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The relationship between intellectual capital and financial performance in Colombian listed banking entities

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ABSTRACT

Purpose: This study aims to investigate the relationship between intellectual capital and the financial performance of 7 Colombian banks for the period 2010–2016.
Design/methodology/approach: The information on the variables analysed was taken from each bank's financial statement and the information on the market variables was obtained from the Colombian Stock Exchange. The value added intellectual coefficient $(VAIC)^{TM}$ method is used to identify whether there is a positive relationship with the following financial performance indicators: Return on assets (ROA), Market value (Market to book – MTB) and Tobin's q (share value indicator). Intellectual capital efficiencies (human and structural capital) and capital employed have been analysed and their impact on financial performance has been measured through and econometric model.
Conclusions: The analysis indicates that associations between $(VAIC)^{TM}$, financial performance and corporate value are varied, so a homogeneous trend cannot be identified.
Originality/value: This is one of the first research works in Colombia which analyses the incidence or impact of $(VAIC)^{TM}$ on financial and market performance of the banking sector in the long term.

1. Introduction

In the current context –marked by technological revolution, market dynamism and interconnection, and the demands from increasingly specialized customers and institutions– the valuation and management of intangible assets is a challenge to all organisations, according to Gutierrez and Sánchez (2015). In the case of Colombia, the developing of conceptual and empirical alternatives to face this task is still incipient. Even though organisations, managers and investors have a notion of what intangibles are to be understood as from their daily experience, limitations are also recognized in terms of identifying them fully, as well as setting the criteria for measuring them, thus hindering their incorporation into either financial information or the decision-making process. (see Tables 1–9)

Hence the need to propose or validate alternatives that allow measuring and recognizing the existence of intangibles in Colombian organisations while helping to ward off conceptual dispersion over such a key element as a source of competitive advantage. Since our organisations do not possess any clear management criteria to enhance the creation of intangibles, they are indeed at a disadvantage in relation to international markets given the recurrent unfavourable market conditions, along with the science, technology and innovation panorama in Colombia (CTeI); "[…] having an educated human capital with the relevant skills is an essential element for innovation so that it makes a decisive contribution toward a sophisticated and diversified economy" (Consejo Privado de Competitividad, 2015, p. 93).

In this way, measuring and managing intangibles, as well as incorporating them into a firm's corporate strategy, will result in more competitive and innovative markets which, according to Rodríguez (1998), provides companies with the agility to respond to changes in the environment, and with a greater chance of improving prices, quality, and delivery times.

Currently, this idea of value creation has shifted from the exploitation of fixed assets to intangible ones, and concepts such as

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Table 1
Models proposed for the analysis.

Number	Denominacion	Formulation
1	Aggregated ROA	$ROA = C + \beta_1 VAIC + \beta_2 DEBT + \beta_3 SIZE + \varepsilon_i$
2	Aggregated MTB	$MTB = C + \beta_1 VAIC + \beta_2 DEBT + \beta_3 SIZE + \varepsilon_i$
3	Aggregated Q	$Q = C + \beta_1 VAIC + \beta_2 DEBT + \beta_3 SIZE + \varepsilon_i$
4	Disaggregated ROA	$ROA = C + \beta_1 HCE + \beta_2 CEE + \beta_3 SCE + \beta_4 DEBT + \beta_5 SIZE + \varepsilon_i$
5	Disaggregated MTB	$MTB = C + \beta_1 HCE + \beta_2 CEE + \beta_3 SCE + \beta_4 DEBT + \beta_5 SIZE + \varepsilon_i$
6	Disaggregated Q	$Q = C + \beta_1 HCE + \beta_2 CEE + \beta_3 SCE + \beta_4 DEBT + \beta_5 SIZE + \varepsilon_i$

Source: González et al. (2017). Denominations are own elaboration.

Table 2
Model variables.

TYPO	VARIABLE	CONCEPTUAL DEFINITION	OPERATIONAL DEFINITION
Dependent	ROA	Return on assets: measurement of the return on the investment made by the firm.	Operating profit/ Total Asset
	MTB	Market to Book: capitalisation method that compares the market value with the book value of the firm.	Market value/ Equity
	Q	Stock indicator: it relates share market price with its equity value.	(Market value + liabilities)/ Equity
Control	SIZE	Firm size; ratio that establishes the dimension of the firm in relation to its asset volume.	Total Assets/ CMLMW of the year * 30,000
	DEBT	Indebtedness ratio: it is used to determine the proportion of business leveraging.	Liabilities/ Assets

Source: Own elaboration; the construction of the SIZE variable responds to the considerations established in Colombia for firm classification by size (Law 590 of 2000 and Law 905 of 2004) MLMW: Current minimum legal monthly wage.

Table 3
Wooldridge autocorrelation test.

	Autocorrelation	
Model	F value	Statistic
1	0.0182	10.351
2	0.0114	12.932
3	0.0041	20.189

Source: Own elaboration.

Table 4
Modified Wald heteroskedasticity test.

	heteroscedasticity	
Model	F value	Probability
1	611.64	0
2	29.46	0
3	1782.87	0

Source: Own elaboration.

intellectual capital have recently begun to play an important role in solving specific organisations' needs or in providing advantages to them —facilitating obtaining funds, improvements in corporate image, and reductions in transaction costs (García Merino et al., 2010). Valuing intangibles, both traditional and hidden, thus mitigates the issues concerning incomplete information to meet the expectations of managers and investors.

In this regard, the relevance of intangibles for the creation of competitive advantages and the overcoming of the limitations of traditional accounting information has been evidenced in other contexts to some extent (Ruz, 2011b), resulting in research progress around the identification and valuation of intangibles. Some examples include research focused on the difficulty of monetary valuation and how complex its methods are, those which analyse the differences of intangible components among manufacturing and service companies, others which analyse the effects on valuation against changes in the environment, or those that deal with assessing the impact on business strategy and operational capabilities.

