Review article
UDC 005.336.4: 001.101: 061.1

Estimation of intellectual capital in the European Union using a knowledge model*

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Abstract

This paper presents a model aimed at measuring intellectual capital as the potential knowledge of a country and apply it to the European Union. The method consists of activating accountable expenses, assumed to generate knowledge. In order to do so, efficiency indicators are used, derived from a summary of variables of structural, human and technological capitals by means of factor analysis. The results of this study for the EU25 in 2006 explain why Northern Europe has greater intellectual capital potential. They are more productive, as they manage and apply new technologies better. In human capital, Eastern countries have strong potential. The paper concludes that, at the conceptual level, this information should be used to design convergence policies and balanced development strategies to ensure economic growth.

Key words: *intellectual capital, knowledge economy, indicators, European Union*

JEL classification: *J24, O18, O3, R5*

* Received: 05-04-2011; accepted: 06-06-2011

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1. Introduction

Nowadays, the economic scenario in which globalisation plays an important role is undergoing constant change. The new demands of international competitiveness are prevailing to the extent that human capital, technological development, innovation and research are becoming enormously important. The main assets of a company with fixed and circulating capital are knowledge, creativity, the ability to innovate, knowhow and the desire to learn. As a result, these new variables are considered the new drivers of social and economic development worldwide. For this reason, Cañibano et al. (2000) warn that new elements have not been included in accounting information for the stock market.

Faced with this situation countries are attempting to react, albeit at different speeds, depending on a multitude of variables. These include the importance that governments give to this change, current extant human capital training and the relationship between the market and innovation. Companies with market power make larger profits that contribute towards the funding of research, which implies a positive relationship between the size of a company and innovation.

For this reason, decision making processes increasingly require abundant quantitative and qualitative information regarding available resources, results, trends and future scenarios. The need for statistical information to analyse and understand the workings of a knowledge management system is, therefore, of the utmost importance. Restricted available resources, scientific policy decisions and knowledge should be based on reliable information in order to achieve growth supported by competitive advantages.

Governments are aware of this and are therefore working on the elaboration of indicators to evaluate impacts and design policies. However, the problem is how to elaborate indicators that can be compared across different countries. In particular, how to meditate creatively on the processes involved in producing, disseminating and applying knowledge to the specific domains of a given country's society and economic activity.

The influence of knowledge has been tackled from various angles. This paper considers the models which have a broader conception of human and structural factors, i.e. Intellectual Capital, using an aggregate approach. These models involve defining a series of groups that make up intellectual capital and establishing a series of indicators in order to measure and evaluate them, which come from the business world (Edvinsson and Malone, 1999; Kaplan and Norton, 1997).

Using this reality as a basis and after revising the specialised research derived from corporate models, we propose a standard management model of regional intellectual capital. This model is different because it develops a new system of information that measures economic growth with the level of intellectual capital in geographical regions. Therefore we framed our research with the following two research hypotheses:

H1: Richer countries, in GDP per capita terms, use intellectual capital more efficiently. That is, the management of intellectual capital is better, in relative indicators terms.

H2: In human capital, Eastern countries have strong potential. That is, training policies and skills of inhabitants are above European average.

In order to test these, we have used a group of indicators derived by means of statistical methods. These methods make results more objective and consistent, helping in turn to enhance comparative analysis across regions. The model determines different fields of knowledge within the domain it is applied to in the European Union with 25 members. While they do not coincide exactly with traditional economic growth processes, they are in keeping with the convergence strategies of certain member states. Knowledge management indicators undoubtedly draw up a map of Europe in which human capital and technological competitiveness represent the potential for growth. Nevertheless, rapid human decapitalisation and slow technological capitalisation in new member states could give rise to marked imbalances in the primary resource - knowledge - and, as a result, in real convergence.

2. National or regional intellectual capital: a literature review

Studying and analysing the process of measuring and evaluating intangible resources is a developing line of research within macroeconomics known as Intellectual Capital of Nations (Amidon, 2001). Human capital and innovation and technology transfers are vital when drawing up a model of intellectual capital and its network of relationships. These factors are known to boost the creation and exchange of information and knowledge in different socio-economic circles. The result is a group of regions with the ability to generate value and social wellbeing in developed economies, in line with “intelligent nations” (Quinn, 1992). According to Stam and Andriessen (2009) “the main motivation for measuring the Intellectual Capital of nations is to get insight into the relative advantage of countries or regions”.

In this sense, we must consider aspects that go beyond economic factors, cash available for the country or region, which in spite of not having a physical or financial nature, can generate sustainable development either on their own or in connection with others (Sánchez, 2006). Several papers emphasize the importance of intellectual capital, or some of its components, in economic development. Capella and Nijkamp (2009) used human and knowledge capitals, Cooke et al. (2007) used mainly knowledge and Acs et al. (2002) innovation. Malhotra (2000) considers that intellectual capital must be analysed in national or regional economies, especially when these economies are in the midst of quickly becoming a knowledge-based society. Yeh-Yun Lin and Edvinsson (2010) claim "…intangibles are one of the most important sources of prosperity and progress". On the other hand, the existing differences between the various sectors in the same society can be significant due to the unequal endowment of intellectual capital. These measures consider aspects of the economy beyond merely economic factors.

