ISCTE Business School
Instituto Universitário de Lisboa

THE IMPACT OF INTANGIBLES ON THE PERFORMANCE OF THE MAJOR TECHNOLOGICAL COMPANIES IN THE WORLD

Catarina Filipa Pitau Ferreira

Dissertation submitted as partial requirement for the conferral of Master in Accounting

Supervisor:
Prof. Dr. Ilídio Tomás Lopes, Prof. Auxiliar, ISCTE Business School, Departamento de Contabilidade

junho 2018

Abstract

Intellectual capital has been the focus of research in the knowledge-based economy, with authors attributing its intangibles the capacity of generating value for the company and constituting competitive advantages capable of enhancing business performance. Thus, if intangibles are associated with expected returns, a positive impact on turnover, and on other key performance indicators, can be expected. This research aims to identify the impact of different intangibles on the performance and profitability of the 25 major technological companies in the world, for a four-year period analysis (2014 – 2017), including characteristics of the board of directors as proxies of human capital. In order to achieve this goal, the correlation between the intangibles and performance was assessed through Pearson's correlation coefficients, and multiple linear regression models were utilized. Broadly, based on the theoretical models, empirical evidence has shown a negative impact of some of the intangible assets disclosed on companies' financial position on performance. The characteristics of the board displayed a positive effect on turnover, when considered alongside disaggregated measures of intangibles, reflecting synergetic effects between the variables. The most significant contribution to performance arises from software and research and development expenses, underlining the crucial role of innovation capital in this sector.

Complementarily, this study assesses whether the distribution of the intangibles varies among regions, finding it does for the variables intangible assets, goodwill, licenses and patents, size of the board of directors, software and R&D and turnover, which presented higher means for the North-American region.

Keywords: Intangibles, intellectual capital, business performance, technological sector.
JEL Classification: G30, M41, L25.

Resumo

O capital intelectual tem sido o foco de investigação na nova economia do conhecimento, com autores a atribuírem aos intangíveis a capacidade de gerar valor e constituírem vantagens competitivas capazes de melhorar a performance organizacional. Assim, sendo os intangíveis associados a retornos futuros, é esperado um impacto positivo no volume de negócios e noutros indicadores de performance. Este trabalho pretende identificar o impacto dos diferentes intangíveis na performance e rentabilidade das 25 maiores empresas tecnológicas do mundo, num período de 4 anos (2014 – 2017), incluindo características do conselho de administração em representação do capital humano das empresas. Deste modo, a correlação entre os intangíveis e a performance foi avaliada através dos coeficientes de correlação de Pearson e foram utilizados modelos de regressão linear múltipla. Evidências empíricas sugerem um impacto negativo na performance por parte de alguns ativos intangíveis divulgados na posição financeira das empresas. As características do conselho de administração mostram um efeito positivo no volume de negócios quando consideradas juntamente com intangíveis desagregados, o que reflete efeitos sinergéticos entre as variáveis. A contribuição mais significativa para a performance é do *software* e das despesas de pesquisa e desenvolvimento das empresas, salientando o papel crucial do capital de inovação neste setor.

Complementarmente, este trabalho testa a diferença da distribuição dos intangíveis segundo regiões, o que se verifica no caso das variáveis: ativos intangíveis, goodwill, licenças e patentes, tamanho do conselho de administração, *software* e P&D e volume de negócios, as quais apresentam médias superiores para a região Norte Americana.

Palavras-chave: Intangíveis, capital intelectual, performance organizacional, setor tecnológico.

JEL Classification: G30, M41, L25.

Acknowledgements

The conclusion of this dissertation represents the end of a journey I never travelled alone. For that reason, I would like to present my gratitude to the ones who made its conclusion possible.

Primarily, I would like to thank professor Ilídio Tomás Lopes for all the guidance, availability and comprehension demonstrated this last year, without which the termination of this study would never be possible.

Secondly, my appreciation goes to my family and friends who supported and motivated me along the way. Nevertheless, there are a few people I would like to highlight. My truest appreciation goes to Francisco, whose unconditional support, never-ending belief in me and patience even in the most difficult days always appeased me and never let me lose sight of what is important.

Finally, to my parents, who transmitted me essential values that are present in everything I do. To my mother, who shows me every day that life is for those who fight and do not give up, and that there is beauty in being a force of nature. To my father, who since an early age always made me believe that I am capable of anything. It is the culmination of an effort that was not only mine. A final note to my brother, who spent all these months saying I was on vacation.

Index

Tables Index

1 Introduction

1.1 Relevance of the topic

The topic of how intangibles contribute to a company's performance is not new, especially when considering them as part of intellectual capital. In fact, intellectual capital has been the focus of several researches in the past decades. Although not having a general definition, this concept is referred to as 'the sum of all of the intangible and knowledge-related resources that an organization is able to use in its productive processes in the attempt to create value' (Kianto *et al.,* 2014: 364). With the shift of focus to intangibles as resources that can constitute a competitive advantage for the firm (Barney, 1991), the search for comprehension on its importance to companies' results is becoming more relevant.

Nonetheless, several studies reveal conflicting results considering this subject and have different perspectives on the contribution of intangibility to performance. Thus, in spite of its continuously increasing importance to the firms, intellectual capital's disclosure on financial reports is still very limited, which reinforces the necessity for further research on the topic in order to make this disclosure possible.

This study aims to contribute to the literature by increasing the knowledge of intangibles and their contribution to organizational performance. Furthermore, this research innovates by analyzing the technological sector, which is a sector that has not been further analyzed by investigators and is here represented by the major companies in the world. It has been shown that the sector in which companies operate can contribute to the transformation of intangibles into company market value (Shakina and Molodchik, 2014) and have impact on their profitability (Tudor *et al.,* 2014). Hence, it would be interesting to assess whether the results for this industry corroborate or refute the literature regarding the vital role of intangibles on performance.

1.2 Objectives

The general purpose of this study is to identify the impact of intangibles on the performance of the main technological companies in the world. The intangibles were selected as proxies of intellectual capital in order to conclude on its contribution to financial performance. The specific objectives consist of (i) investigating the effect of intangibles disclosed in companies' financial position on performance; (ii) examining the effects of disaggregation of intangibles on performance and (iii) evaluating on what extent the characteristics of the board of directors as a representation of human capital

contribute to obtain future economic benefits. Furthermore, it will be determined whether the distribution of these intellectual capital drivers does depend on the region.

1.3 Methodology

The study conducted follows a positivist research approach, which comprehends the existence of an autonomous reality that is separated from the investigator and is independent from the researcher's perspective or belief (Scott, 2012). This methodology permits to validate the knowledge through empirical confirmation by formulating the investigation hypotheses and analyzing the obtained results in order to verify or dismiss the theory. Positivism is commonly associated with a quantitative nature, relying on statistical and mathematical techniques to obtain objective results. This approach is frequently used by investigators when studying matters related to intangibles and intellectual capital.

Regarding the sample, it was selected considering Forbes' ranking 'World's 25 Biggest Tech Companies in 2016' (Forbes, 2017) and this study aims to determine the contribution of intangibles to the financial performance of these companies. This was the chosen sample to represent this sector since it comprehends the major companies in this industry, thus, the ones expected to have higher levels of intangibles and a more complete disclosure of intellectual capital.

The analysis of the data will be realized through descriptive statistics, correlation and multiple linear regressions in order to achieve the objectives proposed for this study, which will be conducted using the Statistical Package for Social Sciences (SPSS) program.

1.4 Structure

The structure of the present dissertation is as follows: chapter 1 constitutes the introduction to the topic, followed by the theoretical framework in chapter 2 and the literature review of the most significant studies about this theme, in chapter 3. The forth chapter explains the methodology chosen to achieve the objectives and introduces the investigation questions. Chapter 5 presents the discussion of the obtained results and, lastly, the sixth chapter regards the conclusion of this study, as well as its limitations and suggestions for future research.

2 Theoretical Framework

2.1 Categories of intangibles

Andriessen (2004: 18) defines intangible resources as 'nonmonetary resources without physical substance that in combination are able to produce future benefits for an organization'. In another definition, Lev (2001) describes intangibles as claims to future benefits that lack physical or financial embodiment, and which are created by innovation, exclusive organizational designs, or human resources practices.

In earlier approaches, Hall (1992) considered that intangible resources should be classified as assets or skills. Intangible assets would include the intellectual property rights of patents, trademarks, copyright and registered designs, contracts, trade secrets and data bases. On the other hand, intangible resources classified as skills would represent the competencies of employees (such as know-how), suppliers and advisers, as well as the organizational culture of the company. Nowadays, intangibles are generally classified as knowledge resources, as intangible assets or as intellectual capital (Lopes and Ferraz, 2016).

2.2 Intangible assets

International Accounting Standard (IAS) 38 is the standard to be applied in accounting for intangible assets that are not under the assumption of another and more specific norm, and which focuses on the recognition and measurement of intangible assets. As supported by this norm, assets are resources from which future economic benefits are expected to flow to the entity if they are identifiable and controlled by it. An intangible asset is a non-monetary asset without physical substance that, to be recognized as so, must meet the previous criteria. Hence, if an item does not meet them, its expenditure (to acquire or generate internally) must be recognized as an expense when it is incurred.

When an intangible asset is generated internally, it must be classified according to two phases: the research phase and the development phase. In the first one, the expenditures occurred shall be recognized as expenses in that period due to the fact that the entity cannot prove that an intangible asset capable of generating future economic benefits exists. This is the case of activities aiming to obtain new knowledge or the search for new alternatives for materials, devices and products, among others. The cost of generating an intangible asset internally is often difficult to distinguish from the cost of maintaining or enhancing the entity's operations or goodwill. This is why internally

generated brands, mastheads, publishing titles, customer lists and similar items are not recognized as intangible assets (IFRF, 2014). In the development phase, the expenses must be capitalized, since it is possible to identify the intangible asset and demonstrate its potential to generate future economic benefits. These expenses are associated with the design, construction and testing of new materials, devices, products, processes, systems or services before their commercial production or use.

Computer software, licenses, trademarks, patents, films and copyrights are some of the resources considered intangible assets under the assumption of IAS 38, whereas expenditure on advertising, research and development activities and similar outflows are not, thus must be recognized as expenses instead of capitalized.

