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# Value creation through intellectual capital in developed European markets

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## Abstract

**Purpose** – This paper aims to investigate the production function of firms based on the use of intellectual capital. The authors come up with this problem since believe that the new economy conditions require an adjustment and a development of classical firm theory.

**Design/methodology/approach** – The research question addressed in this study is mainly related to the empirical validation of the function based on companies' intangibles in the Cobb-Douglas framework. This model enables the authors to advocate the idea of the complementarity of intellectual resources as well as simplifies the analysis of intellectual capital features. To accomplish the purpose of the research, the authors design a log-linear model and estimate it on a sample of more than 400 European and American companies.

**Findings** – Application of Cobb-Douglas framework allowed designing a production function based on intellectual capital. The complementarity of intellectual capital components is justified on the empirical results obtained in this research. The increasing return to scale for intellectual capital was established for the sample examined in this study.

**Research limitations/implications** – The main shortcoming of the approach implemented in this study is related to the proxy indicators of intellectual capital. Nevertheless, the authors statistically validate the chosen indicators applying hedonic approach.

**Practical implications** – Practical accomplishment of this research is mainly associated with the conclusion about an increasing return to scale of intellectual capital. This phenomenon appears to be of a particular importance for investment decisions.

**Originality/value** – The findings of this paper provide a new insight into intellectual resources interrelation that enhances companies' value creation. The authors also hope to assist future research attempts in application of the theory of company's growth driven by its intangible capital.

**Keywords** Intellectual capital, Intangibles, Cobb-Douglas, Complementarity of intellectual resources, Production function, Returns to scale

**Paper type** Research paper



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## 1. Introduction

Production function based on companies' intellectual capital seems to be relevant both from theoretical and practical points of view. The idea of any production function is to draw cohesion between firm's inputs and outputs. This approach appears to be of particular importance when the activities of companies are analyzed in terms of future growth. The classical theory of the firm implemented in the analysis of economic agents' behavior does not face all the requirements of new economy conditions. One of the pivot shortcomings of the existing theoretical frameworks is related to the omission of intangibles as key drivers of firm's growth and success. We would like to challenge this issue placing the emphases on a complementarity of intellectual resources.

This paper aims to design the input-output model on intellectual resources implementation in the frame of Cobb-Douglas function. This framework maintains the idea of resource interrelation that might enhance an output. This phenomenon is known as complementarity of production factors.

Production function is considered in economics as a model that explains the process of the transformation of several combinations of resources into firm output. As stated there a number of different function types to be applied in order to approximate the phenomenon of production. Linear, as well Cobb-Douglas, framework is the most frequently used. The first one appears to be the most easily estimated on the empirical data but has a number of critical shortcomings as does not implicate production factors interdependence. The second one enables to investigate employed resources interrelation as well as issues about economies to scale.

According to Stewart (1999), Roos and Roos (1997), Bontis (2001) and Marr and Schiuma (2003) intellectual capital is becoming almost the only competitive advantage of the company in the new economy. The economic profit or residual income concepts are based on the fact that just the competitive advantages of a particular firm provide additional value creation. Therefore, the close connection of the modern value-based management concepts and knowledge management becomes clear.

Most of the recent studies implying Cobb-Douglas function for investigation of intellectual capital consider both tangibles and intangibles to explain companies' output expressed in turnover or operational profit, like those by Dettori *et al.* (2012) and Bandeira and Afonso (2010). Others try to capture the specific intellectual capital output applying value-based concept for that purpose, like those by Sesil *et al.* (2002) and Marrocu *et al.* (2009). This study seeks to analyze total productivity of intellectual capital expressed in long-term investors expectation. The most common used indicator of intellectual capital output in this case is market value added (MVA). The value-based concept declares that company's everyday activities should lead to value creation. That is the central idea of effective management. In applying this pattern to intellectual capital, presumably we should be able to reveal a positive link between quality and quantity of intangibles and a company's share price. However, a number of empirical studies captured the opposite or else an insignificant relation, like those by Firer and Williams (2003) and Villalonga (2004). We suppose that such outcomes could be related to shortcomings in the information field as well as unclear objective setting and incorrect selection of research instruments. We put a hypothesis in our research that the contradiction mentioned above might be as well explained by non-optimal combination of intellectual resources employed. Analyzing intangibles total productivity we hope to find evidence to the supposition mentioned above.

Thus, we would like to provide an insight into the cohesion of intellectual capital and companies' value creation by taking into account intangibles complementarity. In addition our findings expected to validate that the transformation of intellectual capital is influenced by exogenous shocks, as crisis impact in particular.