The different models that are emerging in macroeconomics originate from those used in the corporate world. Notwithstanding, two types can be said to exist: national or regional intellectual capital models and score card models.

2.1. National or regional intellectual capital models

This field of research is currently still embryonic, as no methodologies have been either ratified or received widespread acceptance. Most proposals are restricted to systematically compiling data, but lack a benchmark framework. In fact, as noted by Dalmau and Baixauli (2005), a large number of the models addressing intellectual capital in a region are the result of extrapolating corporate models of intellectual capital. This is why applications to the business world and those used on a regional scale can be said to be connected.

Prior to relating the diverse research that has been carried out on specific regions, it is worth bearing in mind some clarifications. These should be taken into account when we refer to measuring the intellectual capital of nations. It seems obvious, that the importance of intellectual capital goes beyond the corporate domain and is today a vital asset for regions. Variables such as economic growth, competitiveness or development itself imply that the meaning must be interpreted in macroeconomic terms. In this case ideas and knowhow play a fundamental role in accomplishing the objectives described above (Bradley, 1997a, b). This author states that the companies and countries that take too long to organise themselves run a serious risk of being isolated and falling behind. He distinguishes between intellectual and human capital and defends the supremacy of the former over the latter in economic growth, the creation of wealth and competitive advantage. One important aspect is that this has consequences for policy making: why are aspects related to intellectual capital not included explicitly in school curricula, despite their importance? As a result, we could propose, using Davenport and Prusak (1998) as a basis, how the so-called *'core competences'* can be achieved through intellectual capital management.

Definitions differ when referring to the concept of intellectual capital in a country, but only a difference in scale is observed in relation to those used in companies. Intellectual capital from a company perspective is based on value that is hidden from traditional accounting systems and which is based on the ability to generate future value. Hence, the gap between market value and book value in favour of the former is identified as intellectual capital and is justified by factors related to human skills and organisational structure. When investigating the value of intellectual or intangible capital in a nation, the main difference is the quantity of information involved, as well as the peculiarities of the entity being studied (company versus State). Bradley (1997a) highlights that country's intellectual capital is its ability to transform knowledge and intangible resources into wealth. Edvinsson and Stenfelt (1999) perceive intellectual capital as the value of ideas generated by the union between human and structural capital, which allows knowledge to be produced and shared. They adapt the Skandia Navigator to the public sector, developing the concept of Intellectual Capital of Nations as the source of wealth creation. They use five value creation forces as a basis: innovation, knowledge, human capital, information technologies and investment in intellectual capital. According to Malhotra (2000), the definition would involve a set of hidden assets that explain the growth of a country and the added value of groups of interest. (stakeholders). Therefore, this perception of intellectual capital, methodologically speaking, completes the definition of the value of a country's production. That is, its value would coincide with the value of hidden or immaterial production stemming from factors such as the development of its inhabitants, quality of life and wellbeing and technical progress.

The models most worthy of mention that specifically measure and manage the intellectual capital of nations or regions are presented in table 1.

Table 1: National or regional intellectual capital models

Author	Area	Observations
Dragonetti and Roos (1998)	Australia (Public Sector)	They introduce the concept of an intellectual capital index as aggregations of factors.
Rembe (1999)	Sweden	He studies next capitals: human (standard of living, life expectancy, education...), market (tourism, trade in services,…), process (management quality, ICT…) and renovation (R&D, youth population ratio…). Other papers related: Pasher (1999) in Israel and Bontis et al. (2002) for Malaysia.
Rodríguez et al. (2004)	Madrid Region (Spain)	They measure: human, organisational, technological, social and financial and economic capitals. They propose indicators for each.
Sánchez et al. (2007)	Gran Canaria (Spain)	They identify intangible goods in: economic (tourism) and social activity, the environment, the public administration, professional training and development.

Source: Own elaboration

2.2. Score card studies (competitiveness indicators)

The reason that indicators are required, particularly those related to science and technology, is to justify the use of increasingly abundant resources in research and innovation. The problem that some experts highlight is not so much that indicators do not exist in innovation Systems, but rather that in most cases it is not taken into account that defining the indicators themselves is also a dynamic and interactive process. Therefore, instead of being a tool used in decision making, the indicators themselves become the end result.

Indicators are becoming irreplaceable instruments for decision making, while also providing information that both permits and promotes debate and comparative analysis.

As a result, targets are reached and resources are used more efficiently. One vital aspect is that all the parties participating in the research and innovation process feel involved due to being informed. Moreover, they also value how useful they find it to provide such information related to their activity. This information, once checked and ratified, is transformed into a tool that is indispensable for their own decision making and which allows them to evaluate results at all levels.

In this sense, competitiveness studies and others related to building indicators on a national or regional scale, take control panels as a reference. As regards the research projects related to the objective of these models, it is worth highlighting in table 2.