Intangible assets have a volatile nature and the verification of their existence can be difficult, which leads to complications in their measurement and subsequent exclusion from the financial statements (Lopes and Martins, 2015). In accordance with international accounting norms, 'goodwill recognized in a business combination is an asset representing the future economic benefits arising from other assets acquired in a business combination that are not individually identifiable and separately recognized' (IFRF, 2014). Goodwill acquired in a business combination is within the scope of International Financial Reporting Standard (IFRS) 3, whereas internally generated goodwill is under the assumption of IAS 38 even though it cannot be recognized as an intangible asset because it is not identifiable – which means it cannot be separated from the total value and does not arise from legal rights. Thus, internally generated goodwill is an aggregated amount of all the intangibles that cannot be identified nor separately measured, representing the intangibles not recognized in the financial statements that, in spite of this fact, can have significant (though uncertain) future returns (Lopes and Martins, 2015; Zhang, 2013).

2.3 Intellectual capital

Intellectual capital (IC) is a much broader term. It embodies components such as intangible assets, intangible resources, invisible assets, intellectual property and intangibles in general (Kaufman and Schneider, 2004; Sonnier, 2008). Edvinsson and Malone (1997: 44) define it as 'the possession of the knowledge, applied experience, organizational technology, customer relationships and professional skills that provide a company with a competitive edge in the market'. Overall, it represents 'the sum of all of the intangible and knowledge-related resources that an organization is able to use in its

productive processes in the attempt to create value' (Kianto *et al.,* 2014: 364). Although there is no exact definition of this concept, it is commonly accepted to be divided into three categories: human capital, structural/organizational capital and relational capital (Sveiby, 1997). This model is currently referred to as the tripartite model of IC dimensions or three-dimensional IC measurement model (Inkinen *et al.,* 2017; Hussinki *et al.,* 2017).

IC comprises the valuable knowledge-based resources and the management activities related to them (Kianto *et al.,* 2013). In this regard, human capital represents 'the skills, intellect, attitudes, talent, and other tacit knowledge embodied in employee and management bodies' (Lopes and Ferraz, 2016: 393). In other words, it represents the contribution of the exclusivity of the human factor to the entity. Relational capital refers to the value and the knowledge that reside in the relationships with internal and external stakeholders and the creation of a network between them (Inkinen *et al.,* 2017; Lopes *et al.,* 2016; Sánchez-Segura *et al*., 2014; Sonnier, 2008). Organizational capital concerns the information obtained and transmitted, while structural capital regards the knowledge residing in the organization and technology, fomented by the individual capabilities used in the organizational structure, often represented by processes, information systems, databases, patents, licenses, software and products (Inkinen *et al.,* 2017; Lopes and Ferraz, 2016; Sánchez-Segura *et al*., 2014).

Some studies reveal the importance of enlarging the three-dimensional IC measurement model to include more elements. Inkinen *et al.* (2017) question the applicability of the tripartite model of IC dimensions, stating that it fails to consider the possible variation of intangible assets' value in different conditions. This study suggests a seven-dimension model, including entrepreneurial capital, trust capital and renewal capital, as well as dividing relational capital into internal and external relational capitals. The objective was to assess if the IC structure is universal across its different dimensions or if it varies within countries and cultural background. The authors concluded that the structure of IC across countries is predominantly constituted by the same elements, encouraging researchers to continue to utilize the tripartite universal model. Nonetheless, it would benefit from the inclusion of renewal capital, which represents the skills for learning and development in order to create new knowledge (Kianto *et al.,* 2010), and entrepreneurial capital, consisting on the present value of generated future entrepreneurial behavior, which is the competence and commitment of pursuing opportunities (Erikson, 2002). Their relevance was proven by this paper in the

increasingly globalized business environments. Previous studies support the inclusion of different categories of IC on the tripartite model, supporting the relevance of renewal capital (Kianto *et al.,* 2010; Cesaroni *et al.,* 2015; Buenechea *et al.,* 2016) and entrepreneurial capital (Erikson, 2002; Cesaroni *et al.,* 2015; Buenechea *et al.,* 2016) and suggesting new dimensions. Some of the new dimensions suggested are innovation capital – the ability to build on previous knowledge and generate new knowledge, which consists on the aptitude to develop new products and innovative ideas (Maditinos *et al.,* 2010; Tseng and Goo, 2005; Chen *et al.,* 2004) – and trust capital – willingness to be vulnerable to the actions of another party, hereby specifically referring to the trust embedded in a company's internal and external relationships (Mayer *et al.,* 1995).

The importance of IC in value creation seems to be undeniable, promising to be 'capable of explaining the value of knowledge in knowledge-intensive companies and in growing knowledge-based economies' (Sánchez-Segura *et al*., 2014: 863).

2.4 Resource-based view and knowledge-based view of the firm

According to Barney (1991), a firm has a competitive advantage when it is implementing a value creating strategy different from the ones being implemented by its competitors. This competitive advantage is sustainable when the benefits from that strategy are unable to be duplicated by the company's competitors. The resource-based view (RBV) of the firm relies on the argument that such strategies derive from the resources and capabilities that a company controls. However, not every resource of the firm constitutes a competitive advantage. In this scope, a sustainable competitive advantage exists when a resource is valuable, rare and difficult to imitate, trade or substitute. These resources and resulting competitive advantages are expected to contribute to companies' superior performance.

A different approach that addresses the role of knowledge and its management on organizational competitiveness and performance is the knowledge-based view (KBV) of the firm. KBV is an extent of RBV that understands knowledge as the strategically most important resource of the firm (Grant, 1996). This view recognizes that the production of a good or service involves the application of different types of knowledge which, additionally to the importance of having resources that are valuable, rare, inimitable and non-substitutable (Barney, 1991), requires the firm to be aware and able to integrate, apply and manage different types of knowledge (Grant, 1996; Kogut

and Zander, 1992). Thus, one of the crucial points of KBV is the management of knowledge leading to organizational performance (Kianto *et al.*, 2013).

Both of these approaches highlight the facts that the competitiveness of a company does not solely depend on the product-market positioning in relation to external competitors (Kianto *et al.,* 2013), as it strongly relies on its distinct intern characteristics. While RBV literature focuses on the identification and strategic management of resources that constitute sustainable competitive advantages – which are mainly intangible, knowledge-based assets –, KBV studies the role of management in the value creation, use and appropriation of a firm's knowledge-based assets, that is to say, intellectual capital (Sonnier, 2008). Hence, in a knowledge-based economy that is driven by intellectual capital (Gan and Saleh, 2008; Sánchez-Segura *et al*., 2014; Sharma and Dharni, 2016), the better a company is on managing its intangibles and strategically consider them, the more likely it is for it to achieve high levels of performance (Kianto *et al.*, 2013).

3 Literature Review

Intellectual capital has become a critical concept for evaluating a company's worth. Indeed, Edvinsson and Malone (1997) establish it as the difference between the market and the book value of a business. In the knowledge-based economy, this difference consists of the intangible resources that cannot be properly measured and reported within the traditional accounting framework (Salehi *et al.,* 2014; Pal and Soriya, 2012). These resources are vigorously associated with knowledge, which, in many instances, means they cannot be evaluated by conventional methods due to the non-existence of a market price (Heiens *et al.*, 2007). Contrarily, tangible assets can be easily imitated or purchased in a free market, making them impossible to be considered as strategic assets or to create competitive advantage for the business (Salehi *et al.,* 2014). Accordingly, firms have shifted their focus to intangible assets, whose nature has the ability to permit the creation of a sustainable competitive advantage (Shakina and Molodchik, 2014). Yet, this immaterial nature contributes to a complex evaluation and management of these assets (Pucci *et al.,* 2015) due to the inexistence of an organized market, the difficulty in verifying their existence, the possibility of not having finite lives, the potential fluctuation of their value and the possibility of them being embodied in a specific activity (Lopes and Martins, 2015). Hence, intangibles are expected to be of value for a company although their volatile nature and the difficulties in their measurement commonly exclude them from financial statements (Lopes and Martins, 2015). In fact, Ilmakunnas and Piekkola (2014) argue that the only time IC is fully evaluated is at mergers and acquisitions.

Nonetheless, intellectual capital is a vital resource of any knowledge-intensive company. It comprises all the 'intangible assets that contribute to the delivery of a company's value proposition, like individual and group talents and skills, people's knowledge and experience, patents, copyright, models, methods or procedures' (Sánchez-Segura *et al.,* 2014: 862). Gan and Saleh (2008) refer to IC in two aspects. One comprised by the standards − which includes patents, intellectual property, brand and trademarks − and the second one is the 'soft asset' such as knowledge, information, and experience, which many researchers consider as the core of IC today.

In spite of its continuously increasing importance to the firms, IC's disclosure on financial reports is still very limited, which reinforces the necessity for further research on the topic in order to make this disclosure possible.

As previously mentioned, the transition of the economy from capitalist to knowledge and technology driven motivated the change of focus from tangible resources to intangible (Sharma and Dharni, 2016). Furthermore, the increasing gap between the market value and the book value of the companies has motivated the conduction of several studies in the past decades in order to identify the impact the intangibles have on performance and the extent of their contribution.

According to IAS 38, intangibles are expected to generate future economic benefits for the company, which can be expected to contribute positively to the performance of the entity, and to be reflected on its performance indicators. The literature, in its majority, firmly supports their positive and significant effect on organizational performance, considering intangible assets as the main source of competitive advantage for the firms (Sharma and Dharni, 2016; Shakina and Molodchik, 2014; Sánchez-Segura *et al*., 2014; Omil *et al.*, 2011).

Amadieu and Viviani (2010) highlight two main methodologies used when approaching the relationship between intangibles and companies' performance. The first one regards the study of investment on intangibles and capital market financial performance measures (such as share returns, holding period returns and Tobin's Q). Alternatively, the second one investigates the relationship between intangible assets and performance measures, which can be mainly financial (return on assets (ROA), return on equity (ROE), return on investment (ROI),…) or nonfinancial (for instance, market share and gross margin). This literature review will incorporate both approaches, in order to obtain a general appraisal of IC's effect on performance.

Shakina and Molodchik (2014) stress the importance of intangibles as strategic assets and as a competitive advantage that is the principal cause of additional profit for a company. They used Economic Value Added (EVA) to determine whether the investment attractiveness of the company was influenced by intangible assets and which factors support or obstruct market value creation through IC. The results corroborate their assumption and indicate that the size (measured by book value of total assets and number of employees) and the industry in which the company is inserted influence value creation. This study also reinforces the importance of innovation activities, which were measured by the investment in research and development (R&D), showing a positive and significant relation with value creation.

