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IMPACT OF HUMAN CAPITAL ON THE PORTUGUESE ECONOMY MEDIATED BY INTELLECTUAL PROPERTY

Cátia Rosário
Escola de Ciências Económicas e das Organizações, Universidade Lusófona de Humanidades e Tecnologias
Lisboa – Portugal

António Augusto Costa
Escola de Ciências Económicas e das Organizações, Universidade Lusófona de Humanidades e Tecnologias
Lisboa – Portugal

Ana Lorga da Silva
Escola Superior Náutica Infante D. Henrique
Paço de Arcos - Portugal
Universidade Lusófona de Humanidades e Tecnologias
Lisboa – Portugal

Abstract: Human capital and innovation are essential for the growth and development of nations. Human capital is an essential factor of production, being a positive externality that affects the economy in many ways and one of them is through its impact on innovation. The study presented refers to Portugal, between 2000 and 2015, with the main objective of analyzing the influence of human capital on the Portuguese economy through the results of innovation. Through the use of structural equation models, it was possible to establish a causal relationship between the following dimensions:

- Human Capital, which is the result of a latent factor, considered as the cause of the variables observed with regard to the number of graduates in different areas of education.
- Economic Growth, where the Gross Domestic Product was used as a measure.
- Innovation results, which were measured through intellectual property, more specifically, through the registration of patents, brands and designs.

In the model obtained, the results of innovation were used as moderating variables, allowing the analysis of the indirect impact of human capital on economic growth. This way, it is possible to conclude about the relationship between the mentioned variables, highlighting the importance of economic measures taken in terms of education, science and technology, contributing to the promotion of innovation in Portugal.

Keywords: Human Capital, economic growth, education, innovation, structural equation models.

INTRODUCTION

Currently, knowledge plays a fundamental role in the world economy, where new technologies, studies and information are abundantly generated by universities, laboratories, research centers and accumulated by all individuals in society (Petry & Santos, 2018). This way, human capital and innovation are changing technical capital and energy, and the current era of the knowledge economy is governed not only by creation, but also by harnessing the knowledge and skills of the people who make up the workforce. of countries. This knowledge creation has an impact on the economy, not only directly through the increase of skills and abilities, but also indirectly through other areas, such as innovation.

Although different types of innovation have been increasing in importance, attention must be paid to organizational innovation, marketing innovation, social innovation, among others, the innovation with the greatest impact on the economic and social fabric continues to be technological innovation.

Economist William Baumol points out that "practically all the economic growth that has taken place since the 18th century can be attributed to innovation". In this sense, it is important to assess the impact of innovation outputs on the country's economy. These outputs can be measured using records relating to intellectual property and taking into account that one of the most important inputs of innovation is at the level of human capital, then it is essential to understand how human capital influences innovation and, therefore, therefore, what is its impact on economic growth. This way, it will be possible to assess the adequacy and success of human capital in promoting innovation and the country's economic results.

The analysis of structural equation models allows, among other aspects, to establish a causal relationship between variables, and the model to be built implies the use of manifest variables. Human capital is representative of the general level of knowledge and skills provided by formal education. This way, through the use of exploratory factor analysis it is possible to construct a factor that represents this dimension of knowledge, being possible to evaluate the relationship between the three dimensions mentioned: human capital, innovation and economic growth.

THEORETICAL FRAMEWORK

A knowledge-based economy is based on the ability to generate, store, retrieve, process and transmit information, functions potentially applicable to all human activities (Tigre, 2012). Not being an inexplicable phenomenon with unknown origins, but as a logical step in the evolutionary development of productive forces, resulting from the transfer of scientific knowledge and which allows reaching a new level of quality (Pilipenko, 2015).

"We defined the knowledge economy as production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence. The key component of a knowledge economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources." (Powell and Snellman, 2004, p.199).

According to the Organization for Economic Co-operation and Development (OECD) the definition of a knowledge economy involves "a knowledge-based economy is defined as one where knowledge (codified and tacit) is created, acquired, transmitted and used more effectively by enterprises, organisations, individuals and communities for greater economic and social development." (OECD, 2000, p.13)

According to the Australian Bureau of Statistics (ABS), the definition of the knowledge economy, presented by the OECD, was expanded by the Asia-Pacific Economic Co-operation (APEC), considering that

"KBE does not rely solely on a few high technology industries for growth and wealth production. Rather, all industries in the economy can be knowledge intensive, even so called 'old economy' industries like mining and agriculture." (ABS, 2002, p.2).

The Portuguese Innovation Society (SPI) highlights the importance of the different characteristics of knowledge, its production and application in the country's economy. According to the SPI (2007) the designation «Knowledge Economy» can be seen with a double meaning:

- Refers to economies that have high proportions of knowledge-intensive employment, where the weight of information-related activities is an essential factor for their economic performance and also the fact that the weight of intangible capital is greater than that of tangible capital.
- It can be seen as an economic category, with its own characteristics and typologies, in terms of its mode of production, diffusion and transformation into innovation and its role in the dynamics of economic growth and in its spatial organization. The knowledge economy involves the relationship between institutions, technologies and social regulations, which can facilitate the production and use of knowledge by properly defining the allocation of resources that maximize the creation and dissemination of knowledge.

