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The Objective Value of Intellectual Capital: An Empirical-Quantitative Approach

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Abstract: *The purpose of this paper is to summarize the Ph.D Thesis in Information Science (2019) which dealt with the calculation of the intellectual capital value at Efacec Power Solutions, SGPS, SA (EPS), on December 31, 2017, a heavily capital intensive company, reflected in the weight of intangible assets over total assets. It was concluded that the value was € 1.908 million, being the sum of 4 core competencies: Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networks (Core Competence 2) in the amount of € 766 million, Hardware and Software Design and Development (Core Competence 1), valued at € 670 million, Projection and Exploration of Water Systems and Industrial Installations (Core Competence 4) valued at € 269 million and Solutions for Transportation (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management (Core Competence 3) worth € 202 million. Its calculation depended on choices made by the researcher, namely, regarding the evolution of Consolidated Sales and/or Services Provided and Nominal Annual Rate of Change, for a period of 10 years + 1, which has subsequent effects on other items that depend on this baseline. The main conclusion that can be drawn is that the same time horizon, but based on non-annual but monthly or even weekly or, preferably, daily subperiods, could dictate an outcome that would be closer to reality, especially if it had specified other factors such as the qualifications of the workforce and its changes over time. This would have the ability to be more reliable and re-flect the value created by the workforce in its various categories, from its absolute number to a construct that would reveal the aforementioned qualifications and the value created within the company, in this case EPS.*

Keywords: Intellectual Capital, Measurement Method, Core Competencies

1. Introduction

The topic of intangible assets, in particular on the intellectual capital, has known a set of approaches that focus on its definition, the way of measuring it and, knowing its value. More than knowing these 3 issues, their importance has to do with business performance, the creation of competitive advantages by companies, the production of more improved goods or services that provide greater Well-Being to consumers and world market shares of countries, beyond the companies.

A set of authors, such as Gogan and Draghici (2016), Berzkalne and Zelgalve (2014), Sekhar et al. (2015), Abdullah and Sofian (2012), Arvan et al. (2016), Goebel (2015), among others, have focused on intellectual capital in these 3 issues, namely, in the form of scientific papers. On the other hand, authors such as Palacios and Galván (2007), Pulic (2000) and Gadau (2012), have mentioned in papers that, in the definition-measurement-value triad, it is sequential and

interlinked. Therefore, if there is no consensus regarding the definition of intellectual capital, the following 2 components are restricted in their possibility of interconnected development. Much of what nowadays are reasons for divergence lies in the lack of a definition that can be used universally, whatever the company, sector of activity and country.

Therefore, as long as this obstacle has not been clarified, in-depth developments and universal application remain a limiting factor in the universal application of the definition of what is the intellectual capital. And also of any ways to measure it (in companies) and to know what value it has, in general and in concrete. In addition to not knowing how it is created and can be valued with positive effects on companies in several aspects.

The *research problem* can be stated as follows: *nowadays, there is a difficulty in the scientific community to measure intellectual capital and to obtain an economic value for its reference, in the context of a company*. In turn, the *research question*, which emerges from the problem, is stated as follows: *is it possible to measure intellectual capital in the context of a company and obtain an economic value as a result? And how can this process be carried out? What precise procedures are required to be applied?*

The Andriessen´s (2004) method, is the one through which it is intended to measure the value of intellectual capital, in the specific case, of a Portuguese company: *Efacec Power Solutions, SGPS, SA* (EPS), considering the reference day December 31 of the year 2017.

This *paper* is divided into 3 Sections: Section 1, *Introduction*, Section 2, *Literature Review*, Section 3, *Methodology*, Section 4, *Discussion and Conclusions* and, finally, *References*.

2. Literature Review

Nowadays, several authors have been working on the topic of the intellectual capital. Some relate this to business performance, definition and others to innovation, in particular.

Berzkalne and Zelgalve (2014), carried out a study regarding the relationship between intellectual capital and business performance. Historical values were not suitable for this purpose. They define intellectual capital as being the sum of 3 components: human capital (labor costs - efficiency, measured by Human Capital Efficiency - HCE), structural capital (added value less human capital - efficiency equal to Structural Capital Efficiency - SCE) and capital employed (financial capital, equal to the added value divided by structural capital, being the efficiency equal to Capital Employed Efficiency - EEC). Intellectual capital is equal to the sum of HCE, SCE and CEE and is called VAIC[1]. It is the new value created by each euro invested in a company: if higher (lower, equal) than one, the market value is higher (lower, equal) than the book value and the market overestimates (underestimates or estimates equally) a company. Business performance is measured by the indicator: Tobin's Q-ratio. In a sample of companies listed on the Estonian, Lithuanian and Latvian Exchanges (2005 to 2011), the authors concluded that it was in Estonia (2006) that the highest value of VAIC was obtained and the lowest in Lithuania (2007). In conclusion, in Estonia, in all years, the market overestimated the value of companies and in Lithuania (excluding 2009 and 2011) but, less than in Estonia. In Latvia, except in 2007, the market underestimated the companies concerned. Gogan and Draghici (2016), for their part, intend to know the value of intellectual capital based on their own definition. For these, it consists of 3 components, but different from that of the

