of the main determinants explaining the differences in growth

[3] The State could also play a significant role by supporting research activities.

rates among countries. He stated that human capital externalities in the form of learning spillovers could be sufficiently large to explain differences in long-term performance between rich and poor countries. Lucas also made a distinction between the “internal” and “external” effects of human capital on productivity. He argued that each worker has a certain quantity of human capital (such as education) and that he dedicates a part of his work time to effective production and the other part to acquiring knowledge (i.e. accumulating human capital), which leads to an increase in individual productivity (internal effects). However, these internal effects, obtained from the individual effort to accumulating knowledge will also affect the average level of workers competences because they all benefit from this individual accumulation of human capital (external effects). In this manner, both the internal effects as well as the external effects contribute to the productivity of all the production factors.

Many other authors have studied and reflected on human capital externalities, analysing them from different points of view. One of the most noteworthy works is by MORETTI (2004), who stated that human capital externalities can arise if workers with higher educational levels influence other workers to become more productive. He also pointed out that ALFRED MARSHALL (1890) was one of the first to recognise that social interaction among workers creates opportunities for learning that increase labour productivity. He further argued that if externalities exist, one should be able to observe that companies located in cities with higher levels of human capital can be more productive compared to other similar companies that are located in cities with lower levels of human capital.

According to ACEMOGLU and ANGRIST (2001) there are many different interactions which can give rise to human capital externalities, distinguishing two cases: the non-pecuniary externalities and the pecuniary ones. Non-pecuniary externalities (also known as technological externalities) reflect the benefits derived from the activities of other companies not based on the market mechanisms (these are pure externalities), while pecuniary externalities are benefits obtained from the activities of other companies which are mediated through the markets, by means of the price mechanism. ANTONELLI et al. (2011) added that knowledge spillovers have been seen as a case of pure technological externalities, as they are freely available to anyone with no additional cost. ACEMOGLU and ANGRIST (2001) stressed that the non-pecuniary external effects are derived by means of exchanging ideas, imitation or by “learning by doing”.

ANTONELLI et al. (2011) referred that the empirical literature contemplates three types of knowledge externalities: Marshall-Arrow-Romer (MAR) externalities, derived from the concentration of companies within a single sector; Jacobs externalities, which are associated with a diversity of companies and sectors within a given region; and Porter externalities, which are associated with the idea that local competition between companies concentrated in the same sector favours local development. As DÖRING and SCHNELLENBACH (2004) explained, the term MAR[4] is derived from three classic contributions by MARSHALL (1966), ARROW (1962) and ROMER (1986) stating that externalities are related to the location of sectors and represent spillovers between researchers, entrepreneurs and companies within a single sector[5]. MAR spillovers lead to learning processes, in which knowledge is disseminated among people working to solve similar or at least related problems. Consequently, MAR spillovers are intra-sectorial phenomena and make it possible to exploit local economies of scale.

In this regard and from another point of view, ACEMOGLU and ANGRIST (2001) affirm that JANE JACOBS (1970) in her work *The Economy of Cities* defended that cities are a driving force for economic growth because they facilitate the exchange of ideas, especially between entrepreneurs and managers. LUCAS (1988) also cited Jane Jacobs, associating her vision with the external effects of human capital, although Jacobs did not use this terminology. As DÖRING and SCHNELLENBACH (2004) explained, Jacobs externalities are related to the phenomenon of urbanisation and reflect the effect of the dimension and the heterogeneity of an agglomeration. They represent the spillovers resulting from an interaction between different sectors.

ACEMOGLU and ANGRIST (2001) further added that MARSHALL (1961) defended that an increase in the geographic concentration of specialised production factors increases productivity, as this improves the links between production factors and industrial sectors. These authors mentioned that the majority of theories concerning externalities suggest an important local component[6].

AUTANT-BERNARD and LESAGE (2011) also highlighted that, from the point of view of specialisation (MAR), there is a higher likelihood of spillovers occurring between similar companies which share common knowledge. A consequence of this view is that regions where companies specialise in a particular sector should benefit from increasing returns and produce a more innovative product. Reciprocally, from the point of view of diversification (Jacobs), knowledge spillovers are increased by means of cross-fertilisation and complementarities between companies. From this point of view, regions with diversified production produce more innovation because knowledge is what gives rise to increasing returns, in a complementary manner.

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[4] Introduced by Glaeser et al. (1992:1127), as mentioned by the authors.

[5] An example that is often cited is the concentration of suppliers of semiconductors and related technologies in Silicon Valley, cf. Audretsch and Feldman (1994) and Carlino (1995), cited by the authors.

[6] Citing Glaeser et al. (1992) and Jaffe, Trajtenberg and Henderson (1993) as examples.

4 MODEL SPECIFICATION

The conventional production function considers a set of input factors (mainly capital and labour) which are used to produce the final desired output. This relationship indicates the maximum quantity of output which can be produced from a combination of a given set of productive factors. The endogenous growth approach stipulates that the conventional production function must be augmented to include the stock of human capital as an additional input factor generating higher production and hence economic growth.