According to the authors Tocan (2012) and Pilipenko (2015) the knowledge economy differs from the traditional economy in some aspects, of which the following stand out:

- Unlike most resources that run out when used, information and knowledge can be shared, growing through their application.
- Geographical and temporal barriers can be overcome through the use of appropriate technology and methods, creating marketplaces and virtual organizations that allow a global reach of operations.

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- The purpose of the knowledge economy is to promote creative capacity and increase the level of knowledge, while in the traditional economy it is just to make the most of the invested capital.
- In the knowledge economy, laws, barriers and taxes are difficult to apply at the national level, as knowledge will eventually be channeled to where demand is highest and barriers are lowest.
- Price and value depend on context, ie the same information or knowledge can have very different values for different people at different times.
- In the traditional economy, the maximum exploitation of productive factors such as natural resources, technology and human capital is sought. In the knowledge economy, there is an attempt to create and use new knowledge efficiently, interacting with nature and society, promoting well-being.

The knowledge economy explains the economic growth and development of countries, and it is important to define the structure on which this concept is based (Guile, 2008). This structure is based on the economic and institutional environment that provides incentives for the creation, dissemination and efficient use of knowledge. Alongside this dimension, there is a relationship between three dimensions of equal importance: education (given that a population with high levels of education makes it possible to optimize the use of knowledge), innovation (given that an effective system of organizations makes it possible to adapt and use the knowledge created) and an information infrastructure system (which facilitates the communication, processing and dissemination of information). (e.g. Australian Bureau of Statistics, 2002; World Bank, 2007 and OECD, 2015).

According to the World Bank (2007) the success of the knowledge economy depends on a workforce formed by skilled workers, capable of continually updating and adapting their skills to create and use knowledge efficiently.

ABS (2002) states that, alongside education, the existence of a modern and adequate information and communication structure is essential, facilitating the sharing and dissemination of the knowledge created. However, according to the World Bank (2007), for ICTs to be correctly used, the existence of an adequate structure of human capital is essential. Likewise, an effective innovation system is essential, formed by companies, research centers, universities and other organizations, which, in addition to creating knowledge, are able to materialize this knowledge, thus contributing to economic growth and development.

The economic and institutional structure of a country is essential to the development of the knowledge economy, as it encompasses the set of economic incentives allowing the efficient mobilization and allocation of resources, stimulating innovation and entrepreneurship, as well as the creation, dissemination and use knowledge efficient.

The OECD (2015) also states that economic growth and development largely depend on the creation of a stable and open macroeconomic environment, with an effective information and communication technology structure, capable of promoting the development and diffusion of innovation. Furthermore, an adequate investment in the promotion and development of human capital, creating conditions that stimulate creativity, innovative capacity and entrepreneurship.

As mentioned, the acceptance of innovation and knowledge as fundamental for economic growth is consensual and, as Cunha, Rego, Campos, Cabral-Cardoso and Neves (2016) mention, allows increasing the level of knowledge, expanding the capacity to convert resources into well-being and leads to improvements in the efficiency of the economy.

Porter (2007) states that knowledge is essential for the growth, development and well-being of nations, with innovation assuming a prominent position as it enhances the creation, exploitation and dissemination of knowledge. This way, innovation has become a challenge that defines global competitiveness, having ceased to be an option to become a primordial necessity.

Joseph Schumpeter (1939) highlighted the importance of innovation as a form of "creative destruction" that leads to value creation. This author sought to establish a relationship between technological advances and economic cycles, considering that innovation is essentially reflected in terms of technological changes, improving products and processes that lead to improvements in the production function.

According to the OECD (2015) innovation involves the implementation of a new or significantly improved product (good or service), process or marketing method, or a new organizational method in business practices, the workplace or external relations. The OECD also mentions that innovation is not only reflected at the level of technological development, given that this has a significant weight in the economy of countries.

Cunha et al (2016) emphasize that, in addition to the above and new technological solutions, innovation encompasses the establishment of new agreements with suppliers, as well as new ways of providing after-sales service, new modus operandi for the relationship with customers, among other practices.

Tocan (2012), in his review of the determinants of the knowledge economy, summarizes the main characteristics of innovation, and the World Bank (2007) and the OECD (2015) also present some references on how this dimension can be measured:

- Research and potential for knowledge creation, which is based on the performance of basic research carried out by companies.
- Creation of knowledge with commercial application, which can be expressed by the increase in intellectual property registrations.
- Knowledge networks and flows, which is based on the sharing of knowledge between companies, universities, the state and other organizations.
- Innovation and innovation support activities, which can be described as the market introduction of new or improved products or processes, whether resulting from technological or non-technological innovations. Its development is supported by investments in R&D, as well as in venture capital.