[1] *Value Added Intellectual Coefficient* (VAIC).

previous authors with regard to their content: sum of human capital (knowledge stock), structural capital (relationship with productivity) and customer capital (company links) with the outside world - customers and suppliers). Globally, they dissect methods and models for measuring intellectual capital. In conclusion, the authors infer that intellectual capital should always be seen with the 3 components integrated beyond their value should be regularly reviewed. At a certain moment the knowledge of its value, makes it possible to know if the company is more competitive (or not) in relation to its competitors. On the other hand, this definition makes it possible to know which component has more or less impacts on business performance and, therefore, to know how to develop them. This issue leads to the fact that managers are obliged to adopt knowledge management practices, related with the workers, defining goals to be reached by them, namely.

Abdullah and Sofian (2012), underlie the idea of knowing what are the perceptions that companies listed on the Malaysian Stock Exchange have about the intellectual capital. This is understood as being made up of 4 components: human capital, structural capital, relational capital and spiritual capital (everything that can make Humanity sustainable in the future). Given this definition, these same authors seek to know which of the components has the highest degree of association with business performance, being the predominant component among the 4 that make up this acceptance of intellectual capital. As a most notable conclusion, relational capital appears as the most important component, followed by structural and human capital. The influence of the spiritual capital component in sectors such as services, securities trading, financial and technological sectors is yet to be studied.

Zhicheng et al. (2016), focus the paper on the impacts of intellectual capital on business performance called, respectively, MAKE (Most Admired Knowledge Enterprises) and NON-MAKE (Non-Most Admired Knowledge Enterprises), that is, that were and were not awarded in terms of how they manage knowledge, promote brands and increase business performance. The sample considered was 59 companies in each of the 2 groups (total of 118). Capital proved to be more efficient in the former and, in human capital and in the added value of intellectual capital, a negative correlation was observed with productivity in the latter and positive in the former. In a nutshell, MAKEs create more value because they make better use of financial assets, which comes from creating more income and profits. The focus, therefore, should be on these same financial assets and not on the cost side (related to internal processes). But, by itself, this focus does not guarantee the best business performance, because it leads to the interpretation of intellectual capital as being coincident with goodwill (which is not true). This doubt is a source of future research and avenues that enable more knowledge.

Vosloban (2012), in turn, studied the possible relationships between the performance of labor factors in the growth of companies, framed in economies that are located in so-called emerging markets (economies in accelerated growth and development). One of the corporate strategies that companies can undertake is that associated with investment and know-how, as well as in other company-owned resources. The pursuit of this strategy is dependent on factors such as entrepreneurship responsibility, management skills of management without forgetting the qualifications of the workers themselves.

Defining the concept of business performance is crucial in this context. This is based on the identification and use of the qualifications of the workers. Therefore, if they are high, it requires that they appear in line with business performance, because it induces a positive image and high expectations of the company, its employees and managers. If the performance of workers is high, the same will be true of business growth.

Among the most evident conclusions, we highlight, in the performance of workers, with regard to customer relations, attracting customer loyalty to the products and/or services of companies, Knowing the main features of the markets (emerging) where companies operate is one of the main obstacles faced by managers to offer the products and/or services desired by customers.

Kalkan et al. (2014), investigated the effects of intellectual capital and organizational strategies, as well as innovation (of the incremental type), on business performance. When implemented, they define as the outcomes of decisions made regarding factors of different nature, such as the environment, structures and processes that have repercussions on business performance. This can be financial, product or market. Finally, due to innovation (of the incremental type), the authors understand it as "an implementation of new ideas to create value" (p. 700). The Intellectual capital, in companies, is intrinsically associated with the capacity for innovation of the incremental type, saying the authors that, without the first, there is no second. The basis of this type of innovation is based on the relationships that are established between human capital, organizational capital and social capital.

As main conclusions, some stand out. The intellectual capital, organizational strategies and incremental innovation, have positive effects on business performance. According to Pearson's linear correlation coefficient, it assumes the values of + 0.222, + 0.221 and + 0.101, respectively, for a significance level of 1%. If measured by linear regression coefficients, the respective values are, + 0.226, + 0.192 and + 0.465, respectively, but considering a significance level of 5%.

3. Methodology

The main source of information, from which the Andriessen´s (2004) method was applied, was the Financial Statements of Efacec Power Solutions, SGPS, SA (EPS) [Portugal], which referred to the years 2017, 2016 and 2015 and, therefore, constituting secondary data sources, since they are not specific to this study. Primary data would not be at the reach of the researcher (non-public information) and even if they were, they might not be what was intended for the purposes of the study. In addition to this, and as an accessory but by no means less important, sources of information such as related calculations were also used, for the years 2018 to 2027, such as forecast sales, including interest rates, (average) cost of capital and risk premium which allows the calculation of the discount rate, the discount factor and, finally, the net present value. Thus, the underlying approach was quantitative where Zikmund et al. (2009), in this regard, refer that it is a type of research in which the goals are achieved via empirical evaluations, using measures and forms of analysis.