Table 2: Score card studies

Author	Area	Observations about indicators
Dutch Ministry of Economic Afairs (2000)	Netherlands	Competitiveness indicators for: macroeconomic climate, human capital, innovation, material infrastructure, goods market and financial market.
OECD (2007)	OECD	Indicators related to economics, which boost the development and wellbeing of nations.
European Commission (2002)	EU	Indicators (five per area): R&D: human resources, public and private investment, scientific and technological efficiency and impact on economic competitiveness and employment. Using the United States and Japan as references.
Ernst and Young (1999)	New Zealand	Fifteen indicators to compare countries in terms of the knowledge economy.
Atkinson (2002)	United States	Seventeen macroeconomic indicators in New Economy.

Source: Own elaboration

Generally speaking, all the above studies give the impression that there is no clear method or reference framework for measuring the intellectual capital of nations and/or regions, unlike the case of the business world.

However, this paper takes the proposal from the model used in business by Nevado and Lopez (2002). This model has the great advantage of being a management tool for organisations and is not restricted exclusively to measuring or evaluation. We design an integral model based on both specific models of intellectual capital as well as on competitiveness studies.

The move from business to regional analysis incorporates a method to develop a new synthetic indicator of knowledge, enhanced by the intangible factors in the region under analysis. In order to do so, we undoubtedly have to transfer the changes in accounting information from the microeconomic estimation to the information systems for national and regional accounts, from the perspective of intellectual capital.

Consequently, this paper is the beginning of a necessary line of research that contributes to addressing the comparison and analysis of the Knowledge Society. It provides, in the final stage, a model that measures and manages intellectual capital, which enhances the estimation of a region's capacity for growth. As a result, it will help public and private decisions made by both governments and companies to become more efficient.

3. Methodology: a knowledge model in European Union

The measuring of intangible resources which began at the end of the last century in the business world, is nothing more than a criticism of the traditional accounting system as a value method and information system. Human resource and knowledge management later laid the foundations for proposing systems to complement accounting in order to ascertain the value of an organisation.

When the first models took shape years later, a similar situation occurred in the public sector, which resulted in the wide range of models described in the previous section.

3.1. Methodology

In this process, Nevado and Lopez (2002) and Lopez and Nevado (2006), develop and apply a methodology called INAN (Integral Analysis). It improves on the Skandia Navigator in terms of valuing intangible resources and above all where management is concerned, complementing the research by Kaplan and Norton (1997) on Balanced Scorecards (BSC).

The method reconsiders the accounting information system and determines intellectual capital as the outcome of the future profits an organisation will generate as a result of aspects related to human capital and other structural factors. These factors include innovation capacity, customer relations, process, product and service quality, business culture and communication policy and they enable the organisation to take better advantage of its opportunities. In order to explain the items that intellectual capital comprises, the authors use a complex accounting identity as a basis (1).

$$IC_i = HC_i + SC_i + NEC_i \quad (1)$$

where:

- *IC_i is the Intellectual Capital of organisation i.*
- *HC_i is Human Capital.* Made up of knowledge, skills, motivation, training, etc. of employees; as well as the compensation system and contracting policy. These allow the organisation to have an adequate group of employees for the future.
- *SC_i is Structural Capital*. Defined as the sum of capitals of internal processes (quality), relation or trade capital (customers, suppliers), marketing and research, development and innovation.
- *NEC_i is Not Explained Capital.* The human and structural capital that is not covered by the above terms. This could be due to being of little importance and being difficult to quantify, but they should, as a whole, be taken into account, bearing in mind the randomness of the measuring system.

In order to estimate intellectual capital, its various components are established. Said components require indicators that are pertinent, intelligible, applicable and comparable. These indicators are divided into two groups:

a. *Absolute Indicators (AI)*, measured in monetary units, but not related to other variables. Usually, they are expenses able to generate future value, i.e.: training, R&D…

b. *Efficiency Indicators (EI)* are percentage indexes that filter the part of the expense (absolute indicator) that generates future value. It takes values from 0 to 100, with 0 denoting the least favourable situation and 100 the most favourable. Efficiency indicators are elaborated with a set of weighted variables. For example, training level could be elaborated using variables that measure worker attendance at courses.

Each component (human and structural capitals) is estimated by using the product between these indicators (AI · EI).

The method is based on the idea that an expense, for example professional training, should be at least partially recorded as an accountable asset (the part that determines how efficient the action was). At the same time, this asset will explain the extra accounting value of an organisation. That is, the extra market value over and above the equity figure that appears in pro forma statements.

In aggregate terms, certain expenses such as education and R&D are also assumed to be generators of knowledge and wealth. As a result, they also require an efficiency index in order to correct the value they are assigned. We propose the elaboration of an aggregate model (Integral Analysis of Knowledge –INANK-) in order to correct the information shortfalls of the old economy.

This way, in a geographical region, human and structural developments are correlated to economic growth through endogenous development and capture this new economic resource (knowledge) in the best possible way. Therefore, the great advantage is that a standard model is established which correlates and measures economic growth with the levels of intellectual capital in geographical regions.

3.2. INANK Model

The model for generating intellectual capital at national or regional level through human and structural capitals is condensed in the following equations.

One unit of capital (either human or structural) will be made up of absolute (AI) and efficiency indicators (EI). The multiplying model is the same as that used to generate capital X, but one unit of capital can include more than one generator (2).

$$XC = \sum_{c=1}^{m} AI_c \cdot EI_c \tag{2}$$

with m generators of capital X.