MANKIW et al. (1992) estimated an augmented production function of the Solow type with a set of explanatory variables that includes the growth of population and the accumulation of physical and human capital, respectively. They argue that the inclusion of human capital as an input factor is responsible for increasing the impact of the accumulation of physical capital on per capita income. The authors concluded that these three variables explained almost 80% of the cross-country variation of per capita income.

RAUCH (1993) was the first author to try and estimate human capital externalities[7]. His estimates were based on the differences of average levels of schooling and their effects on the salaries of workers, having found significant externalities, of around 3% to 5%. His study paved the way for many other studies on this topic, which, however, is not free from controversy.

In general, as DAVIES (2003) mentioned, the empirical studies which primarily seek to analyse the existence of human capital externalities by means of the growth of the product or the total factor productivity, use models based on the aggregate production functions having the following general specification:

$$Y_i = AK_i^{\propto} H_i^{\beta} (h_i^{\varepsilon} L_i)^{\gamma} \quad (1)$$

where Y_i is the aggregate product; *A* reflects the level of technology or the total factor productivity; K_i is the volume of physical capital; H_i is the stock of human capital; L_i is the quantity of labour; $h_i = H_i/L_i$ represents the efficiency of human capital; α, β, ε and γ are the elasticities of the respective input factors.

According to DAVIES (2003), while in the neoclassical growth approach *A* is considered to be exogenous, in the endogenous growth models technological progress is assumed endogenous, partly dependent on human capital accumulation and its efficiency. Therefore, human capital is important for the adoption of technology in the production

[7] As mentioned by Acemuglu and Angrist (2001), among others.

process (as in the case of less developed countries) or on innovation (as in the case of developed economies). Some of these effects can be internal to the companies while others may represent externalities.

The inclusion of H_i, as a separate input factor in the production function, allows the stock of human capital to have positive effects on production, especially in the long-term, compensating the diminishing returns of other factors of production. We can determine two alternative forms of the production function as given in equation (1):

Assuming $\varepsilon = 0$ the production function takes the form contemplated by MANKIW et al. (1992):

$$Y_i = AK_i^{\propto}H_i^{\beta}L_i{}^{\gamma} \tag{2}$$

Assuming $\varepsilon = 1$, the production function will take the reduced form:

$$Y_i = AK_i^{\propto}H_i^{\beta+\gamma} \tag{3}$$

In both specifications the hypothesis of constant returns to scale implies that the sum of the inputs elasticities is equal to one, $\propto + \beta + \gamma = 1$.

As DAVIES (2003) has emphasised, if the estimated production function shows increasing returns to scale properties, that is $\propto + \beta + \gamma > 1$, this could be taken as evidence of the existence of human capital externalities in the production function. On the other hand, the dependence of *A* on H_i[8] shows that human capital contributes to the growth in the total factor productivity through its externality effects on technical progress.

5 DATA AND VARIABLES DESCRIPTION OF THE MODEL TO ESTIMATE

The main aim of this study is to estimate the conventional production function by including as additional input factors, variables which express the qualitative nature of human capital related to its efficiency. Beside this contribution we employ the augmented conventional production function to micro panel data considering a specific industrial sector, namely the moulds for plastics sector concentrated in a specific location and constituting a successful cluster for the Portuguese economy. Another specific aim is to verify the possible existence of externalities related to human capital, recognising the fundamental role that knowledge and the dissemination of new technologies play in this sector.

We start our empirical analysis by estimating a standard production function with two factors of production, capital and labour using panel data referred to the moulds

[8] This can be shown by the reduction of the constant term in the estimated production function when human capital is introduced as an additional factor of production.

sector. The reason of doing so is to see what difference it makes in the estimation process when human capital proxies are introduced in the production function, in terms of the input factor elasticities and the economies of scale. This simple production function is given as:

$$Q_{it} = AK_{it}^{\propto} L_{it}^{\beta} e^{u_{it}} \quad (4)$$

The data refers to a sample of 27 companies in this sector located in the *Leiria* district, in particular 15 companies in *Marinha Grande*, 4 companies in *Leiria* and 2 in *Alcobaça*, and 6 companies in the municipality of *Oliveira de Azeméis* belonging to the *Aveiro* district. We use unbalanced panel data, encompassing a maximum period of 26 years (1987-2012) and a minimum period of 7 years, according to the company's data availability[9]. The combination of cross-firm data and time series data allows us to have a sample of 372 total observations in the estimation approach.

Q_{it} in equation (4) is the real value of output (in €)[10], calculated as follows: sales of the product + provided services ± variation of production + work for the entity itself[11]. Given the characteristics of the sector being studied, this would be the most suitable measurement and not production in physical units (units of moulds) which does not reflect the greater or lesser productive capacity of companies.