A general review of the most recent developments in these research works leads to a winding, progressive evolution path in which as many doubts as certainties remain. At first, empirical studies attempted to establish causal relationships between intangible assets, usually measured and recognized in financial information, and traditional measurements such as the book value of the firm, or income increases beyond their natural growth (Wyatt, 2008), to then make the transition toward the decomposition of the factors explaining intangibles creation and their connection with value creation (Basso et al., 2015; Ruz, 2011b)

Deriving from the above, a second wave of research developments include the conceptualization of non-traditional intangibles (or hidden intangibles) and identify the qualitative factors that could be outlined as differentiating factors for the management of organisational capabilities. This leads to the widening of measurement possibilities where global estimations of intangible assets and their components have been made and the valuation spectrum of traditional value indicators involving market measurements has been expanded. Additionally, traditional financial indicators explained through effects stemming from intangibles have been related and reworked, and indexes that attempt to condense and evaluate qualitative factors have been developed.

Even so, results are not conclusive, nor do they allow establishing clearly explicable causal relationships between intangibles and value creation, although some trends have been identified or interesting relationships have been established. Studies show there may be a relationship between benefit increase and financial performance (measured with profitability analysis traditional indicators) but not to a level where proving or confirming the hypotheses proposed be possible (García Merino et al., 2010; Rubio, 2016); similarly, several of the components of intellectual capital cannot always be measured reliably and have relative importance (Wyatt, 2008)

Investigations have also yielded results that, albeit not the expected ones, have ended up indicating some paths to be followed. The apparent failure to measure the contribution of intangibles in determining shareholder performance (Basso et al., 2015) is a case in point although its potential to explain company value in the market is to be noted (Kimouche & Rouabhi, 2016; Rubio, 2016) as long as the analysis be subject to considering intangibles as a whole as opposed to by components, given that the significance of the latter remains in question and cannot be established accurately.

Table 5
Estimation of the models by Feasible Generalized Least Squares.

Model	Independent and control variables	Coefficient	Error	p-Value
1. (Aggregated ROA)	C	0.12303	0.0034195	0.00
	VAIC	−0.0032363	0.0000811	0.00
	DEBT	−0.0910991	0.0041069	0.00
	SIZE	−3.47E-07	5.98E-08	0.00
2. (Aggregated MTB)	C	8.062049	0.4345271	0.00
	VAIC	−0.0616498	0.4987435	0.00
	DEBT	−6.652103	0.4987435	0.00
	SIZE	−0.000043	0.0000716	0.00
3. (Aggregated Q)	C	2.912372	0.255817	0.00
	VAIC	−0.0143829	0.0008559	0.00
	DEBT	−1.954587	0.574194	0.00
	SIZE	−5.77E-06	−5.09E-07	0.00
4. (Disaggregated ROA)	C	0.1250237	0.006367	0.00
	HCE	0.0065512	0.0002266	0.00
	CEE	−0.003397	0.0000963	0.00
	SCE	−0.0379439	0.0021403	0.00
	DEBT	−0.099575	0.0069617	0.00
	SIZE	−7.63E-08	4.47E-08	0.00
5. (Disaggregated MTB)	C	9.18138	0.1907162	0.00
	HCE	0.3066705	0.0058428	0.00
	CEE	−0.1102116	0.0039369	0.00
	SCE	−0.3160017	0.26624837	0.00
	DEBT	−7.825477	0.1644913	0.00
	SIZE	−0.0000296	0.00000407	0.00
6. (Disaggregated Q)	C	−0.113615	0.436732	0.00
	HCE	0.358416	0.0017665	0.00
	CEE	−0.0193887	0.0008338	0.00
	SCE	−0.4504456	0.027318	0.00
	DEBT	−2.5115374	0.0458981	0.00
	SIZE	−0.0000067	6.97E-07	0.00

Source: Own elaboration.

Table 6
Results of hypotheses contrast for aggregated VAIC (H1).

Hypothesis	Confirmed?	Model	Relevant control variables	Observations
H1a. Firms with higher intellectual capital tend to have higher profitability.	No	1	None	The model does not yield any conclusive results; none of the variables have a significant explanatory power.
H1b. Firms with higher intellectual capital tend to have higher market valuation.	No	2	DEBT	DEBT is a negative predictor with a high significance level.
H1c. Firms with higher intellectual capital tend to have higher share value.	No	3	DEBT	DEBT is a negative predictor with moderate significance.

Fuente: elaboración propia.

Table 7
Results of hypotheses contrast for Human Capital (H2).

Hypothesis	Confirmed?	Model	Relevant control variables	Observations
H2a. Firms with higher level of human capital tend to have higher profitability.	No	4	None	HCE is a positive predictor with weak significance; it is not conclusive to validate the hypothesis.
H2b. Firms with higher level of human capital tend to have higher market valuation.	Yes	5	DEBT	HCE is a positive predictor with a high significance level . DEBT is a negative predictor with a high significance level.
H2c. Firms with higher level of human capital tend to have higher share value.	Yes	6	DEBT	HCE is a positive predictor with a high significance level. DEBT is a negative predictor with a high significance level.

Source: own elaboration.

Therefore, and in light of the current developments, the basic aim of this research is finding an alternative for the recognition and quantitative measurement of the hidden intangibles in the stock market-listed Colombian financial sector, as a means to rendering it valid for the analysis of value creation in this type of organisations. To that effect, first a review of the concepts of intangible assets and

Table 8
Results of hypotheses contrast for Economic Capital (H3).