The European Commission, through the publication of the European Innovation Scoreboard (2016), also seeks to measure the innovation performance of EU countries, comparing it with other countries such as Japan and the USA. To this end, it prepares a synthetic index of innovation, based on the Community Innovation Survey (CIS) and which is determined using 25 indicators, grouped into three main dimensions: Capabilities, Business activities and Innovation Outputs. Similarly, The Global Innovation Index (2016) is also a composite indicator, resulting from the partnership between Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO) and in this case, 82 indicators grouped into eight dimensions are used: Institutions, Human Capital, Infrastructure, Business and market sophistication, Creativity, knowledge and technological outputs.

Both the EIS (2016) and the GII (2016) present a set of common indicators:

Expenditure on R&D, registration of patents, brands and designs, scientific publications, exports of medium and high technology, population with higher education, among others.

Transversal to the various organizations that seek to measure innovation is the recognition of human capital and, as Cunha et al (2016) and Planing (2017) emphasize, human capital is fundamental because innovation begins through the creation of knowledge that materializes in an invention, subsequently leading to the creation of a new or improved product/service to be placed on the market.

According to Schultz (1961) the concept of human capital refers to the set of intangible resources inherent to the work factor, improving its quality and productivity. Nelson and Phelps (1966) emphasize that this concept is fundamentally related to the knowledge and skills that individuals acquire throughout their training and experience, and it is extremely important to invest in people.

It is true that several measures of innovation are identified, when it comes to analyzing their inputs, the importance of human capital stands out, given that, as Kotsemir and Meissner (2013) mention and, as stated in the Frascati Manual (OECD, 2015b), one of the foundations for creating innovation lies in R&D, which integrates fundamental research, applied research and experimental development, resulting from the combination of existing knowledge, the creation of new knowledge and the combination of both.

Knowledge is a reflection of the success of human capital and Goldin (2014), Veugelers and Del Rey (2014) and Burgess (2016) define this concept as the set of knowledge and skills that constitute the workforce of organizations and, therefore, can be seen as an intangible asset essential to organizational success.

Benhabib and Spiegel (1994) emphasize the direct impact that human capital has on economic growth, since individuals with superior academic skills can become more productive, entrepreneurial and innovative, and therefore human capital contributes directly to improving productivity. of the factors. Human capital also has an indirect impact on the economy, as it increases the capacity to absorb ideas and technologies from other countries (Nelson and Phelps, 1966; Benhabib and Spiegel, 1994; Teixeira and Fortuna, 2010).

When considering human capital as a dimension of the knowledge economy, Tocan (2012) highlights some characteristics and similarly the World Bank (2007) as well as the OECD (2015) describe the main aspects related to this dimension:

- Stock of qualified people, which is perceived by the population's education and qualification levels.
- Flow of qualified people, related to the loss and gain of workers with knowledge, resulting from schooling and professional experience.
- Investment in the formation of human capital, measured by expenditure on education and training by the government and companies

Karchegani, Sofian and Amin (2013) also mention that examples of human capital are innovative capacity, know-how and previous experience, ability to work in a team, flexibility, tolerance, motivation, satisfaction, ability to learn, loyalty, formal learning in academic organization and training.

Based on the definition of innovation and human capital, it is important to highlight that, as Valente (2014) and Sarkar (2014) refer, innovation is, to a large extent, the successful result of efforts of human capital. It is also highlighted, as mentioned in the GII (2016), that human capital can contribute directly to innovative activity or can do so indirectly, through the absorption of technologies from other countries.

METHODOLOGY

At this point, the methodology used in the data processing performed is presented, supporting the analysis of the results obtained.

STRUCTURAL EQUATIONS MODELS

Structural Equation Models (SEM) are a statistical technique that combines factor analysis and linear regression techniques, based on a theoretical framework that is intended to be confirmed.

"The term structural equation modeling (SEM) does not designate a single statistical technique but instead refers to a family of related procedures. Other terms such as covariance structure analysis, covariance structure modeling, or analysis of covariance structures are also used in the literature to classify these techniques under a single label." (Kline, 2016, p. 9)

Hoyle (2012) highlights the possibility of relating manifest variables (directly observable variables) with latent variables, or constructs, which are the result of a factor common to a given set of manifest variables. According to this author, it is important to differentiate MEE from similar statistical models, such as ANOVA and multiple regression analysis. The MEE are the result of the creation and relationship of parameters, which are intended to better represent the observed data.

In short, an advantage that stands out in the use of MEE is the possibility of establishing transversal and longitudinal causal relationships, which specify direct and indirect effects between variables, which may or may not be directly observable (Hoyle, 2012 and Kline, 2016).

The analysis of structural equations must obey a set of steps defined a priori. It starts with the formulation of the theoretical model, where the endogenous and exogenous variables are defined, being essential an appropriate review of the state of the art so that the selected variables, as well as their relationship, are adequate.

As summarized by Kline (2016), after formulating the theoretical model, it is specified, defining the relationships between manifest and/or latent variables, as well as the restrictions to be imposed, including errors and correlations. This stage therefore consists of the formal formulation of the theoretical model, taking into account the type of model to be built, as it may be in the presence of, for example, simple or multiple linear regression models, Path Analysis, causal models with latent variables, latent growth models, among others.