Restrictions:

$$AI = \sum_{i=1}^{N} AI_i \tag{3}$$

with N absolute indicators belonging to capital X (XC).

$$EI = \sum_{i=1}^{k} w_{ji} EI_i \qquad con \ \sum w_j = 1 \tag{4}$$

with K, efficiency indicators belonging to capital X (XC) and w, weightings that affect efficiency indicators, between 0 and 1, all must add up to 1.

The absolute indicators of one unit of capital belong to that capital and cannot participate in the generation of other units of capital.

The efficiency indicators of one unit of capital are not exclusive to that capital and can participate in the configuration of another unit of capital or its own by affecting another absolute indicator. That is, to participate in more than one generator of one specific unit of capital.

Regarding the main disadvantages or limitations of this approach, in the first place, obtain to all the information necessary is difficult in spite of the fact that in recent years, countries have begun to embark on statistics projects and surveys in this field (for example, the science and technology surveys by EUROSTAT). Secondly, the method used to generate the components of intellectual capital itself is somewhat subjective. Subjectiveness appears in indicator elaboration and also when it comes to establishing the different equations that best summarize each of the components. In order to reduce subjectiveness to a minimum, measurement and assessment criteria must be clear.

Statistical methods must be applied both to reduce the excess of information frequent in aggregate models in areas such as innovation and training and also to apply objective weightings to overcome the lack of criteria for obtaining efficiency indicators. Correcting weightings by means of factor analysis applied to an aggregate model enhances the objectiveness and consistency of the results. The purpose of factor analysis is to group different variables, depending on how consistently they go up and down together, to build efficiency indicators. Therefore, using equations 2, 3 and 4 as a basis, we propose an efficiency indicator in accordance with expression (5).

$$\mathrm{EI} = \sum_{\mathrm{j}=1}^{\mathrm{f}} \mathrm{w}_{\mathrm{j}} \left[\sum_{i=1}^{k} u_i \cdot EI_i \right]_j \qquad con \ \sum w_j = 1 \tag{5}$$

where w would be the percentage of variance retained by each factor (a total of f); u_i, the characteristic vectors of each main component; and EI_i, the efficiency indicators (variables) under consideration. Finally, the generator of each unit of national or regional capital obtained will be expressed in relative terms of Gross Domestic Product (GDP) in order to make regions comparable.

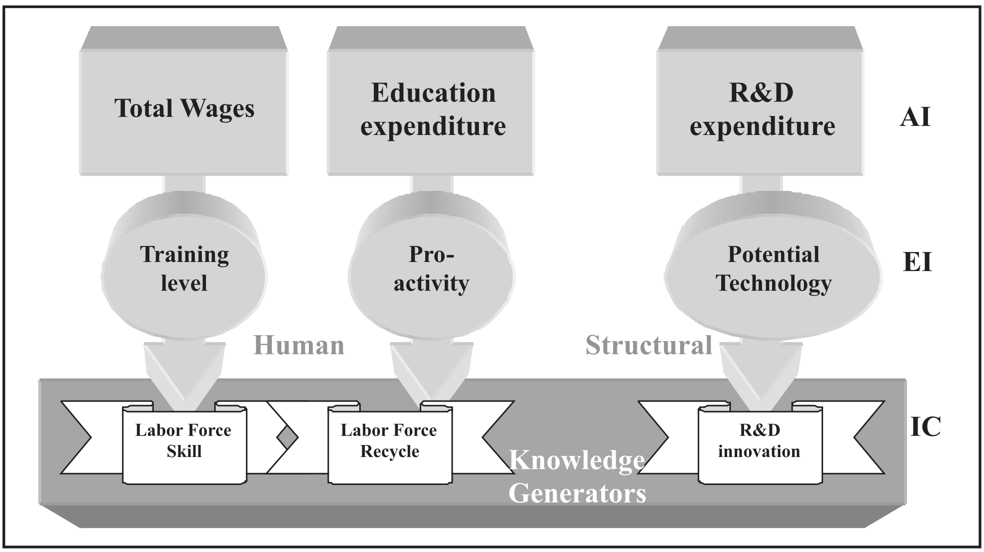
3.3. Structure and praxis of INANK Model

According to the method and equations proposed, the model regarding national or regional knowledge competitiveness (INANK) will include two clearly different elements: human capital and structural capital. Both absolute and efficiency indicators are used to determine each of these elements.

Data are taken from EUROSTAT. If we take a closer look at this information, we can see that it is quite well suited to countries, as there is a large number of indicators at that level of disaggregation. Despite the large amount of information, the study includes a selection of countries and thus, in some cases, the information is incomplete. Hence, information is presented for the twenty-five nations that made up the European Union in 2006, the base year, together with aggregate information for the EU-25 and the EU-15 (1995 enlargement).

INANK structure is shown in Figure 1. We develop the model with two components: human and structural capitals. Human capital is broken down into two generators: labour force skill (static position) and labour force recycling (dynamic position). The structural component is estimated with one generator: R&D and innovation. The structural elements are detailed below.