In a different study aiming to confirm the assumption of IAS 38 that intangibles are associated with future economic benefits (IFRS, 2014), Lopes and Martins (2015) studied 127 listed companies in the Iberian Stock Exchange Markets in order to identify the impact of IC on the businesses' turnover. These results showed a positive and significant correlation between the intangibles capitalized in the statement of financial position and performance. Furthermore, consistently with the previous study, the independent variable size (measured by total assets) presented significant results, confirming firms with higher level of assets tend to generate a higher level of turnover, revealing the presence of scale effects. Pucci *et al.* (2015) analyze the impact of intangible assets, such as patents, copyrights, brands and advertisement, on firms' economic performance through their impact on the level of intellectual capital. Conclusions were taken for the Italian children's clothing industry after the analysis of 45 companies. Intellectual capital was measured using the *knowledge capital scorecard method* and its correlation with profitability measures, namely return on investments, return on sales (ROS), return on assets, return on equity and capital turnover, was evaluated. Empirical evidence suggests that IC value is positively associated with every measure of performance except for turnover, having a high correlation with ROI, ROS and ROA, which are the performance measures commonly used by entrepreneurs (Pucci *et al.*, 2015). Posteriorly, the authors evaluated the impact of the intangible assets on IC, proving a significant contribution of their interaction on IC level. Hence, the authors corroborate the possibility to use intellectual capital value as an indicator that measures the contribution of certain intangible resources to firm results, highlighting the importance of IC to economic performance.

In a recent paper regarding the effects of IC components on performance, Nadeem *et al.* (2016) defend that the relationship between IC and organizational performance is bidirectional and therefore should be considered dynamic, stating that lagged firm performance affects current or future IC efficiency. To conclude on this assumption, the authors measured the relationship between IC efficiency and the performance of 774 firms from the London Stock Exchange. The results show that VAIC (Value Added Intellectual Coefficient) is positively and significantly related to firm performance, mainly with return on assets and return on equity. When analyzing the IC's components separately, Nadeem *et al.* (2016) observed that structural capital and physical capital are of great importance for firm performance, and human capital

was only found significant when using the static approach of Ordinary Least Squares (OLS) regression instead of the dynamic one. These results are congruent with most of the existent studies in the literature regarding the relevance of IC, but display the importance that is still attributed to physical assets on financial performance. A similar study from Sardo *et al.* (2018) analyzed the effect of intellectual capital on small- and medium-sized enterprises' (SMEs) hotel financial performance, using a sample of 934 Portuguese companies. As well, this study adopted the Generalized Method of Moments (GMM) system estimator to analyze a dynamic panel data. The findings suggested that intellectual capital components, i.e., human capital, structural capital and relational capital provide a positive impact on financial performance, with human and structural capitals presenting the higher impact on return on assets. The results support that investments in IC take time to generate profitability and return, stressing that size has a negative impact on financial performance, suggesting that larger companies are less profitable in the hotel industry.

Lopes *et al.* (2016) discovered that, for the top 30 airlines worldwide, intellectual capital drivers, such as intangible assets, are significant in the prediction of 'the most direct indicator of return', turnover. The obtained results support the importance of human capital − namely employees' expenses and benefits and the size of board of directors − and structural capital in the prediction of this indicator of profitability. However, the relationship between IC and other performance indicators, such as ROA, ROE and ROS, could not be validated. They also concluded that only variables associated with financial leverage and scale effects have a significant impact on profitability, with region not playing an important role on performance.

Not many studies find evidence on the negative or null impact of intangibles to performance. Nonetheless, an investigation on the French wine companies' financial performance and its relation with intangible investments came to such conclusion. Amadieu and Viviani (2010) analyzed the financial statements of 207 SMEs of the wine industry and concluded on a negative impact of intangibility intensity on financial performance, measured by return on assets. The authors state that, for this industry, intangible assets are used in an ineffective way and, in order to guarantee financial success, intangible expenses should be accompanied by organizational and managerial changes. Pal and Soriya (2012) compared the IC performance between Indian pharmaceutical and textile industries using VAIC and association of IC with financial

indicators such as turnover, ROA, ROE and market to book value of the companies. Results show that, although both sectors are efficiently using IC, there was no impact of IC on the productivity of the companies, which was measured by turnover. Regarding the other measures of performance, the authors found that profitability measured by ROA increases with IC efficiency. Conversely, ROE is only positively influenced by IC in the case of pharmaceutical industry, due to the fact of it being a knowledge intensive sector. When analyzing the market valuation of the companies, the authors found no impact of IC, which reflects the lack of consideration of intangibles in the stakeholders' decision-making, who prioritize other factors relative to performance.

Bubic and Susaz (2015) analyzed the impact intangible assets have on the profitability of Croatian companies and assessed their relationship with bankruptcy status. Their study established that companies which invest in intangible assets are less likely to bankrupt. In spite of that fact, they found no strong evidence that supports a positive relationship between investment in intangible assets and profitability ratios (ROA, ROE, net profit margin (NPM), gross profit margin (GPM) and return on capital employed (ROCE)), with the exception of EBIT (earnings before interests and taxes) and EBITDA (earnings before interests, taxes, depreciation and amortization), which continually increase as the investment in intangible assets grow.

These studies allow for the conclusion that, even though there is no consensus regarding the contribution of intangibles to performance, their importance has been the focus of the research in the field of accounting and finance in the last two decades (Nadeem *et al.*, 2016), which emphasizes the relevance of this topic.

Lopes and Ferraz (2016) examined 125 non-financial business organizations listed on an Iberian stock exchange with the objective of identifying the impact of IC and the effect of boards' expertise and knowledge on performance. In this respect, turnover was used as the main performance indicator and return on assets, return on equity and return on sales as complementary measures. The authors concluded on the positive and significant impact of intangibles on turnover of non-financial Iberian companies, not finding empirical evidence of the impact on the complementary indicators. Regarding the characteristics of the board, the study proved that the size of the board and the participation of the members on other internal or external boards of the organization are significantly associated with turnover.

In reality, corporate governance literature attributes an increasing importance to board of directors as 'an expression of competence, professionalism, skills, knowledge, experience, culture and management abilities, to conduct the business' (Lopes and Martins, 2015: 471). Board size is an important attribute of board structure and has been widely used as a proxy for human capital, complementary to other boards' characteristics that represent the expertise and tacit knowledge of employees and management parties.

In this scope, Uadiale (2010) conducted a study to examine the impact of board structure on corporate financial performance in Nigeria, investigating the composition of boards of directors in Nigerian quoted firms. The OLS regression was used in order to estimate the relationship between corporate performance measures and boards' characteristics. The findings show that there is a strong positive association between board size and performance, encouraging the companies to have a large board size to improve corporate financial performance. Complementary to this study, Wang *et al.* (2013) also examined the influence of board structure on firms' performance. The size of the board was used as one of the proxies for human capital in order to determine which types of companies should have a larger board size and which ones should have smaller boards with the intuit of enhancing companies' performance. Results showed the size of the board only has impact on complicated firms (firms with large size, high diversification and high leverage), since performance levels decrease with board size for simple firms, but increase with board size for complicated ones. Sheikh *et al.* (2013) conclude that the size of board of directors relates positively to return on assets, earnings per share (EPS) and market-to-book ratio, although boards' effectiveness being sensitive to different economic periods. The authors defend that a board with high levels of links to external environment improves a firm's access to various resources in more advantageous conditions, which positively affects firm's performance.

Other researches present different results. When studying the influence of board structure on firms' financial performance in the pharmaceutical industry of Bangladesh, Nath *et al.* (2015) found there is a significant negative relation between board size and firms' financial performance, including return on assets. Other than the board size, there was no significant relationship between the remaining independent variables and firms' results. The study defends that smaller but representative board sizes are more efficient to enhance companies' performance. Mashayekhi and Bazaz (2008) investigated the relation between corporate governance and firm performance for companies listed in the

Tehran Stock Exchange for the years 2005-2006. Their regression results also show that board size is negatively associated with firm performance (ROE, ROA and EPS), indicating that larger board size generally reflects weaker control and supporting that smaller boards are likely to be more efficient in monitoring management. On Lopes and Martins (2015) investigation of the impact of IC to performance, the authors did not find a statistically significance of board of directors' characteristics, including size, in the model. This reflects an absence of interaction between this human capital proxy and turnover.

Edvinsson and Malone (1997:12) state that 'the core of knowledge-economy is huge investment flows into human capital as well as information technology'. In a broader research, Guo *et al.* (2012) assessed the influence of IC on the performance of 279 biotech firms listed in the US market from 1994 to 2005, discussing the relationship between intellectual human capital, technology innovation and financial performance. Research and development (R&D) expenditures and patents were considered as part of technology innovation, whereas stock return, ROA and ROE were used as financial performance indicators. The results show that human capital (measured by Chief Executive Officer's (CEO) or Vice President's compensation and their academic background) and R&D expenses significantly offset the current earnings in financial reports, decreasing performance in terms of cash flow and return on assets. Nonetheless, results show that R&D expenses and human capital increase future stock returns, enhancing performance in the long term.

Li and Wang (2014) examined the effect of R&D expenses, sales training and employee benefits on Hong Kong's listed Information Technology companies' return on assets. The authors defend that return on assets is the most suitable indicator to measure performance, since it correlates overtime with return on equity and return on investment, with the advantage of being the most stable throughout the years. The results showed that only R&D expenditure and sales training have a positive relation with return on assets, with employee expenses not being correlated with performance.

As research and development may be the most direct indicator to a company's innovation (Omil *et al.,* 2011; Li and Wang, 2014), R&D activities are becoming increasingly important in sustaining firms' competitive advantage. Recent studies have been focusing on this assertion. In this regard, Ruiqi *et al.* (2017) examine the relationship between R&D expenditures and future performance in Chinese companies

listed on the Main Board of Shanghai and Shenzhen stock exchanges. The multiple regression models' results show that R&D expenditures are positively related to firms' future performance measured by Future Operating Performance indicator. The authors stress that R&D expenditures are essential to improve firms' performance through reduction of production costs and creation of new products, which constitutes a competitive advantage in a fierce market. This study also concludes on a positive influence of state ownership on the relationship between R&D investments and future performance, defending that a connection with the government helps improving the efficiency of R&D resources.