Then, the data collection is carried out, that is, the data most suitable for the representation of the variables to be analyzed are selected, in order to later obtain the estimates of the model parameters that reproduce the sample data, this estimate being made from the covariance matrices of the manifest variables. The size of the sample must also be taken into account, as there is no total consensus on the minimum number of observations, since it will depend on the model to be used. Marôco (2014a), in his review of the literature on the minimum sample size, highlights the hypothesis of considering at least 5 observations for each variable, with authors such as Kline (2016) who advocate a sample of at least 100 to 150 observations.

In the model estimation step, factor weights, regression coefficients, covariances, among other estimates related to the model parameters are obtained. In this phase, it is established how the latent variables must be measured, if any, and which structural model to use, since this can be causal or correlational.

Subsequently, the quality of the model is evaluated using the chi-square test (c2), and adjustment quality indices can also be applied. In the case of quality indices, it is possible to distinguish absolute indices that evaluate the model without comparing it with others, relative indices that evaluate the quality of the model in relation to the model with the worst and best fit, parsimony indices that seek to compensate for the artificial improvement of the model obtained. Residual analysis, parameter significance and individual reliability can also be carried out since, as Schumacker and Lomax (2010) mention, the model can have a good global fit, but still present a poor local fit.

If the model cannot be validated, it must be respecified, correcting possible errors in the estimation, or even if it is necessary to change the relationships between variables, taking into account the constraints imposed by the theoretical model that serves as a basis. In the summary of the steps proposed by Hoyle (2012) and Kline (2016) it appears that after the model is respecified, the process must be restarted (if it was necessary to make a new specification), or correct any estimation errors. Since, in both cases, the construction and analysis steps of the model must be carried out again until it is possible to validate it, the results obtained must be analyzed and their comparison with the theoretical framework underlying its construction must be analyzed.

FACTOR ANALYSIS

Yong e Pearce (2013) refer that factor analysis is a multivariate statistical procedure frequently used to identify one or more latent variables that share a common variance and are not observable. In other words, it is a general linear modeling technique, whose objective is to identify a reduced set of factors that explain the correlational structure observed between a set of manifest variables. Thus, Brown (2006) highlights that the basic principle of factor analysis is based on the premise that the covariance/correlation between a set of variables is due to the existence of one (or more) common latent factor(s).) to these same variables.

Factor analysis can be classified into two types, depending on the existence or non-existence, a priori, of hypotheses about the correlational structure between the variables to be analyzed and as mentioned by Brown (2006) when there is a theory that provides prior information about factorial structure, then the method used is of the confirmatory type, which aims to confirm latent factors of certain specific variables, according to a pattern previously established in the theory. Another type of factor analysis is exploratory, where, as mentioned by Taherdoost, Sahibuddin and Jalaliyoon (2014), the objective is to determine and analyze the structure of a set of interrelated variables, in order to build a measurement scale for factors that control the original variables.

The exploratory factor analysis process can be described through 5 fundamental steps (Taherdoost, Sahibuddin and Jalaliyoon, 2014). In other words, for the factor analysis to be correctly applied, one must start by selecting the data, taking into account that they must be quantitative (continuous or discrete). Likewise, the adequacy of the sample size must be ensured and in this case the initial premise was that the number of observations must be as large as possible. However, when you are in the presence of high commonalities (greater than 0.8) then the sample size can be smaller. Equally important to verify that the data are adequate is the analysis of the correlation between the variables. In this case, correlation coefficients lower than 0.3 indicate that the exploratory factor analysis is not adequate and similarly, perfect correlations also do not add value and invalidate the application of this method.

Before proceeding with the factor extraction method, some tests must be carried out to assess the adequacy of the sample, evaluating "when the correlations between the original variables are high enough for the FA to be useful in the estimation of common factors" (Marôco, 2014b, p.476).

The KMO method is a measure of sampling adequacy that assesses the homogeneity of variables, comparing simple correlations with partial correlations between variables (Kaiser, 1974). In this case, the recommendation regarding the adequacy, or not, of the factor analysis is related to the KMO values, considering that it is possible to proceed with the analysis if the KMO value is greater than 0.5, the higher the better. Finally, Bartlett's sphericity test which, as mentioned by Yong and Pearce (2013), indicates whether an identity matrix is present and if that is the case then factor analysis is not adequate.

After validating the adequacy of the data, the method for extracting factors is determined and as mentioned by Osborne and Costello (2009) there are several methods for extracting factors: from principal components; maximum likelihood; main axis factorization; image factorization; generalized least squares; unweighted least squares; among others. These authors highlight the fact that the advantages and disadvantages of each of these methods are not consensually defined in the literature. Even so, three methods used more frequently can be highlighted: of the main components; maximum likelihood and principal axis factorization method.