It reports to December 31, 2017, with the respective method calculations beginning on January 1, 2018. It was in the years 2018 and 2019 that this entire process was carried out with the purpose of knowing the intellectual capital value of EPS on December 31, 2017. In its entirety, the Andriessen´s (2004) method, according to its author, is called the Weightless Wealth Tool Kit, with 20 sequential steps. These are summarized from Tables 1. to 5.

Thus, in Table 1., we have EPS Consolidated Sales and/or Services provided (for the years 2015 to 2017), observed or historical, the standardized average, as well as for the years 2018, 2019 and 2020, the respective values, estimated, also consolidated.

Table 1: EPS Consolidated Sales and/or Services Provided (Years 2015 to 2017), Standardized Average and Forecasted Consolidated Sales and/or Services Provided (Years 2018 to 2020) (in Million € and %)

Heading		2015	2016	2017	Standardized Average (3 Years)	2018 (F)[2]	2019 (F)	2020 (F)
L1	Consolidated Sales and/or Services Provided	+ 422 914 356	+ 437 954 175	+ 431 886 771	+ 430 918 434	+ 436 572 742, 465	+ 441 309 556,72	+ 446 097 765,41
L2	Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided	-	+ 3.55 %[3]	- 1.38 %[4]	+ 1.085 %[5]	-	-	-

Source: Efacec (2017), Efacec (2016) and Efacec (2015).

As can be seen from Table 1, along line 1 (columns 2, 3 and 4), we have consolidated sales and/or services provided, for the years 2015, 2016 and 2017, with the observed values being taken from the Financial Statements. In the same line, but in column 5, we have the arithmetic mean of these same years. In line 2 (columns 3 and 4) we have the nominal annual rate of change of the item shown in line 1. From 2015 to 2016 they grew + 3.55% (see calculation process in note 7) and from 2016 to 2017 they decreased + 1.38% (see note 8), which makes up a standardized average of + 1,085% (line 2 and column 5 - see note 9). In line 1 and columns 6 to 8, we have, from the arithmetic average, the consolidated sales and/or services provided, for the years 2018, 2019 and 2020, respectively. These values have implied, the growth at a nominal annual rate of change of + 1,085%. These are calculations made according to Andriessen (2004, p. 392 and 393). The latter adopts the first 5 years, but we consider only the first 3 years to be more appropriate, due to uncertainty about the future, which is relatively less in 3 than in 5 years. In Table 2., we show the consolidated accounting values of EPS, for the years 2015 to 2017, as well as other necessary auxiliary calculations.

Table 2: Consolidated AccountingValue of EPS (Years 2015, 2016, 2017) and Other Auxiliary Calculations (in Million € and %)

Relevant Items		2015	2016	2017	Average
L1	EPS Consolidated Book Value = Total EPS Equity	+ 308 682 442	+ 309 147 595	+ 345 720 692	+ 321 183 576
L2	Real Economic Growth Rate in Portugal[6]	+ 1.8 %	+ 1.3 %	+ 2.5 %	+ 1.8%
L3	Total Fair Rate of Return	+ 1.8 %	+ 1.3 %	+ 2.5 %	+ 1.8%
L4	Fair Rate of Return for Intangible Assets	(0.66) × (+ 1.8 %)	(0.66) × (+ 1.3 %)	(0.66) × (+ 2.5 %)	+ 1.23%
L5	Fair Rate of Return for Tangible Assets	(0.33) × (+ 1.8 %)	(0.33) × (+ 1.3 %)	(0.33) × (+ 2.5 %)	+ 0.61 %
L6	Standardized Average (3 Years)				+ 430 918 434
L7	Value of Tangible Assets Subtracted from Standardized Average (3 Years)[7]	-	-	-	+ 142 858 828,26
L8	Value of Intangible Assets Subtracted from Standardized Average (3 Years) = Intangibles-Driven Earnings (Past) (IDE-P)	-	-	-	+ 288 059 605,33

Source: Efacec (2017), Efacec (2016) and Efacec (2015).