Hypothesis	Confirmed?	Model	Relevant control variables	Observations
H3a. Firms with higher level of economic capital tend to have higher profitability.	No	4	None	CEE is a negative predictor with weak significance; it is not conclusive to validate the hypothesis.
H3b. Firms with higher level of economic capital tend to have higher market valuation.	No	5	DEBT	CEE is a negative predictor with a moderate significance level. DEBT is a negative predictor with a high significance level.
H3c. Firms with higher level of economic capital tend to have higher share value.	No	6	DEBT	CEE is a negative predictor with weak significance. DEBT is a negative predictor with a high significance level.

Source: Own elaboration.

Table 9
Results of hypotheses contrast for Structural Capital (H4).

Hypothesis	Confirmed?	Model	Relevant control variables	Observations
H4a. Firms with higher level of structural capital tend to have higher profitability.	No	4	None	SCE is a negative predictor with weak significance; it is not conclusive to validate the hypothesis.
H4b. Firms with higher level of structural capital tend to have higher market valuation.	No	5	DEBT	SCE is a negative predictor with a high significance level. DEBT is a negative predictor with a high significance level .
H4c. Firms with higher level of structural capital tend to have higher share value.	No	6	DEBT	SCE is a negative predictor with a high significance level. DEBT is a negative predictor with a high significance level.

Source: Own elaboration.

intellectual capital and their valuation possibilities is presented, to then focus on the model of Value Added Intellectual Coefficient (VAIC), from which the model and hypotheses of the research are established. Lastly, the results that allow for an understanding of the dynamics of intangibles in the selected sector, as well as the explanatory potentials and limitations of the proposed model are presented.

2. A look at the concept of intangible asset

Traditionally, intangible assets are regarded as those that are identifiable, non-monetary, without physical substance, and with the capacity to generate benefits for the entity controlling them (Hollander, 2005). This general definition provides a good idea about the criteria that make the differentiation of intangibles from other assets at least possible, although a certain additional accuracy is required: their identifiability relates to separability from other assets and how they can be transferred, as established in the international accounting framework (IASB, 2013) widely-accepted globally and recently adopted in Colombia.

These criteria prevent the recognition of intangibles that do not comply with such characteristic for accounting purposes; this did not occur in the previous accounting framework (Decree 2649 of 1993, Article 66) where the accounting of "formed" intangibles was in fact allowed for. The discrepancy among definitions has had an impact on financial reports, which recognize acquired intangibles (whose valuation is given precisely because of their acquisition cost) but leave in the shadow those that the company actually generates and controls, and for which there is no clearly established quantitative assessment criterion even though their contribution toward both value creation and the company's differentiating factors has been noted (Scarabino et al., 2007; Álvarez, 2012)

In order to standardize these measurements, IFRS has incorporated intangible valuation criteria developed by the International Valuation Standard Council (IVSC, 2010, pp. 5–7), which prescribes three methods:

- Market activity valuation, difficult to determine directly due to the multiplicity and heterogeneity of intangibles yet useful for determining subsequent recognition under IFRS when the intangible subject to valuation has an active market;
- Cost-based valuation, used for intangibles with no active market or identifiable income sources, prescribed under IFRS for the initial recognition of intangibles and as an alternative criterion for subsequent recognition when faced with the impossibility of determining a fair value; and
- Income-based valuation, referring to the present value of the intangibles themselves, prescribed under IFRS for determining the recoverable amount of the intangible asset and determining value impairment in comparison with its reasonable value.

Thus, even when several valuation possibilities are established, the issue of a proper identification of internally-generated intangibles remains. In this regard, Viloria et al. (2008) offer a more thorough explanation, asserting that there are two groups of non-identifiable intangible assets: those that emerge when there is acquisition of a company by another (goodwill), and those that are internally generated in the companies, defined by the authors as hidden intangible assets.

The process of company acquisition facilitates the valuation of the first type of assets, a matter known as business combination in the international financial accounting framework (IASB, 2008); as for the second case, Viloria et al. (2008) posit intellectual and human capital as the examples of hidden intangible assets, which they define as

> (…) the set of assets of a company which, although not reflected in the traditional financial statements, generate or will create value for the firm in the future as a result of aspects pertaining to

> human and other structural capital such as innovation capacity, relations with customers, the quality of processes, products and services, and cultural and communication capital, which make it possible for a company to take advantage of opportunities better than others, leading to the creation of future benefits (…) (Viloria et al., 2008, p. 22).

3. Intellectual capital: definition and valuation methods

A nodal issue in intangibles valuation matters concerns those described as "hidden," with unique characteristics and imbricated not only in the structure of all assets, but also in the organisational culture or corporate strategies. As can be noted, the problem goes beyond accounting recognition for there is a need to measure them and establish their impact on financial performance and management (Ruz, 2011a). The set of these hidden intangibles has been called intellectual capital.

Brooking (1997, p. 25) states that a company is the sum of material assets and intellectual capital, determining that the latter is the combination of intangible assets which enables the company to operate.

According to Alama, Martín de Castro and López, intellectual capital is

> (…) the set of intangible assets owned by a company and which if managed properly can generate a sustainable competitive advantage over time […] it is useful knowledge as opposed to simple data collection since it is structured knowledge that serves a certain purpose; in addition, it is valuable knowledge because the company is able to create value and obtain higher yields from it (…) (2006, p. 4).

Concerning valuation criteria, some valuation methods of intangibles are categorized by Sveiby (2001). The methods presented can initially be arranged into two groups: on the one hand, quantitative methods, which attempt to obtain a monetary valuation to measure the impact of intellectual capital on financial performance, showing its impact on value creation directly; on the other hand, qualitative methods, which analyse the incidence of business behavior and the environment on the shaping of hidden intangibles with the aim of setting management criteria —strategies and indicators— favoring value creation indirectly.