The third step concerns the retention of factors and for that, there are several rules that must be used together, of which the following stand out: Kaiser Criterion, Scree Plot Criterion, Accumulated Variance Percentage, among others (Taherdoost, Sahibuddin and Jalaliyoon, 2014). In summary, the use of each of the criteria can be clarified as follows: Kaiser criterion (eigenvalue greater than 1), where the factors to be retained must be those that explain more information (variance) than the standardized information of a original variable, which is 1; Scree plot criterion, where the graphical representation of the factors (on the abscissa axis) and of the eigenvalues (on the ordinate axis) allows the analysis of the relative importance of each factor to explain the variance of the original variables. In this case, it is considered that the number of factors to be retained corresponds to those above the breaking point (inflection) (Ledesma, Valero-Moura and Macbeth, 2015); Percentage of accumulated variance, in which, as mentioned by Henson and Roberts (2006), there is no consensus regarding the minimum accumulated variance acceptable for all areas of research, considering, for example, that in natural sciences the admissible values are greater than 95%, while in the humanities values between 50% and 60% are already acceptable (Taherdoost, Sahibuddin and Jalaliyoon, 2014).

The factor rotation method follows, where Osborne and Costello (2009) emphasize that the factor rotation method will not improve the basic aspects of factor analysis, but will allow a more accessible factorial solution to be interpreted. There are two types of rotation that can be applied, oblique and orthogonal rotation and, as Osborne and Costello (2009) mention that the objective is to maximize the weight of a reduced set of variables in one factor and minimize the weight in other factors. Within the orthogonal rotation type, there are several possible methods to apply: Varimax, Quartimax and Equamax. The Varimax method aims to obtain a factor structure where only one of the original variables is strongly associated with a single factor and little associated with the others. According to Taherdoost, Sahibuddin and Jalaliyoon, (2014) this method has a relative consensus, being the one that is frequently used as it provides a simple structure that is easy to interpret.

Once the previous steps have been completed and the factors obtained, it is necessary to proceed with their interpretation. This step lacks an exact methodology, given that the labeling of the factors obtained is, as Taherdoost, Sahibuddin and Jalaliyoon (2014) emphasize, a theoretical and subjective process.

DATA AND VARIABLES

The data collected are related to Portugal, being annual data referring to the period from 2000 to 2015. For this, the PORDATA database, Contemporary Portugal Database, organized and developed by the Francisco Manuel dos Santos Foundation was used. It was found that, for the period under analysis, none of the indicators collected shows a break in the series, nor is there any missing values, thus not compromising the validity of the analysis performed.

Table 1 defines the indicators used and the variables they represent.

The selection of indicators that represent the indicated variables was carried out based on a literature review. GDP per capita is the indicator that gathers the greatest consensus as a measure of the country's wealth, given that it indicates the wealth created per inhabitant, that is, GDP alone does not give an indication of the impact that the wealth generated has on the population, given that the country could increase its wealth and still its inhabitants become poorer. This indicator has been used in numerous studies that aim to analyze the economic growth of countries, such as Barro (1991), Easterly and Levine (1997), Hartwig (2012), among others.

As for innovation, as mentioned in the literature review, it is possible to identify the use of a wide set of indicators, with the registration of patents, brands and designs being present in most studies, as mentioned by Sarkar (2014) and as used by the European Commission through the EIS (2016) and also in the GII (2016), where the intellectual property register has been used as one of the measures of innovation outcomes.

With regard to human capital, the use of indicators to measure this dimension has evolved over the last few decades, depending on the information provided by countries. As an example, Barro (1991) used «enrollment rates by grade», Easterly and Levine (1997) measured human capital using the «average education of the population» and in turn Hartwig (2012) used «expenditure on education and health". However, Valente (2014), in his study on education, innovation and economics in the European economy, sought to use disaggregated information, using the percentage of graduates in social sciences, management and law, engineering and manufacturing, science, mathematics and computing. Likewise, the OECD (2015) highlights the importance of using information on the number of graduates per area of education, allowing a more accurate assessment of the impact that different academic backgrounds have on innovation results and, consequently, on the economy of countries.

ECONOMETRIC MODEL AND DESCRIPTION OF TESTS

Following the steps of the analysis of structural equation models, the theoretical model formulated here relates human capital, innovation and economic growth. In theory, both innovation and human capital contribute to economic growth and, taking into account that the results of innovation are based on inputs, including human capital, then it is necessary to establish the relationship between these two variables. Therefore,

Variable	Indicators		Definition / Description
Economic growth	Gross Domestic Product per capita		The Gross Domestic Product (GDP) is the measure used to evaluate the performance of the economy, and can thus be considered the measure of the wealth that the country manages to create. Wealth that results from production, purchase/consumption, investment and export activities. GDP per capita provides information on average wealth per inhabitant.
Innovation (Intellectual Property)	Patents (Records granted)		Official license granted to those who intend to protect an invention and in order to be allowed to register a patent, requirements regarding the novelty, inventiveness and industrial applicability of the invention must be met.
	Brands (Records granted)		Sign that identifies a company's products or services on the market, distinguishing them from those of other companies, that is, its registration reflects the expectation of a different/better service and free from the risk of imitations, this registration also being conditioned by the need existence of evidence of novelty, inventiveness and industrial applicability.
	Design (Records granted)		Design or model that protects the appearance characteristics of all or part of a product. The possibility of registration implies, as in the previous ones, the satisfaction of the requirements regarding the degree of novelty, inventiveness and industrial applicability.
Human Capital	V1	Graduates in Education	Graduates are those who have successfully completed higher education, which includes advanced academic, vocational or professional education, corresponding to higher educationshort cycle, bachelors or equivalent level, masters or equivalent level, and doctorates or equivalent level. The areas of education used in the data collection supports comply with the revised classification of the International Standard Classification of Education (ISCED).
	V2	Graduates in Arts and Humanities	
	V3	Graduates in Social Sciences, Commerce and Law	
	V4	Graduates in Science, Mathematics and Informatics	
	V5	Graduates in Engineering, Manufacturing and Construction	
	V6	Graduates in Agriculture	
	V7	Graduates in Health and Social Protection	
	V8	Graduates in Services	

Table1.Variables used in the structural equation model.