Capital K_{it} in the production function is the real annual gross value of the tangible fixed assets including the category of '*software*' (in €). The inclusion of '*software*' is justified by the fact that the moulds sector uses cutting edge technology, implying high investment not only in physical equipment but also in acquiring specific software which adds to the capital stock. Considering this aspect the capital stock also embodies innovation and technical progress. The labour factor L_{it} corresponds to the number of workers employed in each company by December 31st of each year[12]. In the same equation (4) e is the exponential constant number and u_{it} the error term with the usual assumptions of homoskedastic and not autocorrelated errors.

In line with the neoclassic theory all factor elasticities are expected to be positive and for constant returns to scale the condition $\propto + \beta = 1$ must be fulfilled.

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[9] Most of the data was obtained by directly contacting the company´s managers; some accounting data for a given set of companies between 2006 and 2012 was kindly provided by the agency "*Informa D&B, Sociedade Unipessoal, Lda*".

[10] The production values are deflated by the Tradable Goods Index (TGI) for the period 1987 to 1996 (BANK OF PORTUGAL, 1987, 1990, 1993) and by the GDP deflator for the period 1997 to 2012 (BANK OF PORTUGAL, 1996; STATISTICS PORTUGAL, 2013), owing to the fact that the data on TGI does not cover the entire latter period.

[11] Taken from the Portuguese accounting standards Sistema de *Normalização Contabilística* (SNC, 2012) (for the period 2010 to 2012) and the *Plano Oficial de Contabilidade* (POC, 2005) (for the period 1987 to 2009), with the necessary adaptations.

[12] It would be preferable to use data on the number of hours worked but these data were not available for all companies forcing us to reduce the sample size significantly.

The augmented production function that includes human capital as additional factor of production analogously is given as:

$$Q_{it} = AK_{it}^{\propto} L_{it}^{\beta} H_{it}^{\gamma} e^{u_{it}} \quad (5)$$

Introducing the human capital variable into the production function we are obliged to reduce the sample size and to consider only 13 companies in the moulds sector, 9 located in *Marinha Grande*, 3 in *Leiria* and 1 in *Alcobaça*[13]. Equation (5) is estimated by using unbalanced panel data covering a maximum period of 26 years (1987-2012) and a minimum period of 7 years having a total sample of 223 observations.

In equation (5) the variables Q_{it}, K_{it} and L_{it} are defined as before. Additionally, two variables are used to measure the impact of human capital H_{it} on production: the professional experience of workers (in years)[14] and the level of business cooperation between companies in this sector[15]. The former captures educational standards (since all workers are subject to training programs) and learning by doing aspects, the latter captures managerial strategy through business cooperation.

Cooperation between companies in this sector is defined by using the annual real value of two items, namely subcontracting + specialised tasks[16]. These two categories together play a substantial role in the cost structure of companies in this sector. Subcontracting may involve the production of the entire mould or refer only to tasks inherent to one or more phases of the production process. Using subcontracting as a measure of cooperation between companies in this sector can be understood in two distinct, albeit complementary aspects. On the one hand, subcontracting implicitly involves typical aspects of business relations which, in addition to reflecting the degree of cooperation between companies in the sector, also assumes a high degree of trust between them[17]. From this point of view, subcontracting entails the sharing and dissemination of technologies, knowledge and management aspects. It is important to note that this cooperation is only possible due to the geographical

13 Given the confidential aspect of information, all the data referring to the qualitative factors of human capital was exclusively obtained by personally contacting the company´s managers. Unfortunately it was not possible to collect information for a larger number of companies.

14 The annual average age minus 18 was used to compute the data of this variable, considering that 18 is the minimum age for the workers to enter in the labour market.

15 It should be desirable to use R&D expenditures or registered patents to express higher levels of human capital related to innovation but data were not available for all companies included in the sample.

16 Taken from SNC (2012) (from 2010 to 2012) and POC (2005) (from 1987 to 2009), with the necessary adaptations.

17 Subcontracted work is closely monitored by technical staff from the subcontracting company, which entails a good relationship and teamwork, in close collaboration with the managers and technical staff of the subcontracted company. The aspect of trust is vital, insofar as moulds for new products are being made, which do not yet exist in the market and there is always the risk of leaks of information to rival companies. Confidence in the quality of the work being executed and rigorous compliance with delivery periods are also important factors.

proximity of the companies. On the other hand, a significant proportion of the subcontracting occurs when companies receive orders in excess that overcome their production capacity. Another case is related to the execution of certain specific tasks in the production process which require equipment and/or human resources in which given companies do not wish to invest. From this point of view, subcontracting has underlying aspects of management efficiency and constitutes a corporate strategy that facilitates the dissemination of technology and the transmission of knowledge between companies.

Given the intrinsic characteristics of this sector which employs highly skilled workers with extensive professional experience, the human capital variables we consider in this study (experience and cooperation) are more suitable than the conventional variables used related to educational standards.

Table 1 reports some elementary descriptive statistics for the variables included in the production function to estimate (equation 4), enhancing the full sample of the companies of the moulds industry. The data shows significant heterogeneity of the production structure in the sample of 27 companies, mostly characterized as small-medium enterprises. The average number of workers employed is 68, the minimum 14 and the maximum 213.