Since the interest of this research is monetary valuation, it is limited to quantitative valuation models. Using a method that allows for comparative analyses between companies, sectors or periods of time to determine measures or impacts that may be identified to value and enhance intellectual capital is also an essential requirement in this research.

3.1. Direct measurement methods

Direct measurement models propose alternatives for estimating the value of intangibles by identifying their components and then evaluating their impact. These methods combine several measurements (quantitative and qualitative), attempting an approximation to the possible value of intellectual capital.

The problem with this group of methods lies in considering subjective elements that make it difficult to standardize the valuation. Such is the case of *The Value Explorer* (Andriesson, 2005; Marti & do Rosário Cabrita, 2012) for which determining the competencies of the company as a requirement for valuation is necessary; similarly, *Technology Broker* (González, 2006) or *Inclusive Valuation Methodology* (Fink, 2004; Skyrme, 1998) are proposals that demand the weighting of intangibles according to managers and experts' opinion. Other models consider prospective or hard-to-define elements limiting their application: for example, they require evaluations of the services that in the future are expected from the human resources linked to the company, such as *Human Resource Costing & Accounting* (Flamholtz, 1999), or the determining of potential business opportunities as required by *Estimated Value Via Intellectual Capital Analysis* (McCutcheon, 2008). Consequently, when making comparative analyses, it is not pertinent to depend on embedded value judgments for the valuation of these elements, despite the statistical refinement that may accompany these models.

3.2. Market capitalisation methods

The essence of the methods clustered within this second category consists in calculating intellectual capital value through the difference between a firm's stock market capitalisation and its stockholders' equity, to then attempt to explain its structure (Fernández, 2007; Luthy, 2008). Use limitations result from questioning the historical accounting basis and value judgments that incorporate several measurements of their own, as well as its application restricted to listed companies.

Tobin's q indicator model (Álvarez, 2012) is an attempt to eliminate the limitation of historical information that determines a relationship between the market value and the replacement value of the assets. Other alternatives, such as *Balance General Invisible* (The Konrad Group, 1990), *Investor Assigned Market Value* (Patalas-Maliszewska, 2013) and the *Financial Method of Intangible Assets Measurement (FiMiAM)* (Rodov & Leliaert, 2002; Toledo Villanueva, 2012) have valuation —as the difference between book value and market value— in common, but involve subjective and non-generalisable elements in identifying and analysing intellectual capital components, posing the same restrictions as direct measurement models.

3.3. Return on assets method

This third set of methods is based on the calculation of return on assets, thus establishing the measurement of intellectual capital as an excess over the average of the average cost of capital or a type of company interest, or also relating to industry average. The advantages of these methods lie in that they refer to the financial information of the company, in the possibility to use them in a broad sense (not limited to listed companies), and in their generalized application to several periods or business sectors.

However, some of these models require companies to be in existence for a minimum time in order to be able to make comparisons with their industry, which may impose certain restrictions to start-up companies, such in the case of *Calculated Intangible Value* (Flores, 2001; Sotomayor, 2005) and *Knowledge Capital Earnings* (Ordoñez et al., 2015).

An interesting alternative that meets the requirements sought for the development of this research is the *Value Added Intellectual Coefficient (VAIC)*, a measure of return on investment in knowledge capital (Kelly, 2004; Nimtrakoon, 2015). This model is circumscribed to financial information, does not require minimum times of existence, and provides information on the efficiency of tangible and intangible assets that can be used to create value in a firm.

VAIC is therefore rendered the chosen model for this research, in order to develop the measurement of intellectual capital in the selected firms, given that the above characteristics, the information available, and the standardised measurements are both easy to calculate and consistent for the analysis of any period; besides, they also hold informative relevance and may be easily interpreted by

investors and managers. For the above reasons, the detail of the model is presented below.

4. The VAIC™ model

The *Value Added Intellectual Coefficient* is a measure of return on investment in knowledge capital developed by Pulic (2000), who posits financial capital (monetary and physical) and intellectual capital (human capital and structural capital) as its main components. In essence, the model states that a higher value for VAIC™ shows greater efficiency in the use of capital, and its calculation comes from the sum of the capital employed, the efficiency of human capital and the efficiency of structural capital (Muhammad & Ismail, 2009). As an intermediate result, intellectual capital efficiency can be determined as the sum between the efficiency of human capital and the efficiency of structural capital (Ståhle et al., 2011).

4.1. The modifications of VAIC™

Starting from the original model of Pulic, refinements or adjustments have been developed that try to improve the explanatory power of VAIC to enhance value generation. The idea behind these modifications is that a greater decomposition of the factors that make up the intellectual capital will allow a better explanation of how it is generated and thus enable to manage it with more elements of measurement and analysis.

One of these modifications is proposed by Nazari and Herremans (2007), who develop an extended VAIC model by disaggregating the components of structural capital (SC), as the sum of commercial capital (CC) and organisational capital (OC), and in turn, disaggregating the latter into process capital (PC) and innovation capital (InC); In this way, the individual participation of these components can be determined, and evaluations can be carried out on their significance in value generation.

A second, less radical, modification is proposed by Ulum et al. (2014) who, applying a variation of the work of Nazari and Herremans, extract from the structural capital the variable corresponding to commercial capital, (denominating it relational capital), and consider it as a fourth element of intellectual capital.

4.2. Empirical evidence with the VAIC™ model

The various investigations applying the VAIC™ methodology show a positive relationship between intellectual capital and some traditional measures of financial performance; in the same way, they aim to characterize the efficiency of some of its components as the most significant value drivers.