The paper is organized as follows. The next section gives a brief overview of the theoretical issues about intellectual capital as key production factor in the conditions of the new economy. In Section 3, we describe the methodology and the model development. Section 4 empirically tests the model that is suggested in this research. The last section concludes the paper by briefly summarizing the main findings obtained.

## 2. Theoretical background

### *(a) Intellectual capital definition*

A critical analysis of the previous studies is conducted in this section in order to obtain an accurate picture of the causes and results of intellectual capital complementarity.

In the relevant scientific and applied studies the interpretation of the intellectual capital is pretty much different. That could be easily explained by the multiple purposes of its study. Apparently, the intellectual capital phenomenon is described by two categories: capital and intelligence (knowledge). The first one reveals the essence of the phenomenon, and the second gives its basic feature.

Most of the definitions of the intangibles of companies are based exactly on the combination of the above-mentioned properties such as "capital" and "intelligence". For instance:

Intellectual capital is the group of knowledge assets that are attributed to an organization and most significantly contribute to an improved competitive position of this organization by adding value to defined key stakeholders (Marr and Schiuma, 2003).

Interpreting this definition, we can conclude that intellectual capital is the company's resources that provide the additional value to stakeholders. That explains a simultaneous development of two intellectual capital concepts: resources-based and value-based approaches. Our research is based on the combination of both approaches applying value-based view on intellectual capital we identify drivers of company's success in terms of stakeholders' motivation to invest. Resources view enables us to investigate properly intellectual capital as a key factor of production. As stated, intangibles refer to very different spheres of companies' activities: marketing policy, human resource development, innovation technologies, etc. That leads to the heterogeneity of intellectual capital. We need to discern it into components and analyze each of them separately.

### *(b) Intellectual capital heterogeneity*

A variety of intangibles compositions options have been proposed and reasoned, including two three, four and five components structures (Edvinsson and Malone, 1997; Bontis, 2001; Stewart, 1991; Sveiby, 1997; Roos and Roos, 1997; O'Donnell and O'Regan, 2000). We follow the approach suggested by Roos and Stewart who identified three components of the intellectual capital: human (HC), relational (RC) and structural resources (SC) (Figure 1). This division fits good in a resource-based logic, as separately describes key areas of company management.

All intellectual capital components are strongly interrelated. This idea is maintained by the empirical evidences got by Bollen *et al.* (2005), Kamukama (2010) and Shakina and Bykova (2011). Meanwhile a number of studies emphasize higher importance of human capital, like those by Bontis (2001), Tseng and Goo (2005), Choudhury (2010) or Calisir *et al.* (2010). Other body of papers pay more attention to the structural capital and established the robust statistical significance of R&D investments and intellectual property. This evidence is presented by Gleason and Klock (2003), Chen *et al.* (2005) and Chang (2007). Most of the mentioned papers claim that the interrelation of intellectual capital components as well as the pre-dominance of one of them seems to vary depending on several industry and country factors.

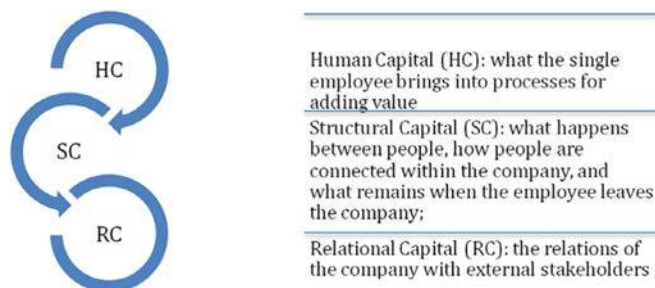
We should carry an exploratory study about the transformation process of companies' intangibles in order to consider intellectual capital in terms of production factors.

(c) *"Inputs-outputs" model of intellectual capital*

Since the "intellectual capital becomes the key driver in providing improved performance" (Roos and Roos, 1997) there has been many attempts to develop common guidelines for measuring intellectual capital itself as well as its ability to enhance business effectiveness, like those provided by several professional organizations and societies (Ricardis, CIMA, 2003). The most famous models are the Sveiby monitor, the balanced score card and the Skandia navigator. These models consider intellectual resources as input and seek to find out their impact on companies outputs.

According to resource-based view intellectual capital is determined as the strategic resources of the firm which are not available to a large number of competitors, lead to potential future benefits which cannot be taken by others, and are not imitable by others or substitutable using other resources. Because of their intangible nature, these resources are non-physical, non-financial, are not included in financial statements, and have a finite life (Kristandl and Bontis, 2007). The specific intellectual nature of this resource complicates its practical employment as well as its theoretical investigation. In addition the lack of intellectual capital disclosure and the accounting standards impedes further development in this field.