Table 1. Elementary descriptive statistics for the variables: Sample of 27 companies in the moulds sector, 1987-2012: minimum 7 years and maximum 26 years.

Variable	**Obs.**	**Mean**	**Median**	**Std. dev.**	**Minimum**	**Maximum**
(1) Q Product (Euros)	372	4875270	3524560	3844710	96120.0	20976500
(2) K Capital (Euros)	372	7003300	5556380	6613230	60128.0	49928800
(3) L Number of workers	372	68.457	59.0	36.9934	14.0	213.0

Source: Own elaboration.

Table 2 records the descriptive statistics referred to the variables included in the production function that considers human capital as additional input factor (equation 5) taking the form of labour experience (Exper) and business cooperation (Cooper). In this case the sample is smaller (13 companies only) due to the lack of data on these variables.

Table 2. Descriptive statistics for the variables: Sample of 13 companies in the moulds sector, 1987-2012: minimum 7 years and maximum 26 years.

Variable	Obs.	Mean	Median	Std. dev.	Minimum	Maximum
(1) Q Product (Euros)	223	4276880	3052920	3556110	96120.0	20976500
2) K Capital (Euros)	223	5733730	4946350	4092360	60128.0	22462500
(3) L Number of workers	223	63.4444	55.5	31.2508	14.0	213.0
(4) Exper Average annual number of years of professional experience	223	18.2072	17.9	3.61452	9.8	26.2
(5) Cooper Cooperation - subcontracting (Euros)	223	1219280	522270	1848480	23663.0	10539400

Source: Own elaboration.

Some changes can be seen in the values of 'capital' and 'labour', due to a reduction in the number of companies in the sample (from 27 to 13). It is important to note that this second sample only includes companies located in the *Marinha Grande* region. It must be emphasised that the average number of years of professional experience of workers in this sector (18.2) is relatively high. The average value associated with subcontracting accounts for about 28.5% of the average production.

6 EMPIRICAL EVIDENCE

6.1 REGRESSION RESULTS FROM THE CONVENTIONAL PRODUCTION FUNCTION

We start our empirical analysis by estimating the conventional production function as given in equation (4). We use unbalanced panel data from 27 companies in the moulds sector agglomerated in the regions *Marinha Grande* and *Oliveira de Azeméis*. Applying logarithms in both sides the production function is linearized and the obtained coefficients reflect constant elasticities showing the percentage change in production due to a percentage change in the respective input factor. The regression results obtained are shown in Table 3. Model (1) corresponds to the estimation of the production function by using fixed effects; Model (2) uses the 2SLS estimation technique to control for the endogeneity of the input factors, and Model (3) is the dynamic estimation of the production function with lagged dependent variable.

Table 3. Regression results of the production function. 27 companies of the moulds sector. Panel data, 1987-2012.

	Convencional Production Function		
	Model (1)	**Model (2)**	**Model (3)**
Variables	**Fixed Effects**	**Fixed effects 2SLS** [a]	**Dynamic Panel GMM**
Dependent variable lnQ_{it}			
Coefficient of lnK_{it} **(**α**)** *t-statistic/z* *p-value*	0.714158*** *(t-stat=38.2166)* *(< 0.00001)*	0.715972 *** *(z= 34.16)* *(<0.00001)*	0.288732 *** *(z=3.781)* *(0.0002)*
Coefficient of lnL_{it} **(**β**)** *t-statistic/z* *p-value*	0.323709*** *(t-stat=5.0885)* *(< 0.00001)*	0.281436 *** *(z=4.153)* *(<0.0001)*	0.279251 ** *(z=2.490)* *(0.0128)*
Constant *t-statistic/z* *p-value*	2.77458*** *(t-stat=9.9066)* *(< 0.00001)*	2.91995 *** *(z=9.245)* *(<0.00001)*	0.0113295 * *(z=1.822)* *(0.0685)*
Coefficient of lnQ_{it-1} **(**$1-\delta$**)** *z* *p-value*	--- --- ---	--- --- ---	0.385969 *** *(2.803)* *(0.0051)*
Number of companies	27	27	27
Number of observations	372	342	315
R^2	0.931903	---	---
F – statistic *p-value*	167.6413 *(0.0000)*	--- ---	--- ---
Hausman test [b] *p=prob > Chi2* R^2 = corr(y,yhat)^2 = SSR	 Chi2(2) = 16.1798 *(0.000306623)* --- ---	 --- --- 0.840874 14.8297	 --- --- --- ---
Durbin-Wu-Hausman test [c] *p-value*	--- ---	Chi2(2) = 18.6491 *(<0.0001)*	--- ---
Sargan test [d] *p=prob > Chi2*	--- ---	LM =1.30969 *(0.519523)*	--- ---
Cragg-Donald test (weak instruments) [e] *Critical value (5%)*	--- ---	8328.04 *(11.04)*	--- ---
H_0**:** $\alpha + \beta$ **= 1** F-statistic/Chi2 *p-value*	H_0 is not rejected F-stat=0.441663 *(0.506767)*	H_0 is not rejected Chi2(1) =0.00180133 *(0.966146)*	--- --- ---
Returns to scale	Constant	Constant	---
Dynamic panel AR(2) [f] *z* *p-value*	 --- ---	 --- ---	 *-0.323607* *(0.7462)*
Dynamic panel - Sargan test [d] *p-value*	--- ---	--- ---	Chi2(217) = 24.1972 *(1.0000)*
Partial adjustment coefficient (δ**)** **Capital long-term elasticity (**α/δ**)** **Labour long-term elasticity (**β/δ**)**	--- --- ---	--- --- ---	0.614031 0.470224 0.454783

Source: Own elaboration.