In this way, Chu et al. (2011) start off from the Pulic model to study the impact of VAIC on the indicators of corporate financial performance of all the companies that make up the Hang Seng index of the Hong Kong Stock Exchange (333 observations company - year) for the years 2001–2009; a total of 8 linear regression models are proposed that relate VAIC (as a global and decomposed value) with traditional financial indicators as independent variables: market value, ROA, ROE and productivity. The models include the financial debt and the size of the firms as control variables and postulate, as a hypothesis, a positive relationship between the increase in VAIC and the improvement in the indicators analysed.

The research concludes that the models that disaggregate VAIC in its components have greater power of explanation than VAIC as a global measure, and provide evidence of a strong positive association between intellectual capital and ROA, where all the components are significant. In the case of ROE, the value driver is fundamentally structural capital, which in the results shows greater significance than physical capital (which is the traditional measure to assess ROE), and there is no significance of human capital.

Regarding market value, the research does not find a strong association with VAIC, and even more, it establishes a negative relationship with human capital for the whole period analysed. Similarly, there is no evidence of an association with productivity, establishing a null significance of human capital and a negative significance for structural capital.

On the other hand, Mondal and Ghosh (2012) investigate the relationship between intellectual capital and the financial performance of 65 Indian banks for the period 1999–2008; a total of 6 linear regression models are proposed that relate VAIC (as a global and decomposed value) with ROA, ROE and productivity as independent variables: market value, ROA, ROE and productivity. The models include financial leverage and the size of the companies as control variables and postulate, as a hypothesis, a positive relationship between the increase in VAIC and the improvement in the indicators analysed.

These results yield similar conclusions to the research of Chu et al. (2011) for the indicators of return: a strong association with ROA, with the exception of structural capital, where the association is weakest; as well as an indetermination of the models to establish a positive association between VAIC and ROE. With regard to productivity, a positive and strong relationship is established between VAIC, human capital - which is the most preponderant component - and physical capital; in this case, the relationship with structural capital is also weaker.

Ulum et al. (2014) also carry out their research in the banking sector, using the financial reports of the main banks of Indonesia for the year 2012, with the aim of establishing a ranking of business performance for the sector and using its M-VAIC modification that is based on the original proposal of Pulic. In this study, only simple linear regression models are established that seek to determine the relationship between the intellectual capital and each of the components of the M-VAIC model (HC, SC, RC, CE).

The research concludes that intellectual capital can be explained by three of the four components analysed in a strong way (HC, SC and CE), with a weaker relationship with the relational capital (RC), conclusion based on the coefficients of determination (R2) of each of the regressions of the models.

Finally, González et al. (2017) propose to determine the impact of VAIC on ROA, the *market to book* MTB (as a market capitalisation value) and Tobin's q indicator (as the level of share value), for a total of 32 companies in the industrial sector, and that are listed on the Mexican stock exchange, for the period between 2006 and 2012; a total of 6 linear regression models are proposed that relate VAIC (as a global and decomposed value) with the measurements indicated above and that operate as independent variables. These models include financial debt and the size of companies as control variables and postulate, as a hypothesis, a positive relationship between the increase in VAIC and the improvement in the indicators analysed.

The research concludes in general terms that all the components of intellectual capital are relevant to explain ROB, MTB and Tobin's q behavior, with the caveat that ROA is better explained considering global VAIC than disaggregated VAIC. In particular, it also concludes that although the correlation is maintained for all the companies analysed, there are differences among them according to the subsector in which they are involved.

Expanding the spectrum of empirical evidence regarding the relationship between intellectual capital and financial performance (Huang & Huang, 2020), make an analysis of organizational capabilities as a general factor associated with intellectual capital and its impact on financial performance. Organizational capabilities are defined as knowledge of the market, the consumer, effectiveness, efficiency, corporate governance, among others. The analysis was

carried out based on interviews with 814 managers of the association of manufacturers of transport vehicles. The model used was the structural equation model and seeks to analyse the incidence of the variables mentioned above with financial performance. The results obtained show that there is a partial incidence of intellectual capital on financial performance, but it serves as a reference for the analysis of its importance in generating value in the companies analysed.

For their part (Lee & Lin, 2019), make an analysis of the incidence of intellectual capital, understood as human capital, process capital, innovation capital and consumer capital. The estimation of the above variables is different from the VAIC methodology, but the estimated models seek to analyse and estimate the incidence of each of these on financial performance. The model includes control variables such as total assets, number of employees (with reference to the size of the company), total income and operating assets. 8 models are constructed with different independent variables and the estimation is made by generalized least squares.

The study is carried out on 2662 accounting and auditing companies, and the results obtained are heterogeneous and the incidence of each of the independent variables (intellectual capital) on the dependent variables that represent financial performance cannot be concluded with absolute certainty.

5. Methodology

This research is of a quantitative nature and seeks to identify through the VAIC model whether in the Colombian banking sector there is a positive association between intellectual capital and three indicators of financial performance: ROA, MTB (market value indicator) and Tobin's q (share value indicator). Likewise, the results allow us to reveal the possible factors that explain the existence and measurement of hidden intangibles, and that can potentially be replicated in other economic sectors. This, in turn, allows framing the research as an exploratory study.

Since the relationships that are intended to be established are not based solely on internal indicators, but also on the impact of intellectual capital on the market benchmarks, all the banking entities that quote their equity instruments in the Colombian Stock Exchange were selected for this study (7 entities), in the period from 2010 to 2016. The information for the construction of the variables comes from the Consolidated Financial Statements of said entities, and for the market values, online historical information was used, provided by the Colombian Stock Exchange.

This selection was made based on the fact that the empirical evidence of application of the VAIC model is broad for the financial sector. The necessary information is available without restrictions, given the sustained practice of accountability based on good governance policies of the sector, and given the ease to examine all the listed banks in Colombia, which are a small number.