Figure 1: INANK Model structure



Source: Own elaboration

The absolute indicators used as competitive frameworks for knowledge in human capital are wage mass (employee compensation in millions of euro) and education expenditure (public expenditure on education in millions of euro). Human capital is measured using these available proxy variables to capture the human active talent in a country (wage mass) and its inhabitants' capacity to learn (education expenditure). Therefore, wage mass is measured in millions of euro, but in order to compare across countries, these absolute indicators are considered in terms of GDP. In this case, the differences among countries are not significant because the wage mass is between the 53% maximum and 31% minimum of GDP in EU countries. Moreover, standard deviation stands at 0.05 and the Pearson coefficient of variance is 0.11.

Notwithstanding, it is a model and, as such, a simplified vision of reality. Moreover, this reality cannot be quantified, that is, it captures an intangible system. When human capital is concerned, we face constraints due to not being able to use an integral approach that gathers information on the administrative structure of education, quality of corporate training, motivation and satisfaction in the workplace, job rotation, etc. Faced with this situation, we have used proxy variables that give a good approximation of the intellectual capital in EU member states in spite of the lack of information.

In the case of structural capital, the absolute indicator used is R&D expenditure (in millions of euro). We are working on developing this capital towards other perspectives, due to being a simple, univariant view. As a result, the structural component requires other variables, such as organisational structure, image and international institutional relations or social and environmental responsibility. Nevertheless, R&D expenditure is a good proxy of structure in a country, particularly if we complete this measure with household and business perspectives.

In response to these constraints, the absolute indicators are filtered by efficiency indexes. Therefore, in the case of human capital, we aim to calculate what proportion of the wage mass is qualified and how much this proportion amounts to, as a generator of value. In addition, spending on education is converted into an asset by means of the index of labour market conditions in activity and development of learning in the country. Finally, we determine structural capital through spending on R&D filtered by company and household technological efficiency. Other models such as that by Yeh-Yun Lin and Edvinsson (2008), only use percentage indicators (for example, in the case of human capital they compare the wage mass in high technology to the situation in the top-ranked country) and obtain similar results, although they do not obtain the monetary value of these intangible assets.

In addition, the filters or efficiency indicators applied will result from a selection and summary of variables by reducing the amount of information using factor analysis. The outcome will be the so-called aggregate knowledge generators, which will quantify national intellectual capital.

The format of the information to elaborate efficiency indicators, obtained in EUROSTAT, is ideal. More specifically, there are percentages of training qualifications, activity and the technological application on behalf of companies and households, which will make up the national knowledge generators. Regarding the elaboration of the technological indicator, it is worth highlighting the fact that information related to the implantation of new technologies in companies and households is considered. This two-fold source of information is indispensable to be able to build a knowledge generator, as knowledge is fuelled by both scenarios. Finally, in light of how decomposed and detailed existing data are, it has been necessary to carry out a prior selection of information in order to avoid repetition.

As a result, on the human capital side, two efficiency indicators have been elaborated: a training level indicator, based on five variables (showed together with a brief definition in table 4) and a pro-activity indicator, which includes two variables (activity rate and companies that use e-learning). As far as structural capital is concerned, we have selected a total of 21 (showed together with a brief definition in table 5) evenly distributed variables to elaborate the potential technology indicator. In order to select these we have taken into account how representative they are when it comes to determining company and household use of new technologies.

4. Results and discussion

After selecting the information to elaborate the efficiency indicators, we analysed how suitable factor analysis was to confirm the theory and to assign weights objectively in order to build the indicators. The value of the Kaiser-Meher-Olkin (KMO) measure of sampling adequacy and the level of significance of Bartlett's sphericity test show that it would be appropriate to carry out factor analysis for both human and structural capital (Table 3). We can therefore reduce the information provided by the selected variables by identifying factors that capture a high percentage of that information. The stability of factor solutions depends on populations and time. When deciding the number of factors to retain, we followed the criteria of considering above average auto values.

Table 3: Kaiser-Meyer-Olkin measure and Bartlett's Test of Sphericit

Statistics		Human Capital	Structural Capital
Kaiser-Meyer-Olkin measure of sampling adequacy		0.702	0.756
Bartlett's Test of Sphericity	Chi-Square Approximation	127.846	777.196
	Degrees of Freedom	10	210
	Significance	.000	.000

Source: Own elaboration

As for human capital, we obtained two factors for the training indicator, which account for 68.62% and 20.43% of variance respectively, representing 89.05% together. Furthermore, a Cronbach alpha of 0.856 was obtained for the two factors as a whole. The first factor took a value of 0.897, while the second factor could not be calculated due to the fact it only takes one variable into account.

In order to make the interpretation of the factors obtained easier, we decided to rotate the component matrix using the VARIMAX method. According to the variables with the largest factor burden, we proceeded to name each of the factors obtained.