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human capital must have an indirect impact through innovation outputs, considered here as intellectual property records.

Since human capital is an intangible and to a certain extent abstract concept, we start by including all areas of training, since the registration of intellectual property is carried out in several areas, and it is not possible to determine a priori which areas of higher education leading to those records.

Figure 1 represents the specification of the theoretical model where the variable «human capital» is observed as a latent variable, representing a theoretical construct that, not being possible to observe directly, is formulated based on the manifest variables related to graduates by area. This way, a variable that represents the intangible and abstract component of human capital is obtained. This variable establishes a relationship with the different forms of intellectual property presented, as well as with GDP per capita. In this model, forms of intellectual property function as mediating variables, seeking to assess the indirect impact of human capital on economic growth.

Bearing in mind that we are not in the presence of a causal model with latent variables and that the appropriate model will be a model of mediation, then we must proceed to the construction of a manifest variable representative of «human capital». To this end, factor analysis was used, in order to obtain a factor that represents the correlational structure of the variables related to graduates by training areas.

The model to be considered in this study is, as seen in Figure 2, a mediation model formed by manifest variables.

Using the SPSS Statistics software (v. 27, IBM SPSS, Chicago, IL), an exploratory factor analysis was carried out, including the 8 different training areas. human capital". Likewise, using the AMOS software (v. 27, SPSS, At IBM Company, Chicago, IL), it was found that the indicators of multivariate normality (Ku) and of asymmetry of the frequency distribution (Sk) presented higher absolute values a 5 and 2 respectively, for the variable V6, and must therefore be excluded from the analysis, according to Kline (2016).

The factor analysis was carried out again, excluding the variable V6, having obtained a single factor, which presents an eigenvalue of 6.195, in line with the Scree Plot and the percentage of variance retained (88.499%), this factor being considered valid for describe the latent structure of the included variables. A KMO = 0.810 was observed and the results of Bartlett's sphericity test also indicate the adequacy of the data to proceed with the exploratory factor analysis. Factor extraction was performed using the principal components method, it is not necessary to evaluate the rotation method, since only a single factor was retained.

Based on the results obtained, we proceeded to the estimation and evaluation of the structural equation model, from which c2(3) = 1.736 with p-value = 0.629 was obtained, that is, the null hypothesis is not rejected: «the matrix of population covariance does not differ significantly from the covariance matrix estimated by the model». The goodness of fit indices (CFI, GFI and NFI) also indicate a model with good/very good goodness of fit. It must also be noted that, regarding the analysis of the population discrepancy, RMSEA = 0 with p-value = 0.643 was obtained, indicating that the model fit is very good. Although the model could be validated in terms of its goodness of fit, it was observed that the relationships between the variables were not statistically significant, consequently, according to the aforementioned stages of analysis of structural equation models, the model was respecified introduced.