5.1. Model and hypotheses statement

The empirical studies presented, based on the VAIC methodology, have found strong association between the components of intellectual capital and return on assets, but they have not been conclusive in terms of their significance to explain market valuations. This is why, based on the set of models proposed by González et al. (2017), a different regression model is proposed seeking to verify whether VAIC can effectively be a good measurement criterion of the indicators proposed and allows to identify the main value drivers. The base models for the analysis are the following:

According to the above, it can be evidenced that the definition of the VAIC independent variables (CEE, HCE and SCE) does not differ from the original model proposed by Pulic; however, regarding the rest of the variables present in the models, their definition is synthetized as follows:

The typology of the variables presented derives from considerations of their own functions; in fact, those considered as dependent variables are the ones that include the effect of the independent variables and whose behavior we want to explain to relate it to the value generation defined in the VAIC methodology.

In turn, although the control variables behave as independent variables (in fact, a control variable is a type of independent variable) and contribute to the explanatory power of the proposed model, they are included with the intention of adjusting or neutralizing the possible effects of their measurement on the rest of the independent variables, which are the ones that, according to the hypotheses to be contrasted, should explain the value generation defined in the VAIC methodology .

In this sense, the SIZE control variable is included to consider the possible effect of the dissimilar sizes of the organisations present in the study; although according to the Colombian classification, all the financial entities analysed are part of the groups of big companies, some of them can be up to fifteen times bigger than others. Similarly, the DEBT control variable is included to moderate the effects of the entities' high degree of financial leverage (which is natural due to the activity they perform and the sector analysed) in order to identify the extent to which this factor impacts the explanation of the independent variables considered, as a separate effect of the value added components defined in VAIC.

In these terms, the modelling proposed expects to find a positive association of intellectual capital with financial performance and corporate value. The positive association between the independent variables (efficiency of intellectual capital) and the dependent variables (financial performance), lies the analysed sector is classified in the tertiary sector of the economy, services, and the dependence of innovation processes, services, relationship with the client and other aspects that relate it to the intellectual capital, the generation depends on value depends on the behavior of these. Thus, using VAIC as an aggregate measure for corporate intellectual capacity, the first set of hypotheses is proposed as follows.

- $H1_a$. Firms with higher intellectual capital tend to have higher profitability. Intellectual capital have positives influences on profitability.
- $H1_b$. Firms with higher intellectual capital tend to have higher market valuation. Intellectual capital have positives influences on market valuation.
- $H1_c$. Firms with higher intellectual capital tend to have higher share value. Intellectual capital have positives influences on share value.

In an analogous way, using the components into which VAIC is disaggregated, the following sets of hypotheses are proposed:

- $H2_a$. Firms with higher level of human capital tend to have higher profitability. Human capital have positives influences on profitability.
- $H2_b$. Firms with higher level of human capital tend to have higher market valuation. Human capital have positives influences on market valuation.
- $H2_c$. Firms with higher level of human capital tend to have higher share value. Human capital have positives influences on share value.
- $H3_a$. Firms with higher level of economic capital tend to have higher profitability. Economic capital have positives influences on profitability.

- $H3_b$. Firms with higher level of economic capital tend to have higher market valuation. Economic capital have positives influences on market valuation.
- $H3_c$. Firms with higher level of economic capital tend to have higher share value. Economic capital have positives influences on share value.
- $H4_a$. Firms with higher level of structural capital tend to have higher profitability. Structural capital have positives influences on profitability.
- $H4_b$. Firms with higher level of structural capital tend to have higher market valuation. Structural capital have positives influences on market valuation.
- $H4_c$. Firms with higher level of structural capital tend to have higher share value. Structural capital have positives influences on share value.

5.2. Data analysis techniques

Studies conducted with VAIC so far employ linear regression models, developed through the Ordinary Least-Squares (OLS) method, and simplify the analysis by using average annual data for the sets of companies selected; besides, a reduction in the number of observations can yield erroneous significance levels, which could hide possible autocorrelation and heteroscedasticity problems. In fact, using annual averages can reduce the variability of errors to a great extent, thereby achieving data adjustment in a contrived way in order to obtain coefficients that significantly explain the behavior of the variables studied.

Based on the exploratory analyses of the model variables for the case of the present research, a series of considerations are taken into account to cast doubt on the use of average annual data, among which the following must be mentioned:

- Control variables such as level of indebtedness (DEBT) and size (SIZE) are in fact heterogeneous not only between one firm and another, but also for the same firm in different time periods. This occurs not only because of the way these variables are measured but also due to changes in capital structure (which is not constant) and the steady increase of organisations in their assets volume, which does not grow in the same way as the criterion used to establish their size (minimum wage).
- The market value of banking entities cannot be compared under the same parameters, since not all shares have the same level of trading, implying that the sensitivity of this measure can very well capture market information for entities with daily quotation, but in a lagged manner for lower quotation levels.

It is thus important to have the total of all the observations to adequately capture their individual aggregate behavior; but this gives rise to two considerations: i) the presence of heteroscedasticity and autocorrelation problems in the model errors is significantly increased; ii) a bi-dimensional analysis must be conducted, since each data is associated to a moment (temporal analysis) and to a particular entity (structural analysis).

These reasons imply the use of other tools; therefore, the model will be developed considering two alternatives: the estimation of the model through Feasible Generalized Least Squares and using the panel data technique.

Estimation through Generalized Least Squares (GLS) (Baronio & Vianco, 2012) allows to carry out a consistent estimation given the existence of serial autocorrelation and/or heteroscedasticity, since it makes the OLS requirement flexible to work with constant variance for the errors, but guarantees that the estimators obtained are linear and unbiased, so it is classified as a robust and appropriate estimator. To validly use this estimation, the mentioned conditions must be tested through the Wooldridge test for autocorrelation and through the modified Wald test for heteroscedasticity.