Table 4: Rotated component matrix for human capital

Variables	Components	
	1	2
Life-long learning (adult participation in education and training) – Percentage of the population aged 25-64 participating in education and training over the four weeks prior to the survey	.057	.959
Youth education attainment level – Percentage of the population aged 20 to 24 having completed at least upper secondary education	.952	-.037
Percentage of the population aged 25 to 64 having completed at least upper secondary education	.948	.216
Percentage of the population aged 65 and more having completed at least upper secondary education	.686	.523
Early school-leavers. 100 – Percentage of the population aged 18-24 with at most lower secondary education and not in further education or training	.954	.148

Source: Own elaboration

The following are used in the elaboration of the training level indicator (Table 4):

- *Factor 1*: Qualifications. A factor related to the skill of the labour force in a country (future, present and past).
- *Factor 2*: Training capacity. A factor related to the presence of professional teachers or personnel from the education sector who are knowledge generators.

We decided to use a weighted average for the pro-activity indicator, as only two variables are taken into consideration. Weights depend on the percentage of variance captured by each variable with respect to the total. More specifically, the activity rate will be assigned a weighting of 49.11% and the variable related to e-learning 50.89%.

More variables were considered in the case of structural capital. As a result, after reducing the amount of information, we considered four factors that account for

62.03%, 11.23%, 8.33% and 5.54% of variance respectively, representing 87.14% together. The four factors record Cronbach alpha scores of 0.971; 0.902; 0.801 and 0.958 respectively, while the group of four variables recorded an overall Cronbach alpha of 0.960. We can therefore conclude that each factor boasts a high level of internal consistency.

The factors included in the potential technology indicator, after rotating the component matrix using the VARIMAX method, are called (Table 5):

- *Factor 1*: Household connectivity. This factor is related to whether or not households have an Internet connection and individual use, with the exception of e-commerce.

- *Factor 2*: E-commerce. A factor related to the use of Internet by individuals and companies for purchasing and selling goods and services.

- *Factor 3*: Company connectivity. A factor related to the availability of computer terminals, Internet connections and their basic use.

- *Factor 4*: E-management. A factor related to carrying out Management tasks with other companies, administrations and clients on the Internet.

Using the matrix of coefficients to calculate component scores, according to equation 5, we proceeded to obtain the principal components. The analysis carried out is based on factor analysis, but we used principal components as the extraction method. This makes it relatively easy to advance from a set of equations where each of the variables is expressed according to each of the common factors obtained plus a specificity factor (factor analysis) to obtain principal components as a linear combination of the original variables (principal component analysis). In this paper we decided to use principal components, as they allow to obtain efficiency indicators that summarise the information from the original variables through a linear combination of the latter. After obtaining the principal components, it was necessary to carry out a scale change to express these components in the same units as the initial variables (percentages). Furthermore, we had to restrict the variation range of these variables, as in the case of the initial variables, to between 0 and 100, as the model requires for efficiency indicators.

Table 5: Rotated component matrix for structural capital

Variables	Components			
	1	2	3	4
Enterprises with purchases by electronic mail	.126	.926	.183	.113
Enterprises having received orders on-line over the last calendar year	.317	.853	.123	.177
Enterprises having computers	.055	.181	.860	.329
Enterprises having local area network	.423	.179	.732	-.245
Enterprises having access to the Internet	.113	.343	.749	.480
Enterprises with broadband access	.496	.234	.578	.114
Enterprises having a web or a homepage	.285	.573	.585	.322
Enterprises using Internet for obtaining forms	.253	.054	.281	.825
Enterprises using Internet for returning filled in forms	.082	.117	.043	.897
Households having access to the Internet at home	.672	.594	.366	-.019
Households using a broadband connection	.768	.406	.323	.013
Individuals who used Internet for downloading official forms	.699	.190	.374	.253
Individuals who used Internet for obtaining information from public authorities web sites	.802	.295	.434	.136
Individuals who used Internet for sending filled forms	.741	.306	.165	.323
Individuals who accessed Internet, on average, at least once a week	.817	.466	.290	.062
Individuals who ordered goods or services, over the Internet, for private use	.436	.747	.413	-.017
Individuals who used Internet for Internet banking	.847	.354	.255	.215
Individuals who used Internet for sending / receiving e-mails	.777	.484	.348	.049
Individuals who used Internet for playing / downloading games and music	.933	.072	-.002	-.015
Individuals who used Internet for finding information about goods and services	.751	.527	.373	.025
Individuals who used Internet for reading or downloading online newspapers/ magazines	.885	-.043	-.055	.212

Source: Own elaboration

The values of each of the components for the 25 countries and the European Union 15 and 25 as a whole are included in Table 6 for the professional training and technology indicators. In professional training, the importance of qualifications in

Eastern European countries stands out, along with the United Kingdom, the country which also boasts the highest training capacity. In technology, household connectivity figures prominently in Northern European countries, while the Internet appeared to be less widespread among companies.