[2] Forecast prepared in September 2018.
[3] Calculation done as follows: ((+ 437 954 175 / + 422 914 356) - 1) × 100 = + 3.55 %. Observed Value.
[4] Calculation done as follows: ((+ 431 886 771 / + 437 954 175) - 1) × 100 = - 1.38 %. Observed Value.
[5] Calculation done as follows: [(+ 3.55 %) + (- 1.38 %)] / 2 = + 1.085 %.
[6] If there were real, negative economic growth rates, an adjustment would be necessary. As this did not happen, no adjustment is need, so it is adopted as it was observed in reality.
[7] This value was calculated by means of a simple 3 rule considering the rates of, total fair return, fair return for tangible assets and for intangible assets. It was carried out according to this procedure because the sum of the two values must give the standardized average. Andriessen (2004, p. 390) suggests that the total fair rate of return should be subtracted from the fair rate of return of tangible assets. This procedure would lead to the failure to obtain the total of the standardized average equal to the sum of the 2 parts. Therefore, this procedure was adopted because the value thus obtained will prove to be very important for the subsequent steps and is the sum of the value (thus calculated) of the tangible assets. Procedure understood as correct carried out on personal responsibility.

Table 2. and line 1, columns 2, 3 and 4 show the consolidated book value of EPS in the years 2015 to 2017. In column 5 of the same line, the average of these 3 years. In line 2, column 1, the Real Economic Growth Rate in Portugal (observed) which is supposed to be the same as the Total Fair Rate of Return which makes an average of + 1.8%. This value, where row 3 (in all columns) coincides with row 2, is an assumption made by the researcher. In line 4, assuming, from the Financial Statements (year 2015 and following, approximately, constant), that the weight of the value of intangible and tangible assets on the total assets is, + 0.66 and + 0.33, respectively, then multiplied. by the respective values of line 3. At the end, it makes an arithmetic average of + 1.23% (line 4 and column 5). The same for line 5, mutatis mutandis. Table 1., shows the normalized average for consolidated sales and/or services provided. By using the simple 3 average rule, in line 7 column 5, we obtain the value of tangible assets subtracted from the normalized average, which amounts to € + 142 858 828.26 and for intangible assets the value of € + 288 059 605.33, mutatis mutandis.

In Table 3, the auxiliary calculations and the intellectual capital value of EPS, as of December 31, 2017 are displayed. They are necessary for the following 2 Tables.

Table 3: Auxiliary Calculations (in Million € and %)

Items		2017	Average	1	2	3	4	5	6	7	8	9	10	11	Units
				2018 (F)	2019 (F)	2020 (F)	2021 (F)	2022 (F)	2023 (F)	2024 (F)	2025 (F)	2026 (F)	2027 (F)	2028 (F)	
L1	Consolidated Sales and/or Services Provided	+ 431 886 771	+ 430 918 434	-	-	-	-	-	-	-	-	-	-	-	€
L2	Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided	- 1.38 %[8]	+ 1.085%[9]	+ 1.085 %	+ 1.085 %	+ 1.085 %	+ 1.13 %	+ 1.175 %	+ 1.22 %	+ 1.265 %	+ 1.31 %	+ 1.355 %	+1.4 %	+1.4 %	%
L3	Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided from EPS in Long Term	-	-	-	-	-	-	-	-	-	-	-	+1.4 %		%
L4	Intangibles-Driven Earnings (Past) (IDE-P) (2017) and Intangibles-Driven Earnings	-	288	291	294	297	301	304	308	312	316	320	325	-	Millions €

[8] Calculation done as follows: ((+ 431 886 771/+ 437 954 175) -1) × 100 = - 1.38 %. Observed.
[9] Calculation done as follows: [(+ 3.55 %) + (- 1.38 %)] / 2 = + 1.085 %.

	(Future) (IDE-F) (2018 a 2028)														
L5	Interest Rate	-	+ 1.4%[10]	+ 2.1% [11]	+ 1.8%	+ 1.7%	+ 1.6%	+ 1.8% [12]	+ 1.8%	+ 1.8%	+ 1.8%	+ 1.8%	+ 1.8%	-	%
L6	Average Cost of Capital	-	+ 3%	+ 3.25 %	+ 3.50 %	+ 3.75 %	+ 4.00 %	+ 4.25 %	+ 4.50 %	+ 4.75 %	+ 5.00 %	+5.25 %	+ 5.50 %	-	%
L7	Risk Premium	-	+ 9.375%	+ 9.625 %	+ 9.875 %	+ 10.12 5%	+ 10.37 5%	+ 10.62 5%	+ 10.87 5%	+ 11.12 5%	+ 11.37 5%	+ 11.62 5%	+ 11.87 5%	-	%
L8	Discount Rate	-	+ 13.775 %	+ 14.97 5%	+ 15.27 5%	+ 15.57 5%	+ 15.97 5%	+ 16.67 5%	+ 17.17 5%	+ 17.67 5%	+ 18.17 5%	+ 18.67 5%	+ 19.17 5%	-	%
L9	Discount Factor	-	-	+ 87.89 3%	+ 75.64 7%	+ 65.28 2%	+ 56.04 6%	+ 47.66 3%	+ 39.64 0%	+ 32.97 3%	+ 27.19 7%	+ 22.24 7%	+ 18.04 7%	-	%
L10	Net Present Value (NPV)	**+ 1,908**	-	+ 256	+ 223	+ 194	+ 169	+ 145	+ 122	+ 103	+ 86	+ 71	+ 59	+480	Millions €

Source: Efacec (2017), Efacec (2016) and Efacec (2015). Values in € and percentages.