GLS estimation has two variants: Weighted Generalized Least Squares, when the structure of the variance and covariance matrix of the model errors is known; and Feasible Generalized Least Squares, when said matrix is unknown, since the errors follow an autoregressive process, that is to say, when there are linearly dependent variations across time, as in the case of the observations that will be used in this research.

In turn, the panel data technique (Baronio & Vianco, 2014) allows to combine the temporal and structural dimensions in the analysis, with the aim of capturing in the model those heterogeneous elements which are not directly observable but which can have significance, due to the drastic changes that can occur between periods or to the specific individual effects of an organisation. In other words, this technique avoids the problems caused by the aggregation of behavior and facilitates individual follow-up over time, while allowing the estimation of models which have permanent, yet not observable, differences between individuals (Arellano & Bover, 1990).

6. Results

6.1. Validation of assumptions for application of the model

Even though the exploratory analysis of the constructed variables points to heteroscedasticity and autocorrelation problems, it is necessary to determine the presence of both situations for the application of the criterion of estimation through GLS. Since the hypotheses formulated tend to validate the assumption that there is a positive linear relationship between VAIC and the three dependent variables chosen, autocorrelation and heteroscedasticity tests were carried out on the models with aggregated VAIC, assuming that the problem persists for the disaggregated models; firstly because serial correlation persists regardless of the number of variables of the model; and secondly, because the variables with possible heteroscedasticity problems also include the control variables, which are identical for all the models proposed.

The null hypothesis of the Wooldridge test posits that there is no autocorrelation and a value close to zero for the F statistic is considered a significant reading to reject the hypothesis. The results obtained for the tested models allow to suppose autocorrelation problems for the models:

To test the models' heteroscedasticity the modified Wald test was used since the normality assumption on the errors cannot be validly maintained. The null hypothesis states that there is no heteroscedasticity, and when the value of the Chi-square probability is lower than 0.015 the null hypothesis is rejected, a situation that occurs for all the models analysed:

6.2. Estimation of the models

After validating the assumptions to conduct the estimation by Generalized Least Squares, the following results were obtained:

The statistical significance of the correlation between the variables of the different models is represented by the p-value, which assumes as significant those variables with a value below 0.05, and as very significant those with a value below 0.01, allowing to assert that the variables are highly significant in all the models.

On the other hand, the estimation method by Generalized Least Squares does not allow to obtain a single determination coefficient

(*R-squared*) for each model, given that the variance of the errors is not scalar, so an evaluation of the significance models with this parameter is not feasible.

6.3. Hypotheses contrast

Given the significance of the variables in all the models, the two hypotheses sets established were contrasted, yielding the following results:

6.4. Observations on the general behaviour of the variables

The model estimation results show a marked difference in the analysis of VAIC as intellectual capital measurement, depending on whether it is considered in an aggregated or disaggregated manner. In fact, when it is used as aggregated independent variable, it shows a linear inverse or negative linear relationship with the dependent variables, unlike it was expected. However, it is important to note that the coefficient value obtained for each one of the aggregated models (1, 2 and 3) is very small and shows that the changes in this variable do not generate a significant effect on the dependent variables defined. Such situation seems to therefore indicate that an analysis where VAIC is disaggregated into its components (models 4, 5 and 6) is more consistent since, although some of the relationships continue showing a behaviour contrary to the expected one, that is, with an inverse relationship with respect to the dependent variable, much more significant value predictors are obtained, conferring explanatory power to the proposed models.

With respect to the control variables, the findings regarding their behavior are quite significant. For the case of the DEBT independent variable, it is observed that the expected negative linear or inverse relationship is met, and that the changes in this variable significantly affect two of the three dependent variables proposed (MTB and Q) which precisely capture the impact the level of financial leverage can have in relation to the firm's market value. Conversely, the SIZE control variable has a null impact for all the models analysed, showing that value added generation via intellectual capital does not keep a direct relationship with the assets volume of the firms analysed.

6.5. Association between VAIC and ROA

The results of the estimations for the models relating VAIC and ROA (models 1 and 4) are not conclusive to determine a relationship between intellectual capital and return on assets; in this sense, the results of this study significantly differ from those reviewed as pre-existing empirical evidence, which established a strong relationship between these two variables.

Model 4 (disaggregated ROA) indicates a weak association between ROA and the three intellectual capital components, indicating that the return on assets is explained by the perturbations that the model does not capture in such variables; this is the reason why significant investment efforts in intellectual capital components will not have much impact on the profitability of the business. The above can explain why the SIZE control variable, which precisely has to do with assets volume, turns out to be of little significance, and could also indicate that there is a structural condition that keeps an inertial behavior for ROA, explained by the structure of its assets, almost all of them of a current nature.

6.6. Association among VAIC, MTB and Tobin's Q

The results of the estimations for the models relating VAIC with MTB and Tobin's q (models 2, 3, 5 and 6) allow to establish a relationship among intellectual capital, the firm's market value and its share value; the effect of the two strong predictors (human and structural capitals) is however dissimilar and posits questions regarding validation of the VAIC model's fundamental assumption.

Model 5 (disaggregated MTB) and model 6 (disaggregated Q) indicate a significant association between these variables and human capital, this being a strong predictor which has a positive incidence on value generation. In this sense, this study results differ from the findings obtained by Chu et al. (2011), who described a negative and little significant relationship of human capital to explain market value, but are in line with the findings of Ulum et al. (2014), as well as with those of González et al. (2017). Given that the coefficient values obtained from the estimation are high and behave as expected in the hypotheses, the relationship between human capital and value generation becomes one of the most significant findings of the present research.