Table 6: Principal components in training and technology, EU 2006

Country	Training level		Potential Technology			
	P.C. 1	P.C. 2	P.C. 1	P.C. 2	P.C. 3	P.C. 4
Austria	70.48	16.93	44.75	59.28	41.20	69.49
Belgium	57.95	10.13	43.48	44.90	45.61	71.06
Cyprus	56.64	7.23	25.56	38.50	45.84	72.98
Czech Republic	79.58	17.33	31.44	54.05	42.92	74.10
Denmark	69.14	21.80	60.96	55.42	47.12	68.66
Estonia	76.46	23.29	42.86	57.88	55.06	64.04
Finland	65.35	11.40	58.81	64.19	51.32	72.36
France	57.20	8.78	35.50	56.62	42.04	66.74
Germany	71.65	26.35	48.08	43.78	37.16	66.94
Greece	50.93	6.65	24.62	66.48	42.16	73.30
Hungary	63.13	19.82	28.80	46.04	49.30	65.13
Ireland	61.71	7.61	38.93	61.01	35.07	65.86
Italy	57.55	7.89	29.23	60.05	44.70	72.40
Latvia	46.01	10.38	31.31	40.28	53.02	68.12
Lithuania	70.52	20.45	29.94	61.80	49.29	64.08
Luxembourg	67.31	5.23	52.81	48.18	46.26	74.15
Malta	59.15	22.73	NA	NA	NA	NA
Netherlands	28.95	25.55	62.11	51.94	48.59	67.44
Poland	70.96	7.87	27.91	55.12	44.02	66.50
Portugal	28.71	23.74	27.27	56.75	48.21	61.07
Slovakia	71.58	7.28	32.11	58.08	47.92	72.35
Slovenia	72.14	14.68	39.36	54.20	46.03	72.78
Spain	41.16	17.43	34.75	49.91	48.07	70.97
Sweden	74.32	21.88	62.08	54.90	45.39	67.46
United Kingdom	71.58	30.65	47.29	45.95	36.74	64.40
EU 15	57.69	16.65	41.19	51.47	41.69	68.19
EU 25	59.88	15.21	39.64	51.89	42.43	68.20

Note: NA Not Available

Source: Own elaboration.

Finally, in order to obtain one index of national efficiency, we considered a weighted average of each of these components. The weightings are measured in terms of their percentage share of the variance retained by the model.

The efficiency indicators (EI) calculated in this way are included in Table 7. It is interesting to note some trends in the EU-25, such as the fact that efficiency in human capital is much more widespread on this map. Emerging economies such as the Czech Republic and Estonia figured prominently, while Sweden, the United Kingdom, Germany and Finland topped the list of countries. As regards technological efficiency, Scandinavian countries recorded the top scores, although the results registered by Hungary, Austria and Estonia were interesting. Obviously, knowledge generators indicate in which emerging Central European nations investments should be made.

Table 7: Efficiency indicators, EU 2006

Country	Training	Proactivity	Technology
Austria	58.20	44.66	47.85
Belgium	46.98	40.65	45.62
Cyprus	45.30	54.03	32.18
Czech Republic	65.30	48.36	38.17
Estonia	64.26	48.71	47.31
Finland	52.97	54.90	59.65
France	46.09	36.43	40.83
Denmark	58.28	46.16	59.41
Germany	61.25	43.33	47.68
Greece	40.78	51.33	34.79
Hungary	49.30	37.30	35.29
Ireland	46.16	52.52	43.12
Italy	37.84	34.28	37.43
Latvia	59.03	49.87	36.89
Lithuania	53.07	53.63	38.07
Luxembourg	50.80	38.36	52.94
Malta	28.17	38.11	43.33
Netherlands	53.20	44.13	59.84
Poland	56.49	39.49	35.42
Portugal	27.57	42.00	35.22
Slovakia	56.83	47.49	39.53
Slovenia	58.96	54.08	44.04
Spain	35.72	44.55	40.28
Sweden	62.29	49.64	59.90
United Kingdom	62.19	47.33	47.19
EU 15	48.28	42.18	44.28
EU 25	49.63	42.00	43.30

Source: Own elaboration

Finally, we included the absolute indicators: wages, education and R&D expenditure, filtering these values by means of the INANK model. We express data as percentages of GDP (Table 8) in order to be able to compare results across countries.

Intellectual capital is measured as an aggregate of human capital components (adding Labour Force Skill and Recycle generators) and structural capital, including R&D and innovation.

Table 8: Intellectual capital in EU 2006

– in percent (%)
– GDP = 100

Country	Human Capital	Labor Force Skill Generator	Labor Force Recycle Generator	Structural Capital (R&D innovation)	Intellectual Capital
Austria	30.87	28.23	2.65	1.17	32.05
Belgium	25.87	23.47	2.40	0.84	26.71
Cyprus	24.19	20.30	3.89	0.14	24.32
Czech Republic	30.32	27.94	2.38	0.59	30.91
Denmark	34.36	30.82	3.54	1.44	35.80
Estonia	31.55	28.61	2.94	0.54	32.09
Finland	28.79	25.58	3.21	2.06	30.85
France	26.17	23.94	2.23	0.87	27.04
Germany	32.09	30.33	1.75	1.20	33.28
Greece	15.82	14.62	1.20	0.20	16.02
Hungary	24.58	22.31	2.27	0.35	24.93
Ireland	21.48	19.29	2.19	0.57	22.05
Italy	17.26	15.57	1.69	0.41	17.67
Latvia	28.49	25.39	3.10	0.26	28.75
Lithuania	25.60	22.66	2.94	0.31	25.90
Luxembourg	24.71	22.94	1.76	0.78	25.49
Malta	14.48	12.36	2.11	0.24	14.71
Netherlands	28.50	26.20	2.30	1.03	29.53
Poland	22.47	20.09	2.38	0.20	22.67
Portugal	16.82	13.84	2.97	0.29	17.10
Slovakia	22.81	20.90	1.91	0.19	23.00
Slovenia	33.71	30.30	3.41	0.70	34.41
Spain	18.54	16.61	1.93	0.49	19.02
Sweden	36.96	33.47	3.49	2.23	39.19
United Kingdom	37.24	34.49	2.75	0.83	38.07
EU 15	25.95	23.75	2.20	0.84	26.80
EU 25	26.38	24.18	2.20	0.79	27.17