Thus, in line 1, we recall the observed value of consolidated sales and/or services provided, reported on December 31, 2017, and the normalized average.

In row 2. and column 3, we have the Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided from 2016 to 2017 and in column 4, the normalized average: + 1,085%. We assume that, in the years from 2018 to 2020, the rate of change is the same, for simplification and, thereafter, it grows + 0.045 percentage points per year, which makes up + 1.4% (long-term growth rate according Banco de Portugal - 2018 consultation year). In line 3, we have the Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided of + 1.4% of EPS in the year 2027 - which coincides with the long term - assumption).

Along line 4, column 4, we have the intangible assets value subtracted from the normalized average: € 288 million. That is, IDE-F. From 2018 to 2027, these grew at the rates shown in row 2, from column 5 (2018) to 14 (2027).

In line 5 and column 4, we have interest rates, based on Banco de Portugal, year 2017, the same occurring for the years 2018 to 2027 (forecasts). In line 6 and for the years 2018 to 2027, average cost of capital, under the same conditions as the interest rates. In lines 7, 8 and 9 we have the risk premium, the discount rate, the discount factor, for the same period, according to the sources Banco de Portugal and other auxiliaries, with regard to the assumed values.
Finally, in row 10 column 3, we have the intellectual capital value, which is no more than the sum of the partial values from 2018 to 2027, reported in 2017.

In Table 4., from the 8 business units, EPS Core Competencies (CC) are defined. In accordance with the arrangement carried out by the researcher and grouping the 4 business segments (corresponding to 8 business areas) that have common denominators in terms of the production and provision of services carried out, we proceeded to the definition of 4.

[10] Observed. Provided from *www.pordata.pt*, on December 30, 2018.
[11]These percentages were provided from Banco de Portugal´s forecasts, available at *https://www.bportugal.pt/page/projecoes-economicas*, and consulted on December 31, 2018.
[12] From 2021 to 2028, it is assumed that they will grow at the average + 0.045 percentage points para, em 2027 (e 2028), coincidir com a taxa de longo prazo de + 1.4% (fonte Banco de Portugal).

Table 4: Calculation of the Value of Each of EPS´s 4 Core Competencies (Value of the Intellectual Capital) (December 31, 2017) (in Million € and %)

Year 2017		Total		Business Segment				Sub otal	Business Segment			Subt otal	Business Segment	Subt otal	Other Unallocated and Adjustments (Residual)	Subt otal	Units
				Energy Products					Systems				Mobility				
				Business Area					Business Area				Business Area				
		Absolute Value	%	Transformers	Equipment	Service	Automation		Energy	Environment and Industry	Transports		Electric Mobility				
L1	Standardized Average	430	-	125	66	24	50	-	93	49	36	-	18	-	-30	-	Millions €
L2	Percentage of the Value of Each Business Area Regarding the Standardized Average	100 %	-	29%	15%	5%	12%	-	22 %	11%	8%	-	4%	-	-7%	-	%
L3	Intangibles-Driven Earnings (Past) (IDE-P) (2017) and Intangibles-Driven Earnings (Future) (IDE-F) (2018 a 2028)	288	-	84	44	16	34		62	33	24		12		-20		Millions €
L4	Value of the 4 Core Competencies Distributed Over the 8 Business Areas = Value of the Intellectual Capital	1908	-	555	293	104	223	1176	413	216	158	787	79	79	-133	-133	Millions €
Core Competencies (4) – Imputation Percentages																	
L5	Hardware and Software Design and Development (Core Competence 1)	-	-	10%	85%	15 %	5%	-	90 %	-	-	-	-	-	-	-	%
L6	Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networ	-	-	90%	15%	10 %	85%	-	-	15%	10%	-	10%	-	-	-	%

	ks (Core Competence 2)																
L7	Solutions for Transportation (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management (Core Competence 3)	-	-	-	-	-	10%	-	-	-	90%	-	90%	-	-	-	%
L8	Projection and Exploration of Water Systems and Industrial Installations (Core Competence 4)	-	-	-	-	75 %	-	-	10 %	85%	-	-	-	-	-	-	%
L9	Total	-	-	100%	100%	100 %	100%	-	100 %	100%	100%	-	100 %	-	-	-	%
Value of Core Competencies (4) – (Value of the Intellectual Capital)																	
L10	Hardware and Software Design and Development (Core Competence 1)	670	35 %	+56	+249	+16	+11	-	+371	0	0	-	0	-	-33.00	-	Millions €
L11	Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networks (Core Competence 2)	766	40 %	+500	+44	+10	+190	-	0	+32	+16	-	+8	-	-33.50	-	Millions €
L12	Solutions for Transportation (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management (Core Competence 3)	202	11 %	0	0	0	+22	-	0	0	+143	-	+71	-	-33.50	-	Millions €

L 13	Projection and Exploration of Water Systems and Industrial Installations (Core Competence 4)	269	14 %	-0	0	+78	0	-	+41	+183	0	-	0	-	-33.50	-	Millions €
L 14	Total	+ **1,908**	100%	+555	+293	+104	+223	+1176	+413	+216	+158	+787	+79	+79	-133	-133	Millions €

Source: Efacec (2017), Efacec (2016) and Efacec (2015). Values in € and percentages.