However, it is interesting to highlight that the models also indicate structural capital as a strong predictor which provides the proposed models with explanatory power, but which does not behave differently from what is expected; in fact it is a negative predictor both for market value and share value, which confirms the findings of Chu et al. (2011), but contradicts those of González et al. (2017).

7. Discussion and conclusions

The empirical findings, based on the correlation and the linear analysis by Feasible Generalized Least Squares, indicate that the associations between VAIC and financial performance and corporate value are mixed, without the possibility of identifying a homogeneous or same-sense trend for the variables being explained.

It was found that intellectual capital, measured by VAIC as the only aggregated indicator, has a different behavior from the one expected according to the fundamental assumptions of the model which were the basis for the formulation of the research hypotheses, and does not have a high explanatory significance. Even though these results confirm the findings of previous research (Chu et al., 2011; Mondal & Ghosh, 2012), it was expected to obtain a different result given the methodological modification of operating with the Feasible Generalized Least Squares model, but its persistence seems to indicate that the models disaggregating the VAIC components still have greater explanatory power.

In fact, when VAIC was divided into its three components (i.e., HCE, SCE and CEE), the strength of the models increased significantly, finding that the individual components of intellectual capital become stronger predictors for financial performance and corporate value. Nevertheless, as explained by the hypothesis contrasts, finding strong predictors is not a generalized result and there are week associations which are not sufficient to categorically assert that disaggregation of the VAIC model conclusively explains the contribution of the hidden intangibles to value generation. This permits, however, to establish that at least some of its constitutive elements do have a strong significance; in this sense, and contrary to claims from previous research (Ståhle et al., 2011), a generalized criticism to the VAIC model is not entirely valid; such criticism must rather establish nuances and consider other methodological alternatives and disaggregations that contribute to tuning the model.

The results of the estimations confirm for the Colombian banking sector one of the central arguments of the capital measurement model through VAIC, which posits that human capital can be seen as a set of knowledge that can bring long-lasting benefits in the future and allows to treat expenses on employees as investment (Muhammad & Ismail, 2009). In fact, human capital efficiency as one of the three components of intellectual capital turns out to be very relevant in explaining market value and share value in the group of firms analysed; nevertheless, its impact on

business profitability is not clear, since although its association with this factor is also positive, the significance of this relationship is relatively low.

In this respect, although significance in either case can be evidenced through the coefficients estimated by the model, this does not account for the causes that make human capital a good predictor for some models but not for others; beyond the treatment of data, the model cannot inquire on those effects different from investment in this factor, measured in monetary terms. Thus there is a limitation of the model in explaining this dissimilar behaviour, which in turn posits the challenge of measuring the possible uncaptured effects of the quantitative (monetary) approximation through other types of variables, or through studies carried out with other types of modeling, so as to complement and allow to increase explanation and incidence of this variable on added value.

The results highlight the contradictory role of structural capital in improving profitability and corporate value. This suggests as alternative that, given that the calculation of structural capital is a residual between the total value added and investment in human resources, a breakdown of this value into its constituent factors – as suggested by Nazari and Herremans (2007) – could have the same effects as the VAIC disaggregation, that is, an increase in the significance and a positive association to explain intellectual capital as generator of value added. It could also be useful to contrast this component with other variables or use complementary modeling allowing to explain its behaviour more accurately.

On the other hand, even though this work presents findings similar to those of previous research, mainly regarding validation of how strong or weak the VAIC components can be as intellectual capital predictors, it must be emphasized that the measurement methodologies used are different. In fact, the model formulation and the estimator employed in this research were the result of the criticism to the simplification done by other research works to reduce their data series through averages; thus the similarity is limited to the results but not to the means through which they were obtained. This opens the door for the revision of the different methodologies and their validity according to the multiplicity of contexts, the availability of information and the higher or lower meticulous rigor in the treatment of the data.

The results obtained with respect to the relationship between the analysed variables endorse the importance that everything that is done in monetary terms with respect to the components of intellectual capital in terms of spending, will become a mechanism for innovation, development and possibilities. to generate value for organisations. This is more important if the sector analysed in this work and its dependence for proper development and operation are contextualized, such as human capital, structural capital and market capital. The Colombian financial system, like that of other countries in the world, focuses its operation on the provision of financial services where employees and structural assets as support for proper functioning play a fundamental role and assume the role of value creation in companies.

In this sense, a research work based on implementing this new measurement methodology in preexisting research could be interesting to observe whether the consistency of the initially obtained findings is maintained, and whether any agreement is found with the results obtained in the present research. Conversely, if a significant difference is found, the reasons by which said situation occurs and the impact this has on intellectual capital measurement can be made explicit.

The main contribution of this research focuses on the measurement and treatment of data. The current empirical evidence on the relationship between intellectual capital and financial performance is centered on the simple treatment of the data and the estimates are based on simple least squares models. Although these models can allow inference and estimation of the variables involved and the results obtained, they have limitations when verifying the relevance or not of these, the significance of the models and the treatment given to the variables. When using advanced methodologies such as panel data and more robust econometric models, such as the one used in this research, it is intended to obtain more precise and punctual measurements about what is to be demonstrated, and behaviors of the variables to be demonstrated are included. may be omitted on other models.

It must be emphasized that the model limits its approximation to the analysis from a quantitative – monetary perspective, so it will hardly be able to explain effects on qualitative variables that may have impact on value added generation. Likewise, the interpretation of the results for the particular sector on which the study is carried out is subject to the conclusions that can be derived from the period analysed, which gather the most recent behavior of such entities, without necessarily enabling to conclude that it is a valid expectation on the future evolution of their value generation strategies.

Finally, a replica of this modelling in other economic sectors will be possible insofar as the necessary adjustments are made on whether or not the use of the established control variables is convenient, and depending on the possibility to modify the models to be contrasted according to the disaggregation of variables and the information available.

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