A thorough understanding of intellectual capital appropriability (or ability to create future economic benefits) is provided by empirical studies based on econometric analysis. If we consider intellectual capital appropriability for potential investors it would be specified (expressed) through market capitalization or its derivatives, and would be determined as dependent variable in the regression model, like those by



**Figure 1.**  
Three-component structure of intellectual capital

Pulic (2000), Yang and Chen (2010) and Pal and Soriya (2012). The most frequently applied indicators are MV, MVA, market to book value ratio (MV/BV) and Q Tobin. Thus, applying economic profit concept we take into account that intellectual capital output does not transform the entire production of the firm but only in the part that is associated with firm's competitive advantages.

The ability to enhance the effectiveness of the others resources, including tangible assets, is the key feature of intellectual capital. Intellectual resources should be considered as a part of the invested capital of companies and characterized according to common approach to capital identification despite of their specific features. We have to consider simultaneously at least two attributes of intangibles: quantity and quality. For instance, a number of employees would be considered in our study as a measure of human capital quantity, employee qualification meanwhile as a human capital quality. Another example can be considered in the frame of relational capital. As stated in this study a number of trademark reflect the quantity of this intellectual resources, a well-known brand indicates relational capital quality.

Even a more relevant issue for our study seems to be the indicators of intellectual capital input.

There are at least two different measurement approaches to intellectual capital inputs. The first one measures the intellectual capital input as a volume of investment, like, for instance, commercial or employee expenses; investments in research and development as in Hagg and Scheutz (2006), Poletti (2003), Huang and Wang (2008) and Orens *et al.* (2009). The second one identifies the intellectual capital quality expressed in an immediate return; for example, Shakina and Barajas (2012) measure the effectiveness of human capital through earnings per employees.

Thus, in the next section we design the production function based on intellectual resources. Since we assume that intangibles are strongly interrelated we use Cobb-Douglas function as a framework for intellectual outputs explication.

### 3. Research design and model development

We place emphasis on apparent discrepancy when a particular company with a high quality of one of the intellectual capital components is unlikely to create value. Meanwhile a comparable company with a lower quality of the mentioned resource employing optimal balance of intangibles is better off. Moreover, we would like to examine if additional investments into companies' intangibles provides higher, equal or lower return.

The idea mentioned above is challenged in this paper. To accomplish the purpose of our research we address the following specification of the production function based on firm's intangibles:

$$MVA = A \times HC^{\alpha} \times RC^{\beta} \times SC^{\gamma},$$

*MVA* MVA that reflects the value created by companies' intellectual capital.

*HC* aggregate characteristic of human capital input.

*RC* aggregate characteristic of relational capital input.

*HC* aggregate characteristic of structural capital input.

( $\alpha$ ,  $\beta$ ,  $\gamma$ ) output elasticities of HC, RC and SC.



$A$  total factor productivity.

Applying this model we estimate the econometric equation having a primary focus on the following research questions:

*RQ1.* Is there a complementarity of intellectual capital components?

*RQ2.* What is the intangibles-based production function total productivity?

*RQ3.* What is the return to scale of firm's intellectual capital?

*RQ4.* What is a sensitivity of returns to scale to exogenous shocks?

In conducting our analysis we hope to carry out an exploration of the optimal combination of different intellectual capital components that might provide a synergy effect of the knowledge management of a company.

We transform the Cobb-Douglas function in the log-linear equation to apply OLS for the estimation:

$$\ln(MVA) = \ddot{A} + \alpha \ln(HC) + \beta \ln(RC) + \gamma \ln(SC)$$

In finding out the elasticity of intellectual capital output to each of the component we interpret that in terms of returns to scale (decreasing, increasing, constant). Wald test enables us to establish the stochastic range of the estimated coefficients sum. In accordance with the features of Cobb-Douglas production function the following causality can be observed (Douglas, 1976):

- if  $\alpha + \beta + \gamma > 1 \Rightarrow$  increasing returns to scale;
- if  $\alpha + \beta + \gamma < 1 \Rightarrow$  decreasing returns to scale; and
- if  $\alpha + \beta + \gamma = 1 \Rightarrow$  constant returns to scale.

To start off with the estimation of our core econometric specification we need to validate first the aggregate proxy indicators for each of the components of intellectual capital and describe the methodology of estimation. To avoid imposing our understanding of the key representative indicators of intangibles component it might be useful to apply the so-called hedonic approach[1] for the validation of each of them. We estimate on the intermediate stage the equations to capture statistical significance as well as explanatory power of the aggregate characteristic of intellectual capital components.