Lome *et al.* (2016) analyzed 247 Norwegian manufacturers in order to evaluate the effect of a high R&D intensity on performance during a financial crisis. Using binary logistic regression, the authors found a very significant connection between R&D intensity and subsequent growth rates through the late 2000s financial crisis. These results introduce the importance of R&D activities during a financial crisis, defending that managers should consider it before cutting R&D spending, as it has a long-term effect and may constitute an important competitive advantage when the economy starts to recover. The literature defends that it takes time for a firm's R&D investment to translate on a firm's financial outcome (Li and Wang, 2014). This study also addresses that question, revealing a period of two years since the investment in R&D and the subsequent improved results on revenue. Thus, Lome *et al.* (2016) consolidate the importance of R&D investments for a company on the long-term, underlining the idea that R&D intensity acts as a form of insurance against future crises, proving that companies that highly invest in R&D activities perform significantly better than the ones that do not, even during recession periods. This conclusion is consistent with Shakina and Molodchik (2014) and Nadeem *et al.* (2016) previous inferences that intangibles are especially important during market instability since they provide most of a company's competitive advantage in the knowledge economy.

Gleason and Klock (2006) investigated whether R&D capital and advertising capital were able to explain the variation of market value (represented by Tobin's Q ratio) for U.S.' chemical companies. The authors found that these measures of intangible capital, especially R&D, have an important and statistically significant role in firm valuation for this industry, particularly in firms established in the market for a longer period of time. Alongside this review, several researches commonly analyze

R&D in simultaneous with advertising expenses. Furthermore, previous studies reflect the importance of R&D efforts being aligned with advertising in order to achieve a higher level of performance.

In fact, Sridhar *et al.* (2014) found that for publicly listed U.S. high technology manufacturing firms, R&D spending and advertising spending have a positive and significant impact on firm value when interrelated. A different study conducted by Mizik and Jacobson (2003) found that value creation through R&D alone does not enhance firm value and that it is necessary to have value appropriation through advertising in order to achieve sustained competitive advantages. They argue that value creation influences the potential magnitude of the advantage, while value appropriation influences the amount of the advantage the firm is able to capture and the persistence of that advantage in time. The first is driven by innovative activities that rely on the firm's technology capabilities, which are linked to R&D expenditures. On the other hand, value appropriation is associated with a firm's ability to differentiate its offering through advertising. The authors used stock return as a measure of long-term financial performance, influenced by the variation in accounting business performance (through return on assets). Empirically, they found that the stock market reacts favorably when a firm increases its emphasis on value appropriation, even in the high-technology markets, where innovation and R&D are essential to companies' success. These results show that, although R&D can create value through innovation, its effects are only maximized when the firm uses advertising to appropriate part of the value it has created.

A research carried out by Hanssens and Joshi (2010) reinforces the importance of advertising, providing conceptual and empirical evidence of a positive relationship between advertising expenditures and the market value of firms. The authors defend that advertising has, simultaneously, a direct and indirect impact on firm value, which contributes to market capitalization. The direct impact arises from the constitution of the brand. By allowing the company to create its brand image, advertising helps guarantee firm's reputation (Tanfous, 2013). Brand awareness proved to be crucial for investors, as they tend to favor well-known and powerful brand names, which causes long-term effects on firm value. The indirect impact of advertising is due to the consequent increase in the level of sales and profits, which will ultimately be reflected in the company's turnover.

A recent study conducted by Acar and Temiz (2017) focused on the association between banks' advertising expenses and the accounting measures of income and

profitability of the Turkish banking sector. This study was the first to investigate the long-term effect of advertising on financial performance of banking sector by using Koyck's distributed lag model. The results show a positive effect of advertising on interest income, total operating income and return on assets. The authors not only confirmed the contribution of advertising to financial performance, as found a positive effect of advertising that extends over time. These results suggest that advertising expenses hold future economic benefits and, therefore, the authors argue they should be capitalized and then amortized rather than being recognized as a cost when it occurs. Another study that establishes advertising as an increasingly important investment for the firm is the one carried out by Assaf *et al.* (2015). This research analyzed 65 Croatian and Slovenian hotels for a six-year period (2007 to 2012) in order to determine the impact of advertising spending on firm performance for the hotel industry. This investigation was conducted using the Bayesian stochastic frontier approach to measure sales performance. This method is widely used in marketing literature as it compares a company's sales performance against its optimal performance while considering competition, which results in a dynamic structure on the sale performance metric. Posteriorly, the effects of advertising were tested and resulted in a positive impact on hotel sales performance. Moreover, results suggest this impact is stronger for large hotels, which explains why advertising is sometimes less effective for some companies. Authors defend that large companies have a lower cost of advertising per customer and are able to reach a larger number of potential clients with the same advertising expenditure, which does not happen for smaller businesses. This paper reinforces the assumption that increased advertising spending enhances performance, hence should be considered as a significant investment for the firm.

Although the contribution of R&D and advertising is mostly supported in the literature, a few studies dismiss their importance to performance. One of these studies was conducted by Heiens *et al.* (2007) who investigated the contribution of intangible assets and expenditures to shareholder value for 1657 traded manufacturing firms for a six-year period. Defending that the traditional financial measures of performance, such as ROA and ROE, are inadequate in strategically planning decisions, the researchers used market-adjusted holding period returns as the measure of corporate shareholder value. The empirical tests suggest the intangible assets other than goodwill strongly and positively affect the values of this indicator, whereas investments in advertising do not

have a significant contribution to the generated long-term financial returns to investors. Additionally, goodwill and R&D expenditures presented a negative impact on this measure of performance. In fact, the more goodwill firms accumulate, the worst impact it has on holding period returns. This may be due to investors not considering the excess of the amount paid to acquire the assets adequate, or the assets not translating the benefits the firms were expecting. In regards to R&D, Heiens *et al.* (2007) defend that these results may be explained by the uncertainty of the future benefits of R&D or by the way markets tend to view the excess spending on intangibles negatively due to the risk involved. Nonetheless, the authors argue that, even though advertising and R&D expenditures negatively affect performance and therefore do not constitute a competitive advantage for the firm, their importance to competitiveness in an industry is undeniable.

A study lead by Tanfous (2013) on 252 non-financial French companies listed on Paris Stock Exchange aimed to demonstrate the aggregated effect of intangibles on value creation and examine whether the sector of the company is associated with intangible activities. The research confirmed the previous assumptions that R&D expenditures and advertising expenses contribute favorably to the value creation of companies when considered aggregately, as well as the participation and training of employees. Even so, the results vary from one sector to another and demonstrate that the technological sector has a lower investment on intangibles than the industrial and service sectors, although displaying the highest values in advertising expenses and motivation of personnel. This low investment diminishes the intangibles' influence on value creation and this study alerts for the possibility of a different impact of intellectual capital among industries, with special focus on the technological one.

In this scope, for a sample of 562 companies listed on Frankfurt Stock Exchange and London Stock Exchange, Tudor *et al*. (2014) found there is a positive and steady relationship between intangible assets and various performance indicators (ROA, ROCE and GPM). This relationship seems to suffer structural differences and scale effects when considering distinct sectors or the two markets as a whole. One possible explanation for this fact regards the uncertainty of the sector in question. It can be argued that in sectors in which intangible assets such as patents, software, trademarks, brands, in-progress R&D, among others, have an important weight in the total value of intangible assets, there is a higher degree of uncertainty and a bigger vulnerability to

market conditions. In comparison, sectors in which intangible assets are protected by formal mechanisms (such as customer contracts, licensing and franchising agreements) tend to suffer less from the market's fluctuations.

In their empirical review of the major topics concerning intangible assets, Sharma and Dharni (2016) validate the previous statement regarding the effect of intangible assets on firm performance across sectors. In their research, the authors observed differences in the contribution of intangibles depending on the sector they are inserted, which they believe may be due to the difference in appropriability of intangibles. This appropriability 'may differ on account of the protection regimes available across sectors, nature of intangibles and the tendency of firm to leverage intangibles for business efficiency' (Sharma and Dharni, 2016: 63). A significant relation between intangible assets and organizational performance was found in the biotechnology, pharmaceuticals and IT industries, which have one important thing in common: all are largely R&D and knowledge intensive firms. This conclusion is congruent with a previous deduction of Shakina and Molodchik (2014), stating that an intensive development strategy, which happens when a company decides to conduct its own research and development projects rather than buying new technologies, is positively correlated with value creation. Consistently, the firms from the food and agricultural sectors were found to have a negative relation with financial performance (Sharma and Dharni, 2016).

The current research regards a sample of the major technological companies in the world, with the respective ranking being based on a composite score from equally-weighted measures of revenue, profits, assets and market value (Forbes, 2017). Thus, one can deduct that these companies are high-profitable firms. In this scope, based on the resource-based theory of the firm, Omil *et al.* (2011) showed that high profitability firms (HPF) are strongly focused on their management of intangibles regarding relational factors, innovation activities, and employee productivity. This research suggests that in comparison with non-high profitability companies, HPF's management of intangibles is reflected on their business performance (measured by return on assets). Among structural factors, innovation activities represent a crucial factor for a company to become high profitable. The study also suggests that 'companies that invest time and resources in developing their business relationships will be able to obtain better business performance rates than others'.

Amadieu and Viviani (2010) offer an explanation for the variation of the impact of intangibles on performance among industries. They state that the nature of the intangible resources that create competitive advantages is different from one sector to another. Hence, the efficacy of the mechanisms that ensure the appropriation of the value generated by intangible assets is also different among industries.

A different factor that is worth analyzing regards the region where a company is located. Diversity has not always been observed in regards to the relation between intangible assets and performance of the firm across different countries. Nevertheless, Sharma and Dharni's (2016) review verified that the majority of studies conducted in the USA, UK, and France establish a negative relationship between the intangible assets and performance of the firm. The authors found no relationship for Israel and Taiwan, while developing countries have shown a positive association with performance, which they justify by arguing that 'firms from developing countries are still having a window of opportunity, while this window may be closing in case of developed nations' (Sharma and Dharni, 2016: 63). Other research found no relation between performance and region (Lopes *et al*., 2016) and, in an investigation on whether the IC value was perceived differently across nations, Inkinen *et al.* (2017) proved the similarity of IC elements across the examined countries, establishing that firms are starting to uniform IC management and, therefore, verify less variation at this level.