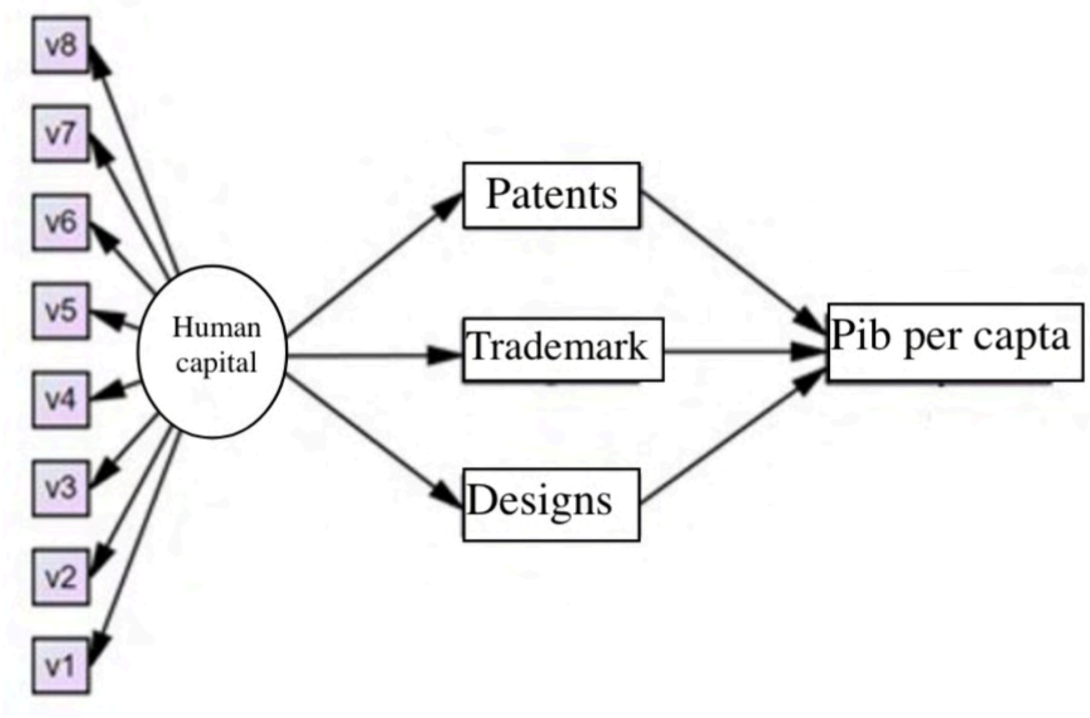

Figure 1. Specification of the theoretical model.

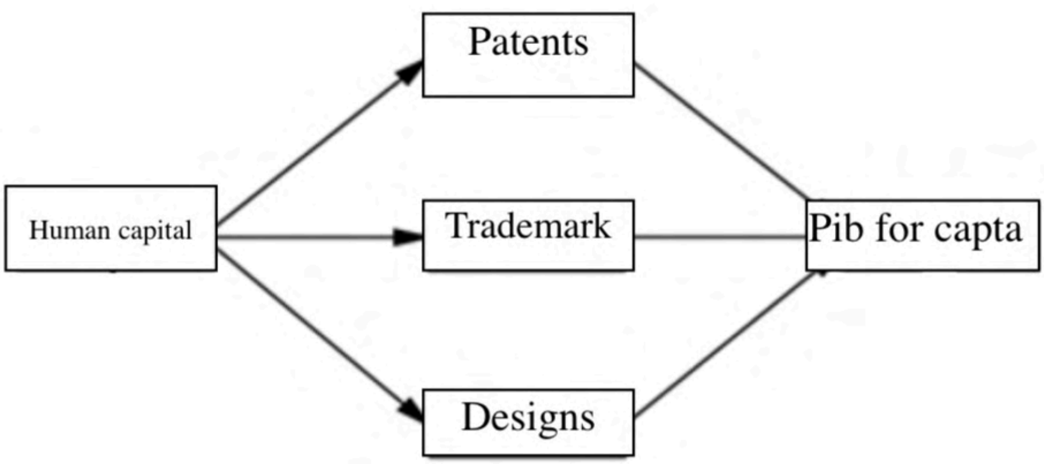

Figure 2. Specification of the innovation mediation model on GDP per capita.

Based on the literature review, it was possible to identify training areas, which are presented as theoretically more significant when it comes to contributing to the increase in intellectual property, namely Social Sciences, Commerce and Law, Sciences, Mathematics and Informatics, Engineering and Industry transformative, considering Education as well, given that it can reflect the quality of education, which is essential for the continuation of adequate training in the most diverse areas of human capital.

Factor analysis was carried out, using the variables v1, v3, v4 and v5 that represent the aforementioned training areas. A single factor was obtained, with an eigenvalue of 3.604 and through the analysis of the Scree Plot and the percentage of variance retained (90.092%) this factor is considered representative of the latent structure of the aforementioned variables. A KMO = 0.692 was obtained and, together with Bartlett's sphericity test, satisfactory conditions are considered to be in place to continue the exploratory factor analysis. As before, the principal components method was used to extract the factors and once again it is not necessary to evaluate the rotation method, having obtained the factor:

$$\widehat{Human\ Capital} = -0{,}252\ V1 + 0{,}263\ V3 + 0{,}263\ V4 + 0{,}275\ V5$$

As it can be seen, the variable v1, relating to graduates in Education, has a negative score, which means that, for the period under analysis, the number of people with higher education in the area of education is not positively explained by the factor considered. as representative of the general level of knowledge and skills provided by formal education. It was decided to keep this variable in the construction of the «human capital» factor, given that the results obtained with the exploratory factor analysis proved to be satisfactory for the analysis carried out.

The estimation and evaluation of the goodness of fit of the structural equations model was again carried out, where it was obtained

$x^2_{(3)}$ = 0,908 with p-value = 0.823, quality scores greater than 0.95, and RMSEA = 0 with p-value = 0.831.

The Minor Expected Cross-Validation Index (MECVI) was also used, which reflects the theoretical adjustment of the model, allowing the comparison of models. In the final model, MECVI = 2.727 was obtained, being lower than the MECVI = 2.782 verified in the previous model, which is indicative of a better validity in the sample under study.

In short, the final model obtained explains the relationship and impact of human capital on economic growth, indirectly (through innovation), and this variable is the result of a latent factor between the manifest variables Education (v1), Science Social, Commerce and Law (v3), Science, Mathematics and Informatics (v4) and Engineering and Manufacturing (v5). As this model presents a good quality of fit, it is possible to proceed with the last stage of the analysis of structural equation models, referring to the interpretation of the results.