We examine the data presented in our sample and finally revealed the characteristics of each intellectual capital component that mainly faces the requirements of the hedonic equation.

The proxy indicators of intellectual capital inputs and output involved in the analysis are presented in Table I.

Some of the proxy indicators in Table I can be attributed to both structural and relational capital. We consider the indicator "owners/directors" ratio as part of relational capital as it reflects a degree of principal-agent conflict but, at the same time, partly identifies the quality of corporate governance as a structural capital proxy. "Presence of subsidiaries" is the likelihood to develop companies' marketing network and simultaneously reflects corporate structure.

We finally introduce the following hedonic equations of intellectual capital components:

Components	Intellectual capital proxy indicators	Authors that mentioned the same or similar proxy indicators	Information source and estimation algorithm for our paper
Intellectual capital outcome – value creation	Market value added	Riahi-Belkaoui (2003), Nogueira <i>et al.</i> (2010), Pal and Soriya (2012), Shakina and Barajas (2012)	Company's annual report, section "financial data" Estimation: $MVA_t = EV - BV$ , where EV – enterprise value (market capitalization and debts); BV – book value of assets
	Human capital	Employee efficiency  Number of employees  Board of directors qualification	Ahangar (2010), Shakina and Barajas (2012) Huang and Liu (2005), Huang and Wang (2008), Baiburina and Golovko (2008), Nogueira <i>et al.</i> (2010), Huang and Wu (2010) Tseng and Goo (2005), Orens <i>et al.</i> (2009), Kamukama (2010), Shakina and Barajas (2012)
Structural capital	Intangible assets	Sellers-Rubio and 'lbez (2007), Shakina and Barajas (2012)	Company's annual report, section "financial data"
	Owners/directors ratio	Baiburina and Golovko (2008), Orens <i>et al.</i> (2009), Liang <i>et al.</i> (2011), Shakina and Barajas (2012)	Company's annual report, sections "shareholder name" and "directors information" The proportion of owners in the board of directors
	R&D investments	Poletti (2003), Gleason and Klock (2003), Sellers-Rubio and 'lbez (2007), Huang and Wang (2008), Huang and Liu (2005)	Company's annual report, section "financial data"
	Strategy implementation	Tseng and Goo (2005), Kamukama (2010), Shakina and Barajas (2012)	Company's web site search for any information (news) about company's strategy

**Table I.**  
Proxy-indicators for  
intellectual resources

(continued)



Components	Intellectual capital proxy indicators	Authors that mentioned the same or similar proxy indicators	Information source and estimation algorithm for our paper
	Patents, licenses, trademarks	Tseng and Goo (2005), Sellers-Rubio and Ibez (2007), Shakina and Barajas (2012)	Search for company's name and number of patents in the web site QPAT: <a href="http://library.hse.ru/e-resources/e-resources.htm">http://library.hse.ru/e-resources/e-resources.htm</a>
	ERP, quality management systems implementation	Kamukama (2010), Murthy and Mouritsen (2011), Shakina and Barajas (2012)	Search on company's location in their web site using the following words as "ERP", "Oracle", "NAVISION", "NAV", "SQL", "SAP" If company has news about these things – 1 point, otherwise – 0 points Important to put "1" or "0" in the year of start implementation Company's annual report, section "subsidiary name" If company has less than 100 subsidiaries put the total number, otherwise use the following vector "first 100 out of Y subsidiaries"
	Presence of subsidiaries	Shakina and Barajas (2012)	Company's annual report, section "subsidiary name" If company has less than 100 subsidiaries put the total number, otherwise use the following vector "first 100 out of Y subsidiaries"
	Commercial expenses share	Gleason and Klock (2003), Huang and Wang (2008), Nogueira <i>et al.</i> (2010)	Company's annual report, section "financial data" Estimation: commercial expenses divided to total costs
	Financial leverage	Poletti (2003), Riahi-Belkaoui (2003), Huang and Liu (2005), Liang <i>et al.</i> (2011)	Company's annual report, section "financial data" Estimation: long term debts divided to equity
Relational capital	Commercial expenses	Gleason and Klock (2003), Chen <i>et al.</i> (2005)	Company's annual report, section "financial data"
	Well-known brand	Riahi-Belkaoui (2003), Hagg and Scheutz (2006), Murthy and Mouritsen (2011), Shakina and Barajas (2012)	Search on company's name in the web site: <a href="http://www.justmeans.com/top-global-1000-companies">www.justmeans.com/top-global-1000-companies</a> If it has a rank – 1 point, otherwise – 0 point
	Presence of subsidiaries	Shakina and Barajas (2012)	Company's annual report, section "subsidiary name" If company has less than 100 subsidiaries put the total number, otherwise use the following vector "first 100 out of Y subsidiaries"
	Foreign capital employed	Shakina and Barajas (2012)	Company's annual report, section "shareholder name", vertical vector "country"

(continued)

Table I.