Notes:

***, **, * denote coefficient statistically significant at the 1%, 5% and 10%, respectively.

a. Instruments used: lnK_{it-1}, $SqlnK_{it}$, lnL_{it-1}, $SqlnL_{it}$

b. Hausman tests random effects against fixed effects, when using panel data models.
c. Durbin-Wu-Hausman tests exogeneity against endogeneity of the regressors, when using instrumental variables models; a p-value < 0.05 means that at least one of the explanatory variables is endogenous.
d. Sargan tests the validity of all the instruments used against its non-validity; if p-value > 0.05 then all the instruments used are valid.
e. When using instrumental variables models with multiple endogenous regressors, the Cragg-Donald statistic tests whether given instruments are weak; if the minimum eigen value of Cragg-Donald > critical value then the instruments used are not weak (see Stock & Yogo, 2005).
f. AR(2) is the Arellano and Bond test for 2nd order serial auto-correlation in first differences, when using dynamic panel models; if p-value > 0.05 it means that there is no autocorrelation of the 2nd order errors.

Model (1) is estimated by the time demeaned method applied to fixed effects specification devolving satisfactory results. The Hausman test[18] indicates that this model is preferable to the random effects model. The goodness of fit is satisfactory showing that 93% of the total variation in production is explained by the two input factors, capital and labour. The estimated coefficients of the explanatory variables are statistically significant (at the 1% level) carrying their expected positive values with elasticities less than 1. The product elasticity with respect to capital indicates that a 1% increase in capital is responsible for 0.71% increase in the product in the moulds sector, everything else remaining constant (*ceteris paribus*). Similarly, the product elasticity with respect to labour shows that if labour increases by 1% it is expected that output increases by approximately 0.32% maintaining capital constant. It is important to note that the elasticity of capital is substantially higher than that of labour, suggesting that the product in this sector is more sensitive to changes in capital than to labour. This is in line with the nature of the moulds industry which implies heavy investment in capital goods as we explained in the introduction including investment in software technology. Testing the presence of economies to scale that the input elasticities with respect to output sum to 1, this hypothesis is not rejected, confirming the neoclassical assumption of constant returns to scale in the production in this sector.

Model (2) is estimated by means of the instrumental variables method (with fixed effects), presupposing that the input factors (capital and labour) are endogenous to the production process. From the economic theory point of view this hypothesis is very important distinguishing the neoclassical approach from the Keynesian perspective on this matter. The neoclassical theory assumes that factors of production and technology are exogenously given and therefore production is constrained by the availability of these means of production. Accordingly production (and economic growth) is supply constrained. On the contrary, the Keynesian approach advocates that production (and therefore growth) is demand constrained since factors of production are endogenous, depending on the strength of demand (the increase in output). Employing this idea to the micro analysis and having into account that the production of moulds for plastic depends exclusively on

18 The null hypothesis of random effects is rejected at the 1% significance level.

customer´s orders, it turns more reliable to assume that capital and labour in this sector are demand determined. This is to say that there will be higher need to acquire more capital goods and hire more labour when the demand of moulds (by customer`s order) increases. From the statistical point of view and in terms of the estimation results, if the hypothesis of the endogeneity of input factors is not rejected then estimates will be biased and inconsistent (not converging asymptotically towards the true value of the population).

To test the endogeneity of factor inputs we use the Durbin-Wu-Hausman test[19]. In the null hypothesis the correlation between the explanatory variables and the error term is tested and if this hypothesis is rejected then input factors are endogenous. In this case the instrumental variables estimation technique[20] (or 2SLS) is the most appropriate to obtain unbiased and consistent estimators. Performing the Durbin-Wu-Hausman test (see Table 3) it is shown that the null hypothesis of no correlation between the input factors and the error term is rejected at the 1% significance level, concluding that capital and labour are endogenous to the production process validating the Keynesian perspective that input factors are demand determined. Additionally, the Sargan test for the over-identification reveals the validity of all the instruments used in the 2SLS estimation approach, and through the Cragg-Donald test the instruments are not weak[21]. All these statistical evidence favours the 2SLS method as the most appropriate to estimate the production function validating the Keynesian approach of the endogenous nature of the factors of production.