This paper will additionally assess the effect of aggregation of intangibles on performance, in light of previous studies carried out by Tanfous (2013) and Lopes and Ferraz (2016). In order to comprehend whether the combination of intangibles has a different impact on performance, these authors conducted researches contemplating two regression models, in which one was represented by the aggregation of intangibles and the other one by their disaggregation, considering intangibles separately according to their typology (goodwill, software, etc.). Their conclusions are similar. Having regressed the theoretical models, a positive and significant correlation between intangible assets and performance indicators was found, considering the first model. Conversely, the analysis of the disaggregated effects showed the independent variables did not have a significant impact on performance. These results reflect that the integration of different intangible assets leads to more value creation than the individual contribution of each one of them (Tanfous, 2013) and that when intangibles of

intellectual capital are aggregated, their 'synergetic effects increase the performance and profitability of businesses' (Lopes and Ferraz, 2016: 411). Nonetheless, for the technology companies, Tanfous (2013) found that the contribution of the different variables has better and more significant results when the variables are considered individually than when aggregated, suggesting the disaggregated effect may be more relevant for this sector.

A less recent, although very relevant study conducted by Chen *et al.* (2005) allowed for interesting conclusions on this topic by exploring the relation between the value creation efficiency and firms' market valuation and financial performance. This study regarding the Taiwanese listed companies used VAIC as the efficiency measure of capital employed and intellectual capital, in order to examine IC's relationship with value creation (using firms' market-to-book value ratios). Two regression models were established concerning (a) the selected aggregated measure of intellectual capital, VAIC, and (b) VAIC's major three components, each representing elements of IC, such as human capital and structural capital, as well as capital efficiency. The authors were able to conclude that firms' intellectual capital has a positive impact on market value and posteriorly examined whether IC is associated with firms' financial performance. Thus, they performed the same models using ROE, ROA, growth in net sales (GR), and net value added per employee (EP) as dependent variables. In a third model, the authors included R&D and advertising expenditures to capture additional IC. Chen *et al.* (2005) verified that VAIC is significantly positive in the financial performance models, suggesting that firms with greater IC perform better in terms of profitability and revenue growth. However, the authors also observed that the explanatory capacity of the disaggregated model was substantially greater than the one in the first model. This means that the three components of IC separately are better than the aggregated measure VAIC in explaining firm value. The authors justify this difference affirming the investors may attribute distinct value to the different components of IC. This assertion was recently assessed by Hussinki *et al.* (2017), who argue that the configuration of IC substantially impacts the subsequent financial performance of the firm. Indeed, their results show that firms which specialize in some aspects of IC tend to achieve higher levels of performance. Moreover, the model containing R&D and advertising expenses reflected an even higher explanatory power than the previous models, with R&D expenses being strongly significant to the increase of performance, while advertising shows a negative impact. Nonetheless, these results underline the importance of

intellectual capital in enhancing firm profitability and revenue growth and highlight the disaggregated effects of intellectual capital in an investor's perspective.

4 Methodology

4.1 Objectives

The general purpose of this study is to identify the impact of intangibles on the performance of the main technological companies in the world, in order to conclude on the contribution of intellectual capital to performance. The specific objectives consist of (i) investigating the effect of intangibles disclosed in companies' financial position on performance; (ii) examining the effects of disaggregation of intangibles on performance and (iii) evaluating on what extent the characteristics of the board of directors as a representation of human capital contribute to obtain future economic benefits. Furthermore, it will be possible to determine whether the distribution of the intellectual capital drivers does depend on the region.

4.2 Investigation paradigm

The study conducted follows a positivist research approach, which comprehends the existence of an autonomous reality that is separated from the investigator and is independent from the researcher's perspective or belief. This methodology permits to validate the knowledge through empirical confirmation by formulating the investigation hypotheses and analyzing the obtained results in order to verify or dismiss the theory. Positivism is commonly associated with a quantitative nature, relying on statistical and mathematical techniques to obtain objective results.

This investigation paradigm is related to the positive theory of accounting which aims to predict the reaction of managers towards new accounting standards and to comprehend the reasons that justify their decisions (Scott, 2012).

4.3 Data

The sample was selected considering Forbes' ranking 'World's 25 Biggest Tech Companies in 2016'. The financial information used for the research was collected from companies' annual financial statements − specifically from their annual reports, corporate governance reports and proxy statements − which are publicly available on their websites. Those financial statements were obtained for the fiscal years ending in 2014, 2015, 2016 and 2017, with the exception of the enterprise EMC, which was purchased by Dell Technologies in 2016, thus does not present annual reports for 2016 and 2017. The information regarding EMC corresponds to its annual statements from 2012 to 2015.

The 25 companies included in the sample are exclusively from the technological sector and the study resulted in 97 observations considering the four years in question. It was not possible to access the financial information of two companies in 2014, and one company had not released its financial statements for 2017 at the moment of this research.

Of the 25 companies analyzed, 14 have their headquarters located in North America, 3 in Europe and 8 in Asia. The data was collected in U.S. dollars for all the companies. The ones that had their financial information presented in other currency had it converted at the exchange rate mentioned in the reports. For the companies that did not mention the exchange rate to U.S. dollars, the one utilized for the conversion corresponds to the rate in place at each company's final fiscal day (commonly, December 31st), through the Oanda currency converter website.

The analysis was conducted using the IBM SPSS (Statistical Package for Social Sciences) Statistics program, version 23.

4.4 Variables

The information concerning the characteristics of the companies studied, which were used as independent, dependent and control variables, were directly obtained from companies' annual statements or calculated from the information collected. Thus, having into consideration the literature review conducted, two dependent variables, ten independent variables and two control variables were selected and are summarized in the table that follows. The time effect was also considered in the models.

Table 1 – Variables' description and framework.

Variable typology	Variable	Description
Dependent	TUR	Logarithm of organization's turnover
	ROA	Ratio of net income to total assets
Independent	IA	Logarithm of total intangible assets recognized in non-current assets
	GW	Logarithm of goodwill recognized in non-current assets
	LP	Logarithm of licenses and patents recognized in non-current assets
	BTRAD	Logarithm of brands, trade names and trademarks recognized in non-current assets
	SRD	Logarithm of software and research and development expenses
	ADV	Logarithm of advertising expenses
	BDSIZE	Size of the board of directors
	BDAC	Logarithm of board of directors' annual compensation
	EMP	Total number of organization's employees
	REG	Region of the organization's headquarters
Control	LEV	Ratio of total book debts to total assets
	SIZE	Logarithm of total assets

Notes: TUR = Turnover; ROA = Return on Assets; IA = Intangible assets; GW = Goodwill; LP = Licenses and Patents; BTRAD = Brands, trade names and trademarks; SRD = Software and R&D expenses; ADV = Advertising expenses; BD = Board of directors; BDAC= Board of directors' annual compensation; EMP = Employees; LEV = Leverage; REG = Region.

To measure the companies' performance, the main dependent variable selected was turnover. According to IAS 38, intangible resources must be capitalized if they are controlled by the owner, if they are identifiable, and if future returns are expected to flow to the entity. Otherwise, their expenditure must be recognized as an expense when it is incurred. Thus, it is expected that the accounting treatment of intangible expenditures affects the companies' future returns and, consequently, the performance indicators. Turnover is the indicator which is expected to be the most susceptible to significant effects of intangibles, as this measure directly represents the economic benefits obtained by a company. Another important key performance indicator commonly used to express economic returns is return on assets. This measure of

profitability translates the return that an organization obtains on its investments, which is associated with the capacity of its assets to generate earnings. Thus, it has been extensively used as a measure of financial performance in previous studies (Gan and Saleh, 2008; Tanfous, 2013; Li and Wang, 2014; Bubic and Susak, 2015; Tudor *et al.* 2014; Lopes *et al.,* 2016; Hussinki *et al.,* 2017) and will be used as a complementary measure in this research. The assumption of IAS 38 that intangibles are associated with future economic benefits (IFRS, 2014) will be supported if a positive and significant impact on these companies' performance indicators is verified.

Logarithms were used in order to adjust the greatest values and standardize the data inserted. The variable size of the board of directors was measured through the number of members on the board (Nath *et al.,* 2015; Wang *et al.,* 2013; Sheikh *et al.*, 2013; Uadiale, 2010; Mashayekhi and Bazaz, 2008) and was used, along with the variables board of directors' annual compensation and total number of organization's employees, as a proxy to human capital. This study introduces the variable BDAC as a proxy to human capital which intends to represent the expenses incurred with the members of the board in the period under analysis. This variable intends to quantify the value attributed to the knowledge of a firm's directors. EMP was used due to the assumption that a company is better at value creation if it is more experienced and has more employees (Shakina and Molodchik, 2014), representing the intensity of labor.

Several measures were aggregated due to limitations on the available information or due to lack of disclosure on the financial statements of the companies analyzed. This was intensified by the fact that, even though these companies must obey to international accounting rules, the diversity of countries and continents in the sample causes a variation on the mandatory international standards to be applied. Furthermore, despite being of great importance at firm level, IC is only partly reported on balance sheets and financial reports. For the convenience and robustness of the study, licenses and patents, as well as brands, trade names and trademarks, were combined due to their often aggregated disclosure on financial statements. The value of software was joined to research and development expenses since in most cases it was impossible to obtain its value separately.

Since the majority of the companies analyzed are from North America (56%) and European and Asian companies represent 12% and 32% of the sample, respectively, the variable REG was created as a dummy variable (the company is North-American =

1; the company is not North-American = 0). The purpose is to identify whether the distribution of the IC drivers depends on the region.

As control variables, total assets was used to represent the size of the company, in light of previous studies (Sardo *et al.*, 2018; Lopes *et al.*, 2016; Lopes and Ferraz, 2015; Li and Wang, 2014; Omil *et al.*, 2011) and leverage as an indicator of the proportion of equity and debt the companies use to finance their assets (Pal and Soriya, 2018; Sardo *et al.*, 2018; Lopes *et al.*, 2016; Tanfous, 2013; Wang *et al.*, 2013).

4.5 Regression models

Intangibles recognized and disclosed in the financial statements of the organizations in study, along with certain board of directors' characteristics, are embodied in the theoretical models regressed, representing the most important proxies of intellectual capital. With the purpose of identifying which variables (X_i; i = 1, …, k) contribute the most to explain turnover and return on assets, three different models were regressed. Model 1 aims to explain the effect of intangible assets under the assumption of IAS 38 on performance, reflecting the impact of the capitalized intangibles comprised in the companies' statement of financial position. Model 2 includes characteristics of board of directors, in order to conclude on the contribution of human capital to performance. Model 3 embodies intangible assets along with intangible resources (software and R&D expenses and advertising expenses), aiming to identify the disaggregated effects of intangibles on performance.