Components	Intellectual capital proxy indicators	Authors that mentioned the same or similar proxy indicators	Information source and estimation algorithm for our paper
			If company has foreign investors it gained 1 point, and otherwise 0 points
	Citations in search engines	Shakina and Barajas (2012)	Search on company's name and its score in the web site: <a href="http://www.prchecker.info/check_page_rank.php">www.prchecker.info/check_page_rank.php</a>
	Owners/directors ratio	Baiburina and Golovko (2008), Orens <i>et al.</i> (2009), Liang <i>et al.</i> (2011), Shakina and Barajas (2012)	Company's annual report, sections "shareholder name" and "directors information" The proportion of owners in the board of directors
	Location in the capital	Shakina and Bykova (2011), Shakina and Barajas (2012)	Search on company's location on their web site, see the status of the city location If it is the capital of the state (or region) – 1 point, otherwise – 0 points
	Site quality	Shakina and Bykova (2011), Shakina and Barajas (2012)	Search on company's web site and estimate site quality according to the following criteria Availability of information for investors (special section or page) Multi-lingual information (with English language) Amount of information (more than ten pages) Design (using flash animation) For every criterion company gains 1 point. The integral index is the sum of points
External and internal factors of intellectual capital transformation	Industry (belonging to manufacture, commerce or oil industry) Company's size (book value of assets) Company's experience/age	Huang and Liu (2005), Swartz and Firer (2005), Orens <i>et al.</i> (2009), Shakina and Barajas (2012) Liang <i>et al.</i> (2011), Komnenic and Pokrajcic (2012) Huang and Wang (2008), Huang and Wu (2010)	Company's annual report, section "common information", the main activity Company's annual report, section "financial data" Company's annual report, section "common information"
	Knowledge economy index (KEI)	Shakina and Barajas (2012)	Search on company's location in the web site: <a href="http://data.worldbank.org/data-catalog/KEI">http://data.worldbank.org/data-catalog/KEI</a>

Table I.

(continued)

Components	Intellectual capital proxy indicators	Authors that mentioned the same or similar proxy indicators	Information source and estimation algorithm for our paper
	KEI: education KEI: economic incentive regime KEI: information and communication technologies		

**Note:** For our study we have used the annual reports from the Amadeus database provided by Bureau Van Dijk ([www.bvdep.com/be-nl/amadeus.html](http://www.bvdep.com/be-nl/amadeus.html))

**Source:** Self-elaboration

Table I.

$$HC = f(PI_{hc}^1, PI_{hc}^2, \dots, PI_{hc}^n, CV),$$

where:

$HC$  represents the aggregate characteristic of human capital input.

$PI_{hc}^i$  the vector of proxy indicators of human capital quality and quantity.

$CV$  the vector of control variables (company's size, age, industry and country):

$$RC = f(PI_{rc}^1, PI_{rc}^2, \dots, PI_{rc}^m, CV),$$

where:

$RC$  represents the aggregate characteristic of relational capital input.

$PI_{rc}^j$  the vector of proxy indicators of relational capital quality and quantity.

$CV$  the vector of control variables (company's size, age, industry and country):

$$SC = f(PI_{sc}^1, PI_{sc}^2, \dots, PI_{sc}^l, CV)$$

where:

$SC$  represents the aggregate characteristic of structural capital input.

$PI_{sc}^j$  the vector of proxy indicators of structural capital quality and quantity.

$CV$  the vector of control variables (company's size, age, industry and country).

Our empirical research is conducted using microeconomic data from public companies placed in developed European countries such as Great Britain, Germany, Finland, Denmark, Spain and Portugal. To gain relatively random observations and capture the industry factor we have selected companies from several industries: financial services, wholesale and retail trade, machinery and equipment manufacture, chemical, and transport and communications. We have chosen these particular industries since they represent a wide range of knowledge-intensive manufacturing and service sectors.