From his observation, we can see along line 1, for the year 2017, the distribution of the observed the values of consolidated sales and/or services provided by each of the 8 business areas. Along line 2, the imputed percentages of each of the 8 business areas regarding the standardized average. Each of these percentages, resulted from dividing the value of each of them by 430. Thus, 29% was calculated by dividing 125/430 and 15% by dividing 66/430 and so on, for the remaining percentages along the entire line 2.

In line 3, we have the same imputation of IDE-P in the year 2017 and IDE-F from 2018 to 2027. It was calculated by multiplying the percentages of line 2 by the value of 288. Thus, we have 84 equal to 29% times 288 and 44 equal to 15% times 288 and so on along the entire line 3.

Finally, in line 4, we have the value of 555, which results from multiplying 29% by € 1.908 million. The same happened to 293 that resulted from multiplying 15% times € 1.908 million. In lines 5, 6, 7 and 8 in column 2, we have the designation of each of the 4 core competencies defined. Thus, along column 2, in line 5, we have Hardware and Software Design and Development (Core Competence 1), in line 6 Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networks (Core Competence 2), in line 7 Solutions for Transportation (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management (Core Competence 3) and in line 8 Projection and Exploration of Water Systems and Industrial Installations (Core Competence 4).

The percentages along lines 5 to 8 are the attribution of each business area to each core competence. It is assumed that each of the business areas absorbs a percentage of the core competencies and that it is a part of the intellectual capital value. Thus, Transformers, absorbs 10% of core competence 1 and 90% of 2. All these percentages resulted from the subjective attribution of the researcher according to the most reasonable criterion of the imputation percentage. In column, the sum of the percentages has to make up 100%.

From lines 11 to 13, we have the partial values and their respective weight in the total of € 1.908 million (EPS's intellectual capital value on December 31, 2017). Each of these was calculated as follows: the value of 56 resulted from multiplying 10% times 555, the 500 from 90% times 555. All other values from all other columns were calculated analogously according to the same criterion. The partial value of core competence 1, in line 10 and column 3, results from the sum, in line 3, of columns 5 to 16. The same is true of lines 11, 12 and 13 in column 3, totaling € 1.908 million. The percentages in lines 10 to 13 in column 4, result from dividing each value of the same lines but from column 3 by the fixed value of line 14 and column 3. Consequently, 35% was calculated by dividing 670 by 1.908, the same happening for the others, mutatis mutandis.

It should be noted that, in the last row, 14, and column 3, is nothing more than the sum of columns 5 to 8, 10 to 12 and 13 to 15.

Finally, in Table 5, we have the 4 core competencies displayed from 1 to 4.

Table 5: Ordering the Importance, in Value, of Each of the 4 Core Competencies (Value of the Intellectual Capital) of EPS

Hardware and Software Design and Development (Core Competence 1) - € 670 million	2nd Place
Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networks (Core Competence 2) - € 766 million	1st Place
Solutions for Transportation (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management (Core Competence 3) - € 202 million	4th Place
Projection and Exploration of Water Systems and Industrial Installations (Core Competence 4) - € 269 million	3rd Place

Source: Own Construction, Referring to December 31, 2017.

It can be seen that, due to their importance in terms of value, the 4 core competencies, 2, 1, 4 and 3, appear in 1st (€ 766 million), 2nd (€ 670 million), 3rd (€ 269 million) and 4th (€ 202 million) seats, respectively.

4. Discussion and Conclusions

According to the calculation processes shown in Tables 1. to 5., the intellectual capital value of EPS, reported on December 31, 2017, is € 1.908 million, of which, € 766 million refers to core competence, *Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networks* (Core Competence 2), € 670 million to core competence *Hardware and Software Design and Development* (Core Competence 1), € 269 million to core competence *Projection and Exploration of Water Systems and Industrial Installations* (Core Competence 4) and, finally, € 202 million to core competence *Solutions for Transport (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management* (Core Competence 3), according to the Andriessen´s (2004) method. It should be noted that, this is a method, the steps of which, in particular, those covered by Tables 1. to 5., are subject to a set of calculations and are assumed to lead to another outcome if they were others.