- Model 1 (effect of intangibles disclosed in companies' financial position)

$$\hat{Y}_{it} = \beta_0 + \beta_1 IA_{i,t} + \beta_2 GW_{i,t} + \beta_3 LP_{i,t} + \beta_4 BTRAD_{i,t} + \beta_5 LEV_{i,t} + \beta_6 SIZE_{i,t} + \beta_7 Time\ effects_{i,t} + \varepsilon_{i,t} \quad (1)$$

(i =company = 1, …, 25; t = year = 1, …, 4)

$\hat{Y}$ = TUR, ROA.

- Model 2 (impact of human capital)

$$\hat{Y}_{it} = \beta_0 + \beta_1 IA_{i,t} + \beta_2 GW_{i,t} + \beta_3 LP_{i,t} + \beta_4 BTRAD_{i,t} + \beta_5 BDSIZE_{i,t} + \beta_6 BDAC_{i,t} + \beta_7 EMP_{i,t} + \beta_8 LEV_{i,t} + \beta_9 SIZE_{i,t} + \beta_{10} Time\ effects_{i,t} + \varepsilon_{i,t} \quad (2)$$

(i = 1, …, 25; t = 1, …, 4)

$\hat{Y}$ = TUR, ROA.

- Model 3 (disaggregated effects of intangibles)

$$\hat{Y}_{it} = \beta_0 + \beta_1 GW_{i,t} + \beta_2 LP_{i,t} + \beta_3 SRD_{i,t} + \beta_4 ADV_{i,t} + \beta_5 BDSIZE_{i,t} + \beta_6 BDAC_{i,t} + \beta_7 EMP_{i,t} + \beta_8 LEV_{i,t} + \beta_9 SIZE_{i,t} + \beta_{10} Time\ effects_{i,t} + \varepsilon_{i,t} \quad (3)$$

(i = 1, …, 25; t = 1, …, 4)

$\hat{Y}$ = TUR, ROA.

For each model, all variables were introduced simultaneously through the method Stepwise in order to determine which were able to significantly predict financial performance.

4.6 Investigation hypotheses

Hypotheses and sub-hypotheses are tested through the econometric analysis specified in the previous regression models and consist of the following:

Hypothesis 1 (H1): *Intangible assets have a positive and significant impact on the performance of the world's major technological companies.*

H1a: *IA has a positive and significant impact on the performance of the world's major technological companies.*

H1b: *GW has a positive and significant impact on the performance of the world's major technological companies.*

H1c: *LP has a positive and significant impact on the performance of the world's major technological companies.*

H1d: *BTRAD has a positive and significant impact on the performance of the world's major technological companies.*

Hypothesis 2 (H2): *Human capital contributes positively to the performance of the world's major technological companies.*

H2a: *BDSIZE contributes positively to the performance of the world's major technological companies.*

H2b: *BDAC contributes positively to the performance of the world's major technological companies.*

H2c: *EMP contributes positively to the performance of the world's major technological companies.*

Hypothesis 3 (H3): *The disaggregation of intangibles has a positive impact on the performance of the world's major technological companies.*

Hypothesis 4 (H4)*: SRD and ADV contribute positive and significantly to the performance of the world's major technological companies.*

Hypothesis 5 (H5)*: The distribution of the intellectual capital drivers of the North-American region is different from the distribution of the intellectual capital drivers of the remaining regions.*

5 Results and Discussion

5.1 Descriptive measures

The sample concerns 25 technological companies for a four-year period analysis. Thus, 100 observations were expected, although only 97 were effectively verified, due to the absence of annual reports for three companies in determined years. Of the world's 25 biggest technological companies, 14 are North American (56%), 3 are European (12%) and 8 are Asian (32%). The descriptive measures are evidenced in the following table.

Table 2 - Descriptive measures.

Variable typology	Variable	N	Minimum	Maximum	Mean	Standard Deviation
Dependent	TUR	97	8.975	12.362	10.56664	0.86967
	ROA	97	-0.135	0.286	0.10335	0.06891
Independent	IA	97	0.000	9.477	7.32373	1.71198
	GW	97	2.950	11.122	8.52672	1.74523
	LP	77	-0.105	9.295	5.61703	1.99847
	BTRAD	53	-1.833	9.000	4.86553	2.18713
	SRD	97	3.440	10.027	8.22385	1.20751
	ADV	86	2.079	9.319	6.18890	1.89157
	BDSIZE	97	5	15	10.08	2.221
	BDAC	92	9.307	18.198	14.78826	1.95616
	EMP	96	7333	830174	128011.09	145404.944
Control	SIZE	97	9.262	13.393	11.08657	0.84408
	LEV	97	0.064	1.134	0.46271	0.20608

It is possible to verify that, when measuring the companies' performance through turnover, each company registered a mean of 10.57$ with 0.87$ of standard deviation. Using return on assets as the measure of performance, one can conclude that each company had a return on its investments of, in mean, 10.34% with a standard deviation of 6.89%.

Regarding the independent variables, the proxies of human capital reveal a BDAC of, in mean, 14.79$ (standard deviation = 1.96$) with the board size being constituted by, in mean, 10 people (standard deviation = 2) and firms having a mean of

128,011 employees (standard deviation = 145,405 people). Of the remaining intangibles, GW is the one with the higher mean of 8.53$ (standard deviation = 1.75$) followed by SRD with a mean of 8.22$ (standard deviation = 1.21$). The variables with lower means are BTRAD and LP, with means of 4.87$ (standard deviation = 2.19$) and 5.62$ (standard deviation = 2$), respectively.

5.2 Correlations

The bivariate correlation analysis was conducted through the Pearson correlation coefficients, which demonstrate the existence of correlations between the intangibles under analysis and the selected measures of performance. The matrix for models 1, 2 and 3 are presented in Table 3, Table 4 and Table 5, respectively.

As can be observed in Table 3 relatively to the intangibles disclosed in companies' financial position, IA and LP are positive and significantly associated with TUR ($r = 0.226$; $p = 0.026$ and $r = 0.409$; $p < 0.001$, respectively). Contrarily, all of the intangible assets are negatively correlated with ROA, i.e. IA ($r = -0.296$; $p = 0.003$), GW ($r = -0.338$; $p = 0.001$), LP ($r = -0.294$; $p = 0.009$), BTRAD ($r = -0.357$; $p = 0.009$).

Table 4 introduces the human capital proxies and translates the significant and positive relation between BDSIZE ($r = 0.171$; $p = 0.094$), BDAC ($r = 0.246$; $p = 0.018$) and EMP ($r = 0.437$; $p < 0.001$) and performance, measured through TUR, although reflecting a negative relation with ROA, i.e. BDAC ($r = -0.224$; $p = 0.032$). Interestingly, EMP shows a significantly negative correlation with BDAC ($r = -0.194$; $p = 0.066$), which suggests that the companies with more employees, offer their board of directors a lower annual compensation.

Table 5 shows that SRD and ADV are significant and positively correlated with TUR ($r = 0.562$; $p < 0.001$ and $r = 0.521$; $p < 0.001$, respectively), although having a negative relation with ROA, i.e. SRD ($r = -0.476$; $p < 0.001$). Corroborating the studies conducted by Sridhar *et al.* (2014) and Mizik and Jacobson (2003), a positive relationship was found between SRD and ADV ($r = 0.447$; $p < 0.001$). SRD and ADV have a positive and strong correlation with the companies' size ($r = 0.703$; $p < 0.001$ and $r = 0.557$; $p < 0.001$, respectively), suggesting that larger companies expend more in R&D and advertising. BDAC is, likewise, positively correlated with the size of the firm ($r = 0.394$; $p < 0.001$), indicating that larger companies offer a higher annual compensation to their directors. Moreover and as expected, the size of the firm is positively related to turnover ($r = 0.850$; $p < 0.001$), reflecting the scale effects.

Table 3 – Pearson correlation coefficients (Model 1).

VAR.	TUR	ROA	IA	GW	LP	BTRAD	SIZE	LEV
TUR	1							
ROA	-0.248* 0.014	1						
IA	0.226* 0.026	-0.296** 0.003	1					
GW	0.092 0.371	-0.338** 0.001	0.526** 0.000	1				
LP	0.409** 0.000	-0.294** 0.009	0.713** 0.000	0.433** 0.000	1			
BTRAD	0.122 0.385	-0.357** 0.009	0.701** 0.000	0.611** 0.000	0.607** 0.000	1		
SIZE	0.850** 0.000	-0.280** 0.006	0.531** 0.000	0.329** 0.001	0.710** 0.000	0.442** 0.001	1	
LEV	0.290** 0.004	-0.456** 0.000	-0.192*** 0.060	0.186*** 0.069	-0.094 0.416	-0.038 0.788	0.152 0.137	1

Notes: *p < 0.05; **p < 0.01; ***p < 0.1.

Table 4 – Pearson correlation coefficients (Model 2).

VAR.	TUR	ROA	IA	GW	LP	BTRAD	BDSIZE	BDAC	EMP	SIZE	LEV
TUR	1										
ROA	-0.248* 0.014	1									
IA	0.226* 0.026	-0.296** 0.003	1								
GW	0.092 0.371	-0.338** 0.001	0.526** 0.000	1							
LP	0.409** 0.000	-0.294** 0.009	0.713** 0.000	0.433** 0.000	1						
BTRAD	0.122 0.385	-0.357** 0.009	0.701** 0.000	0.611** 0.000	0.607** 0.000	1					
BDSIZE	0.171*** 0.094	-0.142 0.166	0.041 0.690	0.387** 0.000	0.008 0.946	0.102 0.467	1				
BDAC	0.246* 0.018	-0.224* 0.032	0.467** 0.000	0.364** 0.000	0.486** 0.000	0.613** 0.000	0.088 0.405	1			
EMP	0.437** 0.000	-0.081 0.434	-0.189*** 0.065	-0.193*** 0.060	-0.166 0.152	-0.344* 0.012	0.128 0.214	-0.194*** 0.066	1		
SIZE	0.850** 0.000	-0.280** 0.006	0.531** 0.000	0.329** 0.001	0.710** 0.000	0.442** 0.001	0.142 0.165	0.394** 0.000	0.123 0.231	1	
LEV	0.290** 0.004	-0.456** 0.000	-0.192*** 0.060	0.186*** 0.069	-0.094 0.416	-0.038 0.788	0.274** 0.007	0.035 0.744	0.262** 0.010	0.152 0.137	1

Notes: *p < 0.05; **p < 0.01; ***p < 0.1.

Table 5 – Pearson correlation coefficients (Model 3).