The dataset for this study derived from the detailed longitudinal database Bureau Van Dijk (Amadeus and Ruslana) based on the annual statistical and financial reports of companies. Due to the nature of intellectual capital and our goals we have used a number of qualitative data from companies' web-sites, citation bases, data from patent bureaus, etc. The entire sample is a balanced panel of 320 companies and covers five years from 2006 to 2009.

The results of the estimation of hedonic equations for intangibles' components input are shown in Table II.

The explanatory models power exceeds 50 percent for all the hedonic equation we estimated. They are significant on 1 percent probability level and most of the regression factors appear to be statistically significant in the introduced model. Presumably we conclude that the proxy indicators such as "employee's efficiency", "commercial expenses" and "intangible assets" reflect the inputs of human, relational and structural capital, respectively.

The architecture of our final model appears to be as shown in Figure 2.

Since we have found the aggregate proxy indicators that reflect inputs of intangibles' components we are enabled to estimate the production function of the "input-output" model of intellectual capital. The next section introduces the empirical evidences if the designed framework describes the companies "value creation" employing intellectual capital.

#### *(a) Empirical justification of the production function*

For the further analysis those companies that present negative results of value creation ( $MVA < 0$ ) are excluded from our consideration. This phenomenon cannot be examined in the framework of Cobb-Douglas production function. The sup-sample for the final estimation of the production function is unbalanced panel. It consists of more than 500 observations and covers the period 2005-2009 of economic prosperity as well as two years of the recession. These data allows us to investigate the crisis impact on intangibles-based production function introduced in our research.

Table III helps us to characterize the type of a company that is used in our study. It presents several descriptive features of the sample, where the mean and the standard deviation of the variables are detailed.

Table IV provides key results and evidence for the key finding of our study. According to our supposition, there are three intellectual component inputs indicators that can be used in the diagnosis of the firm's intellectual capital configuration:

- (1) employee efficiency (human capital);
- (2) commercial expenses (relational capital); and
- (3) intangible assets (structural capital).

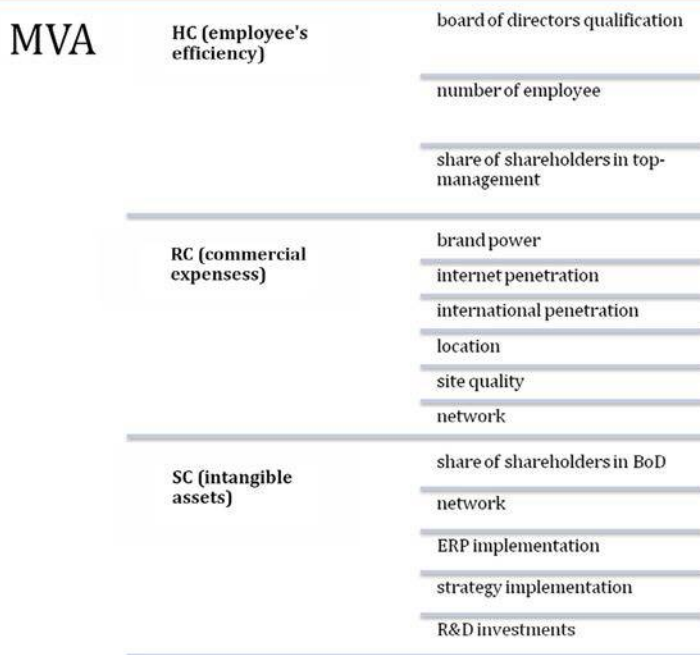
The statistically significant models with relatively high explanatory power are responsible for maintenance of the strong positive link between multiplicative function of inputs of intangibles' components and intellectual capital output.

We conclude that, for the examined companies, a complementarity between all the intellectual capital components exists. Moreover, the presence of complementary of companies' intangibles also has an important positive influence on intellectual capital outputs in terms of value creation. Besides we revealed that the estimation results on the panel referred to economic prosperity period (panel 2) exactly correspond with