ANALYSIS OF RESULTS

In a first analysis of the model obtained and presented below, there are the standardized measures of the regression coefficients and R2. The adjusted model explains 90% of the variability of GDP per capita, and all observed trajectories are positive and statistically significant for a p-value <.01, with the exception of the direct effect of Brands and Designs on GDP per capita.

Through the model presented in Figure 3, it is observed that the constructed factor explains 38% of the variability regarding the registration of patents, 81% when it comes to

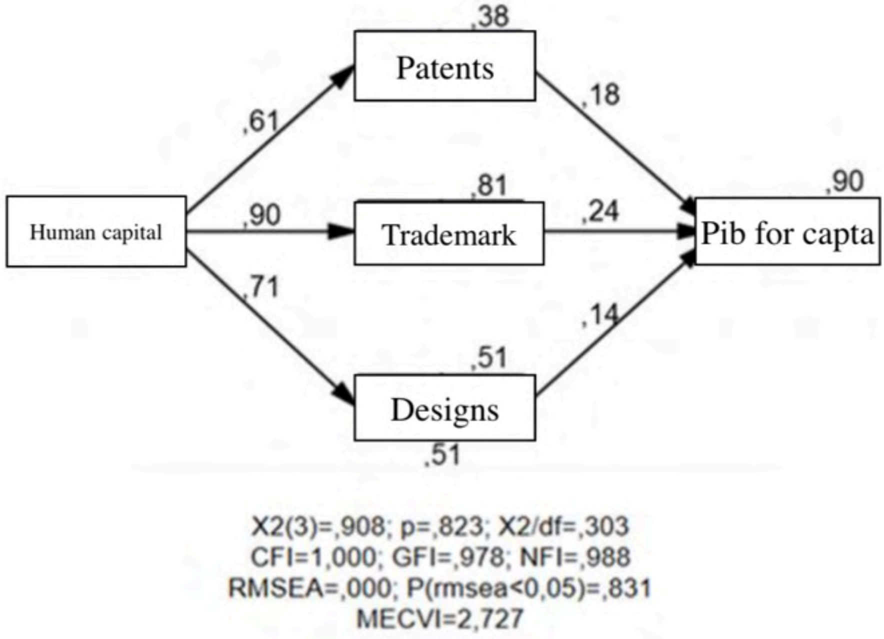

Figure 3. Innovation mediation model on GDP per capita.

the variability regarding the registration of trademarks and 51% of the variability regarding the registration of designs.. The «human capital» presents different contributions to these different forms of intellectual property, with a contribution of 0.61 for «Patents», 0.90 for «Brands» and 0.71 for «Designs».

It appears that the variable «human capital» has a total effect of 0.6198 on GDP per capita, an indirect effect, mediated through the variable «Patents», of 0.1098, confirming the assumptions made in the literature review. The indirect impact reveals that Portugal, despite having a developed economy, has limitations regarding the application of higher education in the development of economically viable innovations.

When analyzing the evolution of the variables presented here, it appears that in terms of human capital, graduates in Education have declined over the last 16 years, with a negative variation of around 2.24%, reflecting the recognition of the need to channel the higher education for other areas. The opposite can be seen when analyzing the other training areas, which have seen an increase in the number of graduates, with a variation of 1.61% in Social Sciences, Commerce and Law, 4.10% in Sciences, Mathematics and Informatics and 5.93% in Engineering and Manufacturing. Based on the model presented, this progress justifies the positive evolution observed in terms of intellectual property registration, where patent grants have increased by an average of 14.61%, brands 20.86% and designs 8.85%.

GDP per capita shows an average growth of 2.25%, with the exception of the period from 2009 to 2012, which was -1.37%, reflecting the economic crisis that was felt essentially in those years, as well as the economic contraction caused for the political-economic measures necessary to overcome it.

This way, based on the results obtained in the model and analyzing the evolution of the variables under study, it appears that the country's economic growth has evolved at a slower pace, being positively explained by the human capital that, in the same way, does not show high growth rates. Alongside this situation, there is a strong effort to increase the country's stock of intellectual property. However, human capital does not have a marked impact through innovation outputs, which means that a part of intellectual property records is the result of other constraints.

CONCLUSIONS

Through the application of the structural equation model, based on manifest variables, in which the human capital variable was obtained using factor analysis, it was observed that in the period from 2000 to 2015, Portugal presents a dimension of knowledge with a reduced contribution to economic growth, mediated by innovation outputs.

Even so, human capital, using higher education as a proxy, has a positive impact on economic growth, which reflects the adequacy of education in areas other than innovation, which may include increasing the capacity for technological absorption.

As a limitation of this study, we can point out the fact that it includes a not large number of available observations (sixteen years), and the results obtained may have also been influenced by the economic crisis that worsened in 2009.

As a future working hypothesis, there is the possibility of including the dimension of ICT, evaluating the impact they have on the relationship between human capital and innovation. It is also possible to try to assess the contribution of higher education, by area, but in a disaggregated way, and also to include other dimensions of human capital, such as professional experience.

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