Using Model (2) as the most appropriate we can infer that the estimated coefficients of the explanatory variables ‘capital’ and ‘labour’ are statistically significant (at the 1% level) carrying also their expected positive sign. Although the capital elasticity is similar to that found in Model (1), the labour elasticity is smaller (0.281 versus 0.324). Therefore, when the endogeneity problem is ignored the labour elasticity is overestimated as a result of an upward bias. Finally, the hypothesis of constant returns to scale (sum of the input factors elasticities equal to 1) is not rejected again, as in Model (1).

Model (3) in Table 3 corresponds to the dynamic estimation of the production function with a lagged dependent variable. The dynamic panel data model estimation uses the Generalised Method of Moments (GMM) technique as has been suggested by ARELLANO and BOND (1991). The model is estimated by using variables in first differences and lagged variables or lagged differences as instruments to control for the endogeneity of the lagged dependent variable. The obtained results are satisfactory. All short run elasticities

[19] See Notes a and c of Table 3.

[20] The instrumental variables method (IV - *Instrumental Variables* or 2SLS – *Two Stage Least Squares*) consists of finding exogenous explanatory variables highly correlated with the endogenous regressors but not correlated with the error term of the structural equation (see Wooldridge, 2009). The lagged values of capital and labour and their squared values are used as instruments in the 2SLS to remove the correlation that exists between the input factors and the error term in the production function.

[21] See Notes d and e of Table 3.

of input factors are statistically significant, but the elasticity of labour only at the 5% level. The coefficient of the lagged dependent variable is also statistically significant validating the hypothesis of the stock adjustment mechanism[22]. The speed of adjustment runs at 61.4% showing a relatively high degree of adaptation of the actual production to the desired level.

The dynamic panel model estimation allows to determine the long-run input elasticities (by dividing the short run elasticities by the coefficient of the speed of adjustment), getting 0.47 for capital and 0.45 for labour, respectively. In the dynamic estimation the long-run capital elasticity is slightly higher than the labour elasticity. These long-run elasticities are higher than the respective short-term elasticities, as expected and their sum is less than 1 favouring the neoclassical hypothesis of decreasing or constant returns to scale.

6.2 AUGMENTED PRODUCTION FUNCTION WITH HUMAN CAPITAL

We extend the previous estimated production function to include human capital as an additional productive factor, as shown in equation (5). Two proxies are used to express the human capital contribution in the production process in the moulds industry: professional experience and business cooperation between the companies included in the sample. However, in doing so our sample reduces from 27 to 13 companies due to the lack of data on human capital. Table 4 reports the regression results.

Table 4. Production function including human capital, moulds sector. Panel data, 1987-2012 (annual data)

	Production function including human capital		
	Model (4)	**Model (5)**	**Model (6)**
Variables	**Random Effects**	**Fixed effects 2SLS [a]**	**Dynamic panel GMM**
Dependent variable lnQ_{it}			
Coefficient of lnK_{it} (α) *t-statistic/z* *p-value*	0.439422 *** *(t-stat=11.45)* *(<0.00001)*	0.358433 *** *(z=7.560)* *(<0.00001)*	0.127194 *** *(z=3.601)* *(0.0003)*
Coefficient of lnL_{it} (β) *t-statistic/z* *p-value*	0.242945 *** *(t-stat=3.636)* *(0.0003)*	0.377929 *** *(z=4.831)* *(<0.0001)*	0.276611 *** *(z=5.712)* *(<0.00001)*
Coefficient of $lnExper_{it}$ (γ1) *t-statistic/z* *p-value*	0.276353 ** *(t-stat=2.556)* *(0.0113)*	0.549846 *** *(z=3.837)* *(0.0001)*	0.0159486 *(z=0.1143)* *(0.9090)*
Coefficient of $lnCooper_{it}$ (γ2) *t-statistic/z* *p-value*	0.324240 *** *(t-stat=13.87)* *(<0.00001)*	0.324108 *** *(z=11.24)* *(<0.00001)*	0.238838 *** *(z=10.19)* *(<0.00001)*

[22] The stock adjustment mechanism is defined as $(lnQ_{it} - lnQ_{it-1}) = \delta(lnQ^*_{it} - lnQ_{it-1})$ where δ shows the speed of adjustment ($0 \leq \delta \leq 1$), that is, how fast the actual variation of the production adjusts to its optimal level Q*. The short-run model with variables in levels can be presented as $lnQ_{it} = \delta a + \delta\alpha lnK_{it} + \delta\beta lnL_{it} + (1-\delta)\, lnQ_{it-1}$ (see Gujarati, 2003).