Independent variables	Panel 1		Panel 2		Panel 3	
	HC (employee's efficiency)	RC (commercial expenses)	RC (commercial expenses)	SC (intangible assets)	SC (intangible assets)	SC (intangible assets)
Board of directors qualification	0.3072533 (0.0824512) ***	-	-	-	-	-
Number of employees	0.0000924 (8.87 × 10 <sup>-06</sup> ) ***	-	-	-	-	-
Owners/directors ratio	-0.4578791 (0.1622338) ***	-	-	-	-	0.5186698 (0.2515338) **
Well-known brand	-	0.0383713 (0.1183926) ***	0.0383713 (0.1183926) ***	-	-	-
Citations in search engines	-	0.4270755 (0.1072872) ***	0.4270755 (0.1072872) ***	-	-	-
Foreign capital employed	-	-0.0671803 (0.1026425) ***	-0.0671803 (0.1026425) ***	-	-	-
Location in the capital	-	-0.1467243 (0.0737733) **	-0.1467243 (0.0737733) **	-	-	-
Site quality	-	0.3737487 (0.0909207) ***	0.3737487 (0.0909207) ***	-	-	-
Presence of subsidiaries	-	0.001661 (0.0001974) ***	0.001661 (0.0001974) ***	-	-	0.0038444 (0.0008377) ***
ERP, quality management systems implementation	-	-	-	-	-	0.323405 (0.1475837) *
Patents, licenses, trademarks	-	-	-	-	-	-0.0003489 (0.0003595)
R&D investments	-	-	-	-	-	-0.0040848 (0.0046914)
Strategy implementation	-	-	-	-	-	0.6874165 (0.1331279) ***
Company's size	0.0003626 (0.000032) ***	0.0004535 (0.000031) ***	0.0004535 (0.000031) ***	-	-	0.0006359 (0.0000567)
Company's age	0.00034 (0.0010755) ***	0.0020437 (0.0010911) *	0.0020437 (0.0010911) *	-	-	0.0042351 (0.0017712)
Belonging to a manufacture	-0.5757213 (0.1242169) ***	-0.4688209 (0.122166) ***	-0.4688209 (0.122166) ***	-	-	-1.705738 (0.1814214)
Belonging to an oil industry	0.383835 (0.3138599)	-0.8640901 (0.1820289) ***	-0.8640901 (0.1820289) ***	-	-	0.2335524 (0.4552656)
Belonging to a commerce	-0.6329166 (0.0882428) ***	0.1347698 (0.0816787) *	0.1347698 (0.0816787) *	-	-	-0.8340934 (0.1569676)
Knowledge economy index	0.565317 (0.0631901) ***	-	-	-	-	1.700764 (0.1588331)
Knowledge economy index_education	-0.1990363 (0.0765033) ***	-	-	-	-	-
Knowledge economy index_economic incentive regime	-	0.0685716 (0.0317626) **	0.0685716 (0.0317626) **	-	-	-
Knowledge economy index_information and communication technologies	-	-	-	-	-	-0.2664283 (0.1631003)
Intercept	6.594405 (0.5383593)	2.660538 (0.2349223)	2.660538 (0.2349223)	-	-	-10.13535 (0.5577308)
Number of observations <sup>a</sup>	1,025	924	924	-	-	1,269
Adjusted R <sup>2</sup>	0.5018	0.5157	0.5157	-	-	0.6196
F-statistic	97.86 ***	73.55 ***	73.55 ***	-	-	148.43 ***

**Notes:** Significant at: \*  $p < 0.1$ , \*\*  $p < 0.05$  and \*\*\*  $p < 0.001$ ; <sup>a</sup>the number of observations varies as a result of missing data from some companies in particular years; however, this fact is not relevant at this stage of the analysis because it does not influence the conclusion about the explanatory power of the indicators presented at then of the paper; the analysis at this phase aims to prove that proxy indicators like employee's efficiency, commercial expenses or intangible assets reflect the human, relational and structural capital, respectively; this fact is validated by establishing the significant multifactor relationship between the above mentioned indicators and proxies of intangibles' quality and quality as stated in this paper

**Source:** Self-elaboration



**Figure 2.**  
Architecture of the model

Variable	Number of observations	Mean	SD	Min.	Max.
Number of employees	685	4,955	4,155	508	19,580
Company's age	665	37	35	0	161
Market value added	514	1,254.59	3,490.97	0.41	42,589.91
Employee costs	600	163.40	224.01	1.13	1,839.50
Earnings per employee	676	23.28	75.97	0.00	1,017.21
Commercial expenses	637	188.23	439.75	0.69	4,714.36
Intangible assets	658	228.08	607.11	0.00	6,627.11

**Table III.**  
Descriptive statistics  
of the finale sample

**Source:** Self-elaboration

average values (panel 1) of the regression coefficients. The third panel meanwhile introduces the shift towards the human capital impact on intellectual capital output. That supports the results got in the previous studies that captured higher relevance of human resources over the economic instability, like those by Baxtera and Matear (2004) and Maditinos *et al.* (2011).