This is what happens with Table 1., where the Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided of + 1.085% is considered, which, in turn, results from the average of the years 2016 and 2017. Note that, here, we have a negative rate of change in the year 2017. If it were positive the average would be over + 1.085% which would give forecasts from 2018 to 2020 (and following years), higher in the calculation of the IDE- F that, for the same discount rate, ceteris paribus, in line 8 of Table 3., would give lower values, so its sum reported on December 31, 2017 would also be lower and, therefore, the intellectual capital value of EPS. Thus, there is a sensitivity of the final intellectual capital value to this rate: if it were higher (lower) it would give a lower (higher) the intellectual capital value. The consideration of the evolution of FDI-F at other, well-founded rates, would be more appropriate because it would provide more accurate values of the intellectual capital value.

It should also be noted that, there is a sensitivity to the absolute value of the referred rate: the higher (lower) it is the lower (higher) the intellectual capital value. Thus, this rate, according to the importance underlined, is shown to be the first conditioning step of everything that is subsequent, *per se* or in a chain.

In Table 2, some particularities are also highlighted. The weight of intangible assets over total assets, it was assumed that, from the Financial Statements, it was approximately + 0.66 (which

is to be expected in a highly technological and capital-intensive company). If the weight were lower (higher), the average fair rate of return for intangible assets would be lower (higher). It is assumed that the weight of tangible assets is + 0.33 (0.66 + 0.33 = 1). Thus, there is a sensitivity to these weights, with effects on the values of lines 7 and 8 of column 5. In particular, on the value of IDE-P of € 288 million. For higher weights, the intangible assets value, taken from the Financial Statements on total assets, IDE-P would be higher.

Consequently, according to Table 3., from 2018 to 2027, for the same Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided (remember that it is + 1,085%), they would be higher than what, ceteris paribus, would originate IDE- F, also higher and its corresponding value in each of these years also higher and, ultimately, a higher NPV, that is to say, a higher intellectual capital value. It can be concluded, then, that the weight of the intangible assets value over the total asset, denotes significant effects on the final intellectual capital value.

Also in Table 3, the higher (lower) the percentages of lines 5, 6 and 7, the higher (lower) the discount rate, resulting in a lower NPV, which means that the intellectual capital value will also be lower. If these percentages evolve to such an extent that, resulting in few changes in the sum of the 3, for each year, from 2018 to 2027, the sensitivity of the NPV, that is, the intellectual capital value, will change little. Thus, it is necessary to emphasize the idea that, if the percentages of these 3 items, behave in a way that significantly changes the discount rate, the intellectual capital value (NPV) will also know the same relevant variation: to increase or to decrease.

From Table 4, it is worth noting the values assumed along line 2. It is the weight of the value of each busi-ness area. If there are relevant changes (upward or downward) the values of IDE-P and IDE-F change, and the value of each core competence. By lines 5 to 8, it is noted that the attribution of each business area to each core competence. If these imputations, subjective according to what is most indicated from the researcher's point of view, are changed, the values assumed by each core competence and, consequently, their importance are changed too. The total EPS's intellectual capital value remains unchanged. Thus, it appears that there is sensitivity to the percentages assumed in line 2 and in lines 5 and 6 of Table 4. If only in line 2, the values of each core competence and its total are modified and, therefore, of the EPS's intellectual capital value. It depends on the amounts recorded in the Financial Statements, for each business area. If only on lines 5 and 6, only the partial values of each core competence are modified but the total value remains the same, meaning that the EPS's intellectual capital value remains unchanged.

Thus, in Table 5., according to what is mentioned in Table 4., the composition, order and how important are the core competencies may be different and the final value of the 4, as well. There may be a new EPS's intellectual capital value, resulting from the aforementioned changes.

The *research problem* regarding the intellectual capital, is related to the difficulty of measuring the intellectual capital value in a company. Our contribution made it possible, via Andriessen´s (2004) method to know the same thing, on December 31, 2017, in a technological company: EPS.

Regarding the *research question, is it possible to measure intellectual capital in the context of a company and obtain an economic value as a result? And how can this process be carried out? What precise procedures are required to be applied?*

In the first sub-question, the answer is affirmative: it is possible to measure the company's intellectual capital value and obtain a concrete and objective value. The case in point, is an example, a concrete value was obtained, dated in time, according to an integrated method of application. It can be applied to companies in various activity sectors (in particular technological, because they are more intensive in intangible assets). This method also has the ability to have a set of 20 structured and sequential steps, it is only necessary to follow them to apply it, constituting the procedures required for its application. It should be noted that, despite having 20 steps, it can be summarized only to the content of what is found in Tables 1. to 5.

In the second sub-question, the execution process consists of following the steps of theAndriessen´s (2004) method, with adaptations that simplify it and make it feasible in an empirical application.

In the third, among the most important procedures, included in the method, are the Consolidated Sales and/or Services Provided and Nominal Annual Rate of Change, deriving from here procedures subsequent to the values assumed by them (see the referred Tables).

The most evident advantage, is the fact that it is influenced by the environment related to the evolution of the economy, in general, in the country, in a prospective way, via Consolidated Sales and/or Services Provided and Nominal Annual Rate of Change. It also makes it possible to enter into account with the value, separately, only from here what is intangible, in this case, from EPS instead of an amalgam of intangible and tangible assets.