	Production function including human capital		
	Model (4)	Model (5)	Model (6)
Variables	Random Effects	Fixed effects 2SLS [a]	Dynamic panel GMM
Constant *t-statistic/z* *p-value*	2.22722 *** *(t-stat=7.127)* *(<0.00001)*	2.10544 *** *(z=6.423)* *(<0.00001)*	0.00910383 ** *(z=2.331)* *(0.0198)*
Coefficient of lnQ_{it-1} $(1-\delta)$ *z* *p-value*	--- --- ---	--- --- ---	0.410645 *** *(7.940)* *(<0.00001)*
Number of companies	13	13	13
Number of observations	223	209	205
Hausman test [b] *p=prob > Chi2* *R2 = corr(y,yhat)^2 =* SSR	Chi2(4) = 4.55554 *(0.336013)* --- ---	--- --- 0.894434 4.26857	--- --- --- ---
Durbin-Wu-Hausman Test [c] *p-value*	--- ---	Chi2(3) = 16.89 *(<0.001)*	--- ---
Sargan test [d] *p=prob > Chi2*	--- ---	LM =0.0536085 *(0.973552)*	--- ---
Cragg-Donald (weak instruments) [e] *Critical value (5%)*	--- ---	94.5252 *(9.53)*	--- ---
H_0: $\alpha + \beta + \gamma 1 + \gamma 2 = 1$ F-statistic/Chi2 *p-value*	H_0 is rejected F-stat=5.38753 *(0.021205)*	H_0 is rejected Chi2(1) = 14.5818 *(<0.001)*	--- --- ---
H_0: $\alpha + \beta + \gamma 1 + \gamma 2 = 1.4$ F-statistic	H_0 is not rejected F-stat=0.921756	--- ---	--- ---
p-value	*(0.338078)*	---	---
H_0: $\alpha + \beta + \gamma 1 + \gamma 2 = 1.8$ Chi2 *p-value*	--- --- ---	H_0 is not rejected Chi2(1) = 1.40852 *(0.235302)*	--- --- ---
Returns to scale	Increasing	Increasing	---
Dynamic panel - Auto-correlation AR(2) [f] *z* *p-value*	--- ---	--- ---	-1.38537 *(0.1659)*
Dynamic panel - Sargan test [d] *p-value*	--- ---	--- ---	Chi2(181) = 225.161 *(0.0143)*
Partial adjustment coefficient (δ)	---	---	0.589355
Capital long-term elasticity (α/δ)	---		0.215819
Labour long-term elasticity (β/δ)	---		0.469345
Experience long-term elasticity (γ_1/δ)	---		---
Cooperation long-term elasticity (γ_2/δ)	---	---	0.405253

Source: Own elaboration.

Notes:

***, **, * denote coefficient statistically significant at the 1%, 5% and 10%, respectively.

a. Instruments used: lnK_{it-1}, $SqlnK_{it}$, lnL_{it-1}, SqlnLit, $lnExper_{it-1}$

See Notes b to f of Table 3.

Model (4) reports the results from the random effects[23] specification estimated by Generalised Least Squares (GLS), since the Hausman test indicates to be more suitable in comparison to the fixed effects model. As it can be seen all elasticities are statistically significant at the 1% high significance level (except the experience elasticity which is significant at the 5% level only), and all carry their expected positive sign. Once more the capital elasticity is higher than the labour elasticity, and also higher than the other additional factors of production, work experience and cooperation. In this augmented production function, work experience and cooperation between companies are shown to generate higher production in the moulds sector, therefore are suitable proxies for human capital, the former related to the learning by doing activities, the latter to the management strategy through cooperation. In particular our evidence shows that a 1% increase in work experience is responsible for 0.28% increase in the moulds production (everything else constant) and that output increases by 0.32% for each 1% increase in company´s cooperation in this sector. Capital and business cooperation are the input factors with the highest impact on the moulds production.

Another important result to analyse is the evidence on the economies to scale, testing the hypothesis that all factor elasticities sum to 1. This hypothesis is rejected at the 5% significance level, but the hypothesis of the sum of the factor elasticities being equal to 1.4 is not rejected at the conventional significance levels (see Table 4). Therefore, we have evidence that increasing returns to scales are at work in this sector when additional factors are added in the production function related with human capital in the form of work experience and business cooperation strategy. This evidence is in line with the endogenous growth approach that input factors associated with human capital are responsible for generating higher productivity (at least in the long-run) compensating the diminishing returns of other factors of production, such as capital.

Model (5) of Table 4 shows the results of the 2SLS estimation approach applied to the augmented production function with fixed effects. The new variables used as indirect proxies for human capital can also be endogenous, insofar as the decision to increase the product can entail the need to resort to greater cooperation among the companies (by means of a greater volume of subcontracting) or the need to incorporate a higher level of technology in the equipment may require more experienced workers. As it can be seen by the Durbin-Wu-Hausman test, the hypothesis of the exogeneity of the explanatory variables (no correlation between the input factors and the error term) is rejected confirming the use of instrumental variables to tackle the problem of the endogeneity of regressors. As the

[23] The regression results from the fixed effects model do not differ significantly from those obtained using the random effects model. We present the results from the random effects model in order to be coherent with the Hausman test conclusion.

Sargan test shows all the instruments used in the estimation approach are valid and by the Cragg-Donald statistic the instruments used are not weak[24].

Analysing the estimated coefficients, all elasticities are statistically significant at the highest 1% significance level, and all carry their positive sign. Comparing with the previous model (4) where the endogeneity problem of regressors is ignored, the capital impact on production is found to be lower, but the labour and work experience impacts are higher, while the impact of business cooperation remains the same. Therefore, the capital elasticity is overestimated and the labour and work experience elasticities are underestimated in model (4) when the endogeneity problem of input factors is not controlled for. In this new 2SLS estimation, there is a notable reinforcement in the elasticity of the work experience showing that the moulds production increases by 0.55% when work experience increases by 1%, everything else being constant.