Further steps of our research are related to the investigation of economies to scale of the estimated production function. That might be valuable to know if the employed intellectual capital is able to provide synergy towards company's growth. If the sum of all the elasticity values of intangibles components would be less than 1, the diminishing return to scale is bound to happen. Otherwise a company would be able to raise its

Independent variables	Dependent variable		
	Panel 1 Intellectual capital output (MVA), period 2005-2009	Panel 2 Intellectual capital output (MVA), year 2007	Panel 3 Intellectual capital output (MVA), year 2009
HC input (employee's efficiency)	0.6916572 (0.0469629)***	0.6925076 (0.0826269)***	0.7705943 (0.1147555)***
RC input (commercial expenses)	0.4831912 (0.0567147)***	0.4813444 (0.0867117)***	0.475137 (0.1180106)***
SC input (intangible assets)	0.1650471 (0.0346792)***	0.1630832 (0.0636862)**	0.1635717 (0.0792416)**
Intercept	0.8197956 (0.2390988)	0.8332453 (0.468749)	0.6537213 (0.5171071)
Number of observations	446	101	81
Adjusted $R^2$	0.5612	0.6386	0.6285
F-statistic	199.37***	52.77***	40.62***

**Note:** Significant at: \* $p < 0.1$ , \*\* $p < 0.05$  and \*\*\* $p < 0.001$

**Source:** Self-elaboration

**Table IV.**  
Results of the production  
function estimation

efficiency accumulating intellectual resources taking into account their optimal configuration. The results of the stochastic Wald's test are presented in Table V.

According to the estimations we conclude that the production function based on intangibles accomplished in this study is characterized by the increasing return to scale. In this sense the company gains additional benefits extending the employed capital or the larger is a company the more benefits will have investing in intangibles.

It should be noted that in conducting the same analysis for the panel 2 (year 2007 with economic prosperity) and panel 3 (year 2009 during the economic crisis) we find out the following:

- the production function during the period of economic prosperity has the same degree (average) of an increasing return to scale ( $\alpha + \beta + \gamma = 1.3$ ); and
- the production function during the period of economic crisis has a higher degree of an increasing return to scale ( $\alpha + \beta + \gamma = 1.4$ ).

That can be explained by the phenomenon "Too Big to Fail" emerged during the economic collapse in 2008. Considering the company's powerful position during the crisis in terms of its intellectual capital we emphasize that human and relational capital

Test results and conclusion	Hypothesis		
	$\alpha + \beta + \gamma = 1$	$\alpha + \beta + \gamma < 1$	$\alpha + \beta + \gamma > 1$
	H0: $\alpha + \beta + \gamma \neq 1$	H0: $\alpha + \beta + \gamma \neq 0.5$	H0: $\alpha + \beta + \gamma \neq 1.3$
	H1: $\alpha + \beta + \gamma = 1$	H1: $\alpha + \beta + \gamma = 0.5$	H1: $\alpha + \beta + \gamma = 1.3$
F(1,442)	35.92***	219.34***	0.49
Conclusion	H0: cannot be rejected	H0: cannot be rejected	H0: is rejected

**Note:** Significant at: \* $p < 0.1$ , \*\* $p < 0.05$  and \*\*\* $p < 0.001$

**Source:** Self-elaboration

**Table V.**  
Results of return to  
scale estimation



in particular enabled large corporation to survive during the difficult economic conditions. Nevertheless, to draw more precise conclusion we need to undertake an analysis of particular cases. The rough estimations made in this research do not allow obtaining an accurate picture of the causes and results of a growth of economies to scale during the recession in 2008-2009.

#### 4. Conclusion and discussion

Considering the purpose set in our research and following the results already shown and commented, we summarize the following conclusions:

- A validity of proxy indicators of intellectual capital components was proved. Namely we estimated hedonic equation for aggregate characteristics of companies' intangibles and revealed a high statistical significance and explanatory power for each of the model.
- The complementarity of intellectual capital components was justified on the empirical results obtained in this research. Application of Cobb-Douglas framework allowed designing a production function based on intellectual capital.
- The increasing return to scale for intellectual capital was established for the sample examined in this study. Moreover, we found out the shift of the elasticity of substitution towards the human capital during the economic crisis of 2008-2009. The phenomenon of economies to scale was more pronounced at this time as well.

The approach to design a production function based on intellectual capital introduced in this paper is expected to be useful for further empirical studies as well as for practical accomplishment.

Despite a number of shortcomings and limitations the empirical results established in this research have clear interpretation and correspond with previous studies.

The analysis of the intellectual capital of developed European markets provided a number of valuable findings concerning a measurement of intangibles and their specific interrelation by creating companies' value.

#### Note

1. Initially this approach was applied by Slottje (1989) for validation of aggregate characteristics of pillars of quality of life.

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