It also has the advantage of considering cash-flows updated to a desired date, through a discount rate, which includes interest rates, the average cost of capital and the risk premium inherent to the activity sector and external influences that have effects on it. There is another advantage of the method: it is possible to combine the Consolidated Sales and/ or Ser-vices Provided, according to the qualifications that EPS holds and that are dispersed by their production. This facilitates the identification of both the number and the designation of core competencies, in total and in part, subject to the researcher's point of view, as being the most appropriate.

On the other hand, it also makes it possible to establish a quantified relationship between, in this case, the core competencies with the business segment and business areas and to adapt, with internal changes in these. Regarding to the disadvantages, from the outset, it can be seen that the combination of the content of the tables in which its main steps are embodied, are a little complex, which makes it difficult to calculate.

Since it has subjective elements (dependent on the researcher), its elaboration by 2 different people can lead to different results as well. For this reason, the intellectual capital value of the same company, on the same date, is not necessarily the same.

It needs to specify some elements that are the basis of intangible assets and, therefore, of the intellectual capital and respective value. Among them, human resources (quantity and quality held - should include their variation) in the calculation of the intellectual capital value stand out. At the end of the day, all factors that may change the value of all intangible assets (in addition to intellectual capital itself) must be made explicit.

In the conclusions, about the main features of our Ph.D Thesis in Information Science, year 2019, Andriessen´s (2004) method of calculating the intellectual capital value of a Portuguese company was presented: Efacec Power Solutions, SGPS, SA (EPS) (technological sector), as

of December 31, 2017. This choice resulted not from mere chance but based on the purpose of being a company with a strong weight in the total assets of intangible assets which is consistent with those of the technological sector.

It was concluded, from all the assumed assumptions, that the intellectual capital value was € 1.908 million [sum of the 4 core competencies: € 766 million (*Development of Technologies, Simulation of Equipment Behaviors and Management of Electrical Networks* (Core Competence 2)), € 670 million (*Hardware and Software Design and Development* (Core Competence 1)), € 269 million (*Projection and Exploration of Water Systems and Industrial Installations* (Core Competence 4)) and € 202 million (*Solutions for Transportation (Rail, Road and Metro) and Energy for Electric Vehicles and Network Management* (Core Competence 3)).

This value appears to be excessive, meaning that its shareholders would be placed in a tempting position to sell it immediately. However, this value may not actually be excessive since, in truth, the intellectual capital value is not known, either according to other methods or according to it.

There are also external factors that have increased it: the Nominal Annual Rate of Change of Consolidated Sales and/or Services Provided that is supposed to coincide with the Real Economic Growth Rate in Portugal, for the period from 2018 to 2027. The best would be to use rates in these 2 factors that reflect more the expected behavior of the company and less the Portuguese economy, because both one and the other, may know negative rates in these 2 which will decrease the intellectual capital value. It would be more useful to consider values (positive and or negative) such that they would be more adjusted to reality, aided by more detailed specifications of the business segments and business areas. This detail would make more objective information available, allowing more reliable and objective calculations. Thus, the value obtained, implies the idea of the impossibility of saying that it is or is not excessive, in view of the above.

One of the ways that would most enrich the work of calculating the intellectual capital value is the periodization considered. In fact, if instead of being for annual periods, it was for semiannual, quarterly or monthly periods, or even lower, the calculation came, more detailed and closer to reality, reflecting variations in the basic assumptions and their respective effects on the calculated intellectual capital value.

One of the limitations that this work has is due to the fact that the internal information translated in the Financial Statements is limited and, it is not possible, to accurately know the average cost of capital and its variations in the period from 2018 to 2027. The same is true, specifically, in EPS, with the risk premium and interest rates (how do they change annually?). Do the market ones agree with how, specifically, they would apply to EPS in the period considered? This factor is particularly important in the context of negative interest rates as is the case today (2021 and before). The most certain are changes (upwards or downwards) in these 3 indicators which have an effect on the discount rate and, therefore, on the intellectual capital value on December 31, 2017. The same applies to everything depends on the analysis according to the researcher. It should be noted that, if the changes made the intellectual capital value decrease, this would not be to the liking of the managers, but, nevertheless, it would translate the truth of the company's position.

EPS or any other company, if it had the intellectual capital value, calculated in real time (with the help of spreadsheets, in particular), would have a strong (competitive) advantage over all of its competitors which would mean that the market and investors, in particular, could know the total market value and EPS´s managers could make more informed decisions with greater transparency to the outside.

As future avenues for research, the application of this method to monthly (and shorter) periods can be mentioned. On the other hand, the application, perhaps, modified to other activity sectors, capital intensive or not, would allow to know the applicability to other sectors (or not) and in what terms. Would application to other sectors require adaptations of the Andriessen´s (2004) method? Which are?

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