Testing the presence of economies to scale, once again the neoclassical hypothesis of constant returns to scales is rejected in favour of the presence of increasing economies to scales which are higher now in comparison to model (4), (1.8 against 1.4). This is important evidence showing the presence of significant externality effects generated from the additional human capital proxies, work experience and business cooperation.

Model (6) of Table 4 reports the results of the dynamic estimation of the augmented production function including human capital. The GMM estimation technique is applied as suggested by ARELLANO and BOND (1991). The estimation results are also satisfactory except the fact that the work experience factor losses its statistical significance. All other short-run estimated coefficients are significant at the 1% highest level, including the lagged dependent variable, justifying that the stock adjustment model applies quite well in the moulds augmented production function. The stock (or partial) adjustment coefficient denotes a relatively quick adjustment, that is, 58.9% of the actual variation of the production adjusts to its optimal level within the same year, although is slower than that found when we estimated the conventional production function (see Table 3).

The advantage of estimating the dynamic production function is that allows to determine the long-run input factors elasticities (see Table 4). The long-run elasticities suggest that if capital, labour or business cooperation between companies were to increase by 1%, it is estimated that the average increase in the product obtained in the long-run would be around 0.22%, 0.47% and 0.41%, respectively (*ceteris paribus*).

In general, the results obtained by means of the estimates from the diverse models demonstrate the relevant role human capital plays not only as a factor of production but also as a factor that contributes to generate increasing returns to scales through externality effects that increase the productivity of other factors of production.

[24] See the Notes of Table 4.

7 SUMMARY AND MAIN CONCLUSIONS

The main objective of this study was to analyse the production function of a specific industrial sector in Portugal referred to the moulds for plastics industry. Three aspects distinguish this study from others in the relevant literature: (i) an attempt was made to employ macroeconomic theory based on the neoclassical growth approach, the endogenous growth approach and the Keynesian doctrine to a micro-data analysis considering a particular sector (moulds for plastics companies) as a case study in Portugal; (ii) estimate the conventional production function assuming that factors of production (capital and labour) are endogenous to the production process and also a dynamic form by using unbalanced panel data. Quantifying the economies of scale was also an objective in this step; (iii) estimate an extended production function with human capital proxies as additional factors of production and verify whether increasing returns to scale are at work due to externalities induced by learning by doing process through work experience and business cooperation strategy.

Estimating the conventional production function with labour and capital (incorporating advanced and innovative technology) we confirmed the presence of constant economies to scale favouring the neoclassical hypothesis on this matter. However, applying the 2SLS estimation approach we verified that input factors are endogenous and if this problem is not tackled properly the labour elasticity would be overestimated. The confirmed endogeneity of the productive factors gives support to the Keynesian point of view that production is demand constrained and not supply constrained as the neoclassical approach assumes. Estimating a dynamic production function we concluded that the stock adjustment mechanism is well adapted to the micro data panel analysis revealing a relatively high degree of adjustment (61.4%) of the actual production to its desired level.

Extending the model to include human capital was the core issue to address in our study and the results are interesting even though the company´s sample becomes smaller. Professional experience was used to reflect skilled human capital, representing the high level of professional and personal skills of workers and their capacity for innovation and adaptation to the cutting edge technology used in the sector. Additionally the level of cooperation between companies was considered as another factor reflecting management strategy, measured by means of the subcontracting of one or more phases of the production process or even the final product. This strategy reflects not only the cooperation spirit of the involved companies and the underlying trust, but also the ease and speed of the implicit dissemination of knowledge and innovation as well as the management efficiency.

The augmented production function was estimated by means of the random effects specification and showed that human capital in the form of work experience and business cooperation are two important additional factors contributing significantly in the increase of output in the moulds sector. The most important evidence found was that by introducing human capital measures in the production function the sector shows increasing returns to scale properties confirming therefore the endogenous growth approach that human capital, in the long-run is responsible for increasing the productivity of other factors of production and therefore generating positive externalities in the production process. Given the sector's peculiar characteristics, these human capital externalities are purely technological, occurring by means of an exchange of ideas, imitation or learning by doing, but also MAR type externalities, via the diffusion of knowledge promoted by innovation, work experience, cooperation between companies (located in close proximity) and corporate strategy. Estimating the augmented model by 2SLS it was again shown that factors of production are endogenous and demand driven as the Keynesian approach postulates. Finally, the estimation of the dynamic form of the production function revealed that business cooperation was the most significant input factor among the two human capital proxies used and that the adjustment process is slower, about 58.9% of the actual variation in the production of moulds adjusts to its optimal level within the same period.

In general, our empirical evidence shows the relevant role human capital plays, along with the physical capital (including cutting edge technology) generating positive externalities in the production process, thus helping to explain the success that the moulds industry has achieved over the recent decades.

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