Source: Own elaboration

As regards the results of intellectual capital Sweden, the United Kingdom and Denmark stand out within the EU-25 in 2006. There is a slight difference in the generation of capital for Sweden, compared to the other two countries in terms of technology and more specifically the connectivity in households and businesses, noting the results of its factors.

On the other hand, the Southern European countries such as Spain, Italy, Greece, Portugal and Malta were the worst ranked. In this case the problem is essentially of qualification and training of human capital coupled with mediocre levels achieved in the technological factors, connectivity and its low investment in R & D.

Recent member states, except for Malta, are well poised in terms of knowledge capital, which bodes well for more stable growth in these economies. In these cases, it is interesting to note the capacity achieved in human capital, both in training and pro-activity and mainly based on the qualifications of the labor force. Thus, the main generator of future development must be preserved by their governments, and that if there are qualified people migrating to other countries could cause serious consequences for their development, in this sense is available the work of Nevado et al. (2010).

5. Conclusions

The results for EU25 countries in 2006 indicate that Northern Europe has greater intellectual capital potential, which was particularly outstanding where the technological generator was concerned. This corroborates the hypothesis 1 (H1) and explains why these countries are more productive and rich, in GDP per capita terms. As they manage and apply new technologies better, we have shown that efficiency indicators in technology are superior. On the human capital side, Eastern European countries have strong potential, therefore corroborates the hypothesis 2 (H2): they have good efficiency indicators in human capital and values of absolute indicator, in general are are close to European average. The inhabitants of these countries have a good level of professional training, whereas Technologies are not used as efficiently as in Northern European countries. Moreover, the results obtained in this paper show that the major intellectual capital of the nations is in the most developed countries. This research also studied the relationship between national intellectual capital and GDP showing that this relationship is positive as has been proved in this paper.

Moreover, the favourable position of all the countries must be highlighted with the exception of Malta, that have recently acceded to the EU, in terms of intellectual capital, one of the main drivers of economic development in any given country. This situation indicates great potential for growth as well as stability. Southern Europe in particular should take note of this, in light of the low level of existing intellectual capital this area records.

The main contribution of this paper for economic science is to provide a model based on the intellectual capital that complements the macro-economic information system and allows the measurement of national economic development. The method offers a more objective way of measuring intellectual capital through statistical techniques. On the other hand, it enables comparisons and checks on the efficiency of knowledge management between different territories.

The directives for future research are developing, basically, in three directions: first of all, we need more desegregation of components in the structural capital to extract image, relational, processes, social or environmental effects. Second, we can use dynamic studies with panel data models to analyse relationship between intellectual capital and Gross Domestic Product. Finally, we want to develop an application and study of intellectual capital at international level considering the World Bank data collection as basic database source.

The institutional implications of the investigation results be taken into account when designing national policies and strategies, as it reveals the aspects that should receive more attention in order to foster convergence and balanced development within the Union. However, if countries do not take advantage of certain European knowledge processes to converge, rapid human decapitalisation together with slow technological capitalisation processes in poor countries and new member states could give rise to two groups of countries that grow at different speeds.

Finally, despite the limitations of the information and of the empirical research, it is necessary to comment that the indicators of human capital, we considered, the information with the greatest impact on the level of professional training in a given country, as well as the activity rate and activities related to e-learning. In the case of the technological indicators, we considered the information that was most relevant from the new surveys on science and technology elaborated by EUROSTAT.

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Procjena intelektualnog kapitala u Europskoj uniji korištenjem modela znanja

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Sažetak

U ovom radu se predstavlja model usmjeren na mjerenje intelektualnog kapitala kao potencijalnog znanja zemlje i primjenjuje se na Europsku uniju. Metoda se sastoji u aktiviranju troškova koji doprinose generiranju znanja. Kako bi se to učinilo, koristimo pokazatelje učinkovitosti izvedene iz sažetka varijabli strukturalnih, ljudskih i tehnoloških kapitala pomoću faktorske analize. Rezultati ove studije za EU25 2006. godine objašnjavaju zašto sjeverna Europa ima veći potencijal intelektualnog kapitala. Oni su produktivniji jer bolje primjenjuju i upravljaju novim tehnologijama. Istočne zemlje imaju jak potencijal ljudskog kapitala. U radu se zaključuje da, na konceptualnoj razini, te informacije treba iskoristiti za dizajniranje konvergencijskih politika i uravnotežene strategije razvoja kako bi se osigurao gospodarski rast.

Ključne riječi: *intelektualni kapital, ekonomija znanja, pokazatelji, Europska unija*

JEL klasifikacija: *J24, O18, O3, R5*

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