VAR.	TUR	ROA	GW	LP	SRD	ADV	BDSIZE	BDAC	EMP	SIZE	LEV
TUR	1										
ROA	-0.248* 0.014	1									
GW	0.092 0.371	-0.338** 0.001	1								
LP	0.409** 0.000	-0.294** 0.009	0.433** 0.000	1							
SRD	0.562** 0.000	-0.476** 0.000	0.513** 0.000	0.641** 0.000	1						
ADV	0.521** 0.000	-0.114 0.295	0.224* 0.038	0.489** 0.000	0.447** 0.000	1					
BDSIZE	0.171*** 0.094	-0.142 0.166	0.387** 0.000	0.008 0.946	0.096 0.350	-0.134 0.219	1				
BDAC	0.246* 0.018	-0.224* 0.032	0.364** 0.000	0.486** 0.000	0.541** 0.000	0.416** 0.000	0.088 0.405	1			
EMP	0.437** 0.000	-0.081 0.434	-0.193*** 0.060	-0.166 0.152	-0.131 0.204	0.182*** 0.096	0.128 0.214	-0.194*** 0.066	1		
SIZE	0.850** 0.000	-0.280** 0.006	0.329** 0.001	0.710** 0.000	0.703** 0.000	0.557** 0.000	0.142 0.165	0.394** 0.000	0.123 0.231	1	
LEV	0.290** 0.004	-0.456** 0.000	0.186*** 0.069	-0.094 0.416	0.108 0.292	0.035 0.751	0.274** 0.007	0.035 0.744	0.262** 0.010	0.152 0.137	1

Notes: *p < 0.05; **p < 0.01; ***p < 0.1.

5.3 Multiple Linear Regression Models

Multiple linear regression models were realized in order to determine which intangibles have a higher impact on the performance of the world's biggest technological companies.

As explained by Laureano (2011), each coefficient β indicates the variation in the outcome variable (in this case, the variation on performance) caused by the unitary variation of the predictor variable, maintaining the remaining variables constant. The adjusted coefficient of determination (adjusted R^2) is used in order to assess the explanatory capacity of the model and can be interpreted as the proportion of the dependent variable's total variance that can be explained by the model. This indicator is widely used since it reflects the explanatory capacity of the model without being influenced by the number of variables in the equation. F-test concludes on the global significance of the model and allows for the verification of whether any of the independent variables contributes to explain the total variation of the dependent variable relatively to its mean.

5.3.1 Explanatory factors of performance for each model

In this section, the effect of the explanatory variables on performance will be assessed for the three models in question. Using the method Stepwise, two tables per model are obtained: one containing the statistically significant variables that better contribute to explain the model, and one with the excluded variables. Model 1, which demonstrates the effect of intangibles disclosed in companies' financial position was validated for TUR (adjusted $R^2 = 77.0\%$; $F = 51.139$; $p < 0.001$) and ROA (adjusted $R^2 = 64.1\%$; $F = 41.243$; $p < 0.001$). Model 2, aiming to verify the impact of the human capital proxies, was validated for TUR (adjusted $R^2 = 83.4\%$; $F = 52.600$; $p = < 0.001$) and ROA (adjusted $R^2 = 65.0\%$; $F = 39.011$; $p < 0.001$). Model 3, representing the disaggregated effects of intangibles, was also validated for TUR (adjusted $R^2 = 90.7\%$; $F = 91.049$; $p < 0.001$) and ROA (adjusted $R^2 = 53.2\%$; $F = 38.016$; $p < 0.001$).

The effect of the independent variables on performance is represented from Table 6 to Table 17. Although not being presented in the following tables, the time effects were contemplated in the models and did not display statistical significance.

Table 6 - The effect of the significant explanatory variables on TUR, in Model 1.

Variable typology	Explanatory variable	Unstandardized coefficient (β)	Standardized coefficient (β)	t	Sig.
(Constant)		0.952		1.075	0.289
Independent	GW	-0.160	-0.359	-4.692	0.000***
Control	LEV	1.055	0.276	3.800	0.000***
	SIZE	0.954	0.849	10.998	0.000***
R^2		78.5%	**TUR mean**		10.52672
Adjusted R^2		77.0%	**F**		51.139
Standard error of the estimate		0.400278	**Sig.**		< 0.001

Notes: *p<0.1; **p<0.05; ***p<0.01.

Table 7 - The effect of the excluded variables on TUR, in Model 1.

Variable typology	Explanatory variable	Standardized coefficient (β)	t	Sig.
Independent	IA	-0.181	-1.475	0.148
	LP	-0.217	-1.863	0.070
	BTRAD	-0.027	-0.282	0.780

The results obtained in the first model allow concluding that, of the independent explanatory variables that are statistically significant, GW has the biggest weight in explaining the companies' performance, presenting a negative relation with TUR (standardized $\beta = -0.359$; $p < 0.001$), causing the rejection of H1b. The remaining variables representing intangible assets, namely IA (standardized $\beta = -0.181$; $p = 0.148$), LP (standardized $\beta = -0.217$; $p = 0.070$) and BTRAD (standardized $\beta = -0.027$; $p = 0.780$) are not statistically significant to explain the model, which leads to the rejection of H1a, H1c and H1d, culminating in the rejection of hypothesis 1.

As expected considering the literature review, the control variables LEV (standardized $\beta = 0.276$; $p < 0.001$) and SIZE (standardized $\beta = 0.849$; $p < 0.001$) are positive and statistically significant in the prediction of TUR.

Regarding the quality of the model evaluated by its explanatory capacity, the results of adjusted R^2 evidence that Model 1 explains in 77% the variance of performance measured through turnover.

Table 8 - The effect of the significant explanatory variables on ROA, in Model 1.

Variable typology	Explanatory variable	Unstandardized coefficient (β)	Standardized coefficient (β)	t	Sig.
(Constant)		0.351		11.474	
Independent	IA	-0.022	-0.571	-6.306	0.000***
Control	LEV	-0.233	-0.682	-7.525	0.000***
R^2		65.7%	**ROA mean**		0.09361
Adjusted R^2		64.1%	**F**		41.243
Standard error of the estimate		0.044501	**Sig.**		< 0.001

Notes: *p<0.1; **p<0.05; ***p<0.01.

Table 9 - The effect of the excluded variables on ROA, in Model 1.

Variable typology	Explanatory variable	Standardized coefficient (β)	t	Sig.
Independent	GW	0.117	0.959	0.343
	LP	0.022	0.159	0.875
	BTRAD	-0.100	-0.818	0.418
Control	SIZE	-0.132	-1.112	0.273

Approximately 64% of the variance of ROA is explained by this model. The performance measured by ROA is negative and significantly explained by IA (standardized $\beta = -0.571$; $p < 0.001$), which means that the increase of intangible assets decrease the value of return on assets. This causes the rejection of H1a. The remaining intangibles disclosed in financial position are not statistically significant in this model (rejection of H1b, H1c and H1d), which, combined with the negative effect of IA, leads to the rejection of hypothesis 1 for this measure of performance.

Table 10 - The effect of the significant explanatory variables on TUR, in Model 2.

Variable typology	Explanatory variable	Unstandardized coefficient (β)	Standardized coefficient (β)	t	Sig.
(Constant)		-0.185		-0.212	0.833
Independent	IA	-0.098	-0.238	-2.584	0.014**
	EMP	$1.702E^{-6}$	0.368	5.246	0.000***
Control	LEV	0.645	0.169	2.430	0.020**
	SIZE	0.984	0.881	10.196	0.000***

R^2	85.0%	**TUR mean**	10.44914
Adjusted R^2	83.4%	**F**	52.600
Standard error of the estimate	0.331283	**Sig.**	< 0.001

Notes: *p<0.1; **p<0.05; ***p<0.01.

Table 11 - The effect of the excluded variables on TUR, in Model 2.

Variable typology	Explanatory variable	Standardized coefficient (β)	t	Sig.
Independent	GW	-0.068	-0.641	0.525
	LP	-0.154	-1.385	0.175
	BTRAD	0.034	0.374	0.711
	BDSIZE	0.055	0.808	0.425
	BDAC	-0.039	-0.461	0.647

Model 2 explains 83.4% of the performance's variance measured through TUR. This model is negative and significantly influenced by IA (standardized β = -0.238; p = 0.014), with absence of significance of the remaining intangible assets, causing the rejection of hypothesis 1. The positive and significant impact of EMP on TUR (standardized β = 0.368; p < 0.001) reflects the contribution of human capital to performance, thus, H2c cannot be rejected. Nevertheless, since BDSIZE (standardized β = 0.055; p = 0.425) and BDAC (standardized β = -0.039; p = 0.647) are not statistically significant in explaining Model 2, hypothesis 2 is rejected for these variables (rejection of H2a and H2b).

Similarly to the effect presented in Model 1, control variables LEV (standardized β = 0.169; p = 0.020) and SIZE (standardized β = 0.881; p < 0.001) are positive and statistically significant in the prediction of TUR.

Table 12 - The effect of the significant explanatory variables on ROA, in Model 2.

Variable typology	Explanatory variable	Unstandardized coefficient (β)	Standardized coefficient (β)	t	Sig.
(Constant)		0.360		11.252	
Independent	IA	-0.023	-0.593	-6.304	0.000***
Control	LEV	-0.241	-0.682	-7.246	0.000***
R^2		66.7%	**ROA mean**		0.09410
Adjusted R^2		65.0%	**F**		39.011
Standard error of the estimate		0.044649	**Sig.**		< 0.001

Notes: *p<0.1; **p<0.05; ***p<0.01.

Table 13 - The effect of the excluded variables on ROA, in Model 2.

Variable typology	Explanatory variable	Standardized coefficient (β)	t	Sig.
Independent	GW	0.128	1.020	0.314
	LP	0.066	0.461	0.648
	BTRAD	-0.105	-0.823	0.416
	BDSIZE	0.074	0.765	0.449
	BDAC	-0.066	-0.588	0.560
	EMP	-0.006	-0.063	0.950
Control	SIZE	-0.112	-0.905	0.371

Model 2 is able to explain 65% of ROA's variance. Similarly to the results of Model 1, the performance of the companies measured by ROA is negative and significantly influenced by IA (standardized $\beta = -0.593$; $p < 0.001$), which is the only variable representing intangible assets that influences the model, having a negative contribution to it, culminating in the rejection of hypothesis 1. Since none of the human capital proxies were found to be significant in predicting ROA, hypothesis 2 is rejected for this measure of performance.

Table 14 - The effect of the significant explanatory variables on TUR, in Model 3.

Variable typology	Variable	Unstandardized coefficient (β)	Standardized coefficient (β)	t	Sig.
(Constant)		0.382		0.591	0.557
Independent	GW	-0.104	-0.246	-4.462	0.000***
	LP	-0.146	-0.333	-4.853	0.001***
	SRD	0.218	0.341	5.330	0.005***
	ADV	0.050	0.114	2.236	0.029**
	BDSIZE	0.058	0.172	3.334	0.001***
	EMP	$1.447E^{-6}$	0.287	6.085	0.000***
Control	SIZE	0.817	0.745	9.969	0.000***

R^2	91.7%	**TUR mean**	10.40845
Adjusted R^2	90.7%	**F**	91.049
Standard error of the estimate	0.250066	**Sig.**	< 0.001

Notes: *p<0.1; **p<0.05; ***p<0.01.

Table 15 - The effect of the excluded variables on TUR, in Model 3.

Variable typology	Explanatory variable	Standardized coefficient (β)	t	Sig.
Independent	BDAC	-0.052	-1.052	0.297
Control	LEV	0.057	1.337	0.186

The independent variables of this model have an explanatory capacity of 90.7% of the variance of TUR. Results show GW has a significant and negative impact on explaining this indicator (standardized β = -0.246; p < 0.001) and LP also reflects significant and negative results (standardized β = -0.333; p = 0.001), causing the rejection of H1b and H1c.

SRD and ADV present a positive and significant impact on TUR (standardized β = 0.341, p = 0.005; standardized β = 0.114, p = 0.029, respectively), with SRD being the independent variable that contributes the most to explain performance. Thus, H4 cannot be rejected.

When assessing the disaggregated effects of intangibles, the human capital proxies utilized in this study were found to be positive and significantly explainable of performance in the case of BDSIZE (standardized β = 0.172; p = 0.001) and EMP (standardized β = 0.287; p < 0.001), not rejecting H2a and H2c. Contrarily, BDAC was

found not to be statistically significant in the prediction of TUR (standardized β = -0.052; p = 0.297) causing the rejection of hypothesis 2 for this variable (rejection of H2b). Since the intangible assets show a negative impact on TUR and human capital proxies present mixed effects, no conclusions can be taken regarding H3, which cannot be validated.

Although SIZE is positive and significantly associated with TUR (standardized β = 0.745; p < 0.001), contrarily to the observations on models 1 and 2, LEV was excluded from the significant variables (standardized β = 0.057; p = 0.186).

Table 16 - The effect of the significant explanatory variables on ROA, in Model 3.

Variable typology	Explanatory variable	Unstandardized coefficient (β)	Standardized coefficient (β)	t	Sig.
(Constant)		0.385		10.869	
Independent	SRD	-0.027	-0.533	-6.232	0.000***
Control	LEV	-0.139	-0.448	-5.241	0.000***

R^2	54.7%	**ROA mean**	0.10795
Adjusted R^2	53.2%	**F**	38.016
Standard error of the estimate	0.044561	**Sig.**	< 0.001

Notes: *p<0.1; **p<0.05; ***p<0.01.

Table 17 - The effect of the excluded variables on ROA, in Model 3.

Variable typology	Explanatory variable	Standardized coefficient (β)	t	Sig.
Independent	GW	-0.573	1.020	0.569
	LP	-1.752	0.461	0.085
	ADV	0.859	-0.823	0.109
	BDSIZE	0.350	0.765	0.728
	BDAC	0.574	-0.588	0.568
	EMP	-0.195	-0.063	0.846
Control	SIZE	-0.123	-1.048	0.299

Model 3 explains in, approximately, 53% the variance of ROA, with SRD being the most significant variable in the model. Contrarily to its effect on TUR, SRD is negative and statistically significant in the prediction of ROA (standardized β = -0.533; p < 0.001) and ADV is not statistically significant (standardized β =0.859; p = 0.109),

leading to the rejection of H4. The absence of significance of the remaining intangibles in the model results in the rejection of hypotheses 1, 2 and 3 regarding this measure of performance.

5.3.2 Global analysis and discussion of results

Table 18 synthetizes the impact of the independent and control variables on the two measures of performance in the different models.

Table 18 – Synthesis of the independent variables that explain performance.

Independent variables	Performance measures					
	TUR			ROA		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
IA	n.s.	−	/	−	−	/
GW	−	n.s.	−	n.s.	n.s.	n.s.
LP	n.s.	n.s.	−	n.s.	n.s.	n.s.
BTRAD	n.s.	n.s.	/	n.s.	n.s.	/
SRD	/	/	+	/	/	−
ADV	/	/	+	/	/	n.s.
BDSIZE	/	n.s.	+	/	n.s.	n.s.
BDAC	/	n.s.	n.s.	/	n.s.	n.s.
EMP	/	+	+	/	n.s.	n.s.
LEV	+	+	n.s.	−	−	−
SIZE	+	+	+	n.s.	n.s.	n.s.

n.s.: The variable is not statistically significant in the model;
+: There is a positive and statistically significant impact of this variable to the model;
−: There is a negative and statistically significant impact of this variable to the model;
/: Variable not included in the model.

The first objective of this study was to investigate the effect that the intangible assets disclosed in companies' financial position have on performance. In regards, Model 1 revealed a negative and statistically significant impact of GW (β = -0.359; t = -4.692; $p < 0.001$) on TUR, which was the only intangible asset statistically significant in the prediction of performance, rejecting H1b. Model 2, which incorporated the human capital proxies, showed a negative and statistically significant impact of the aggregated measure of intangible assets (IA) in the model (β = -0.238; t = -2.584; p = 0.014),

leading to the rejection of H1a, with none of the remaining intangible assets being significant to the equation. Only EMP revealed a positive relation with TUR ($\beta = 0.368$; $t = 5.246$; $p < 0.001$). Lastly, Model 3, which represented the disaggregation of intangibles, found that GW and LP (the only intangible assets in the model) have a negative and significant contribution to TUR ($\beta = -0.246$; $t = -4.462$; $p < 0.001$ and $\beta = -0.333$; $t = -4.853$; $p = 0.001$, respectively), resulting in the rejection of H1b and H1c. Ultimately, hypothesis 1 is rejected for turnover in each model.

According to international accounting norms, internally generated goodwill is an aggregated amount of all the intangibles that cannot be identified nor separately measured in order to be recognized in the financial statements. Its negative contribution to performance (models 1 and 3) is congruent with the findings of Heiens *et al.* (2007), who argue that the more goodwill firms accumulate, the worst impact it has on future performance. The authors defend that it may be due to the assets not translating the economic benefits the firms were expecting.

The negative or null impact of intangible assets on performance is not the most accepted premise in the literature. In fact, these results directly contradict the ones obtained by Lopes and Martins (2015) who found a positive influence of intangible assets capitalized in the statement of financial position and the turnover of the Iberian Stock Exchange Market companies. Furthermore, these results are not consistent with the commonly positive effect of intangibles on performance, in particular on turnover (Lopes *et al.,* 2016; Lopes and Ferraz, 2016; Shakina and Molodchik, 2014; Tudor *et al.*, 2014; Tanfous, 2013; Omil *et al.*, 2011; Heiens *et al.*, 2007), although corroborating the findings of Pucci *et al.* (2015) who found no positive impact of IC measured by intangible assets on turnover. The negative effect of IA in Model 2 opposes to the observations of Tanfous (2013) and Lopes and Ferraz (2016), who argue that the aggregated measures of intangibles contribute to a better financial performance.

Regarding the indicator ROA, none of the intangible assets are statistically significant to explain performance, with the exception of the accumulated value of IA that is disclosed in companies' financial position, for which a negative and statistically significant impact on performance was found in models 1 and 2 ($\beta = -0.571$; $t = -6.306$; $p < 0.001$ and $\beta = -0.593$; $t = -6.304$; $p < 0.001$, respectively), causing the rejection of H1 for ROA. These results contradict the ones achieved by Nadeem *et al.* (2016), Pucci *et al.* (2015), Tudor *et al.* (2014) and Pal and Soriya (2012), who defend the positive association between intangible assets and ROA. In spite of that fact, the evidence

supports the studies conducted by Lopes *et al.* (2016), Lopes and Ferraz (2016) and Bubic and Susaz (2015) who found no significant influence of intangible assets on ROA.

The rejection of hypothesis 1 for these measures of performance, particularly turnover, does not allow for the validation of the assumption of IAS 38 that intangible assets are associated with future economic benefits that flow to the entity.

Regarding the human capital proxies, EMP has a positive impact on TUR ($\beta = 0.368$; $t = 5.246$; $p < 0.001$ in Model 2 and $\beta = 0.287$; $t = 6.085$; $p < 0.001$ in Model 3), confirming that companies with higher intensity of labor achieve better results (Shakina and Molodchik, 2014), not rejecting H2c.

Although BDSIZE is not significant to measure TUR in Model 2, when combined with the variables on Model 3, a positive and significant impact was determined on TUR ($\beta = 0.172$; $t = 3.334$; $p = 0.001$), not rejecting H2a. This positive effect on TUR is similar to results found on previous papers (Lopes and Ferraz, 2016; Lopes *et al.*, 2016) and indicates that large boards of directors are more likely to enhance corporate performance measured through TUR. Nonetheless, no conclusions can be taken regarding its contribution to ROA, thus failing to corroborate or refute the findings of Sheikh *et al.* (2013), Nath *et al.* (2015) and Mashayekhi and Bazaz (2008) regarding the association between these two variables.

This research introduces the original variable BDAC as a proxy to human capital which intends to represent the expenses incurred with the members of the board, expecting to quantify the value attributed to the knowledge of a firm's directors. Nonetheless, BDAC was not statistically significant in the prediction of the main dependent variable TUR (rejection of H2b) although being positively correlated with it ($r = 0.246$; $p = 0.018$). BDAC fails to represent the importance of board of directors' knowledge and skills to financial performance. Nonetheless, the positive and significant results regarding BDSIZE corroborate the assumption that an effective board composition is valuable for enhancing firm performance.

None of the human capital proxies utilized in this study had a significant impact in the prediction of ROA. Hence, H2 could not be validated for this measure of performance.

SRD and ADV were introduced to Model 3 in order to capture additional IC. In this scope, hypothesis 4 is rejected for ROA, since SRD presented a negative impact on this variable (β = -0.533; t = -6.232; p < 0.001) and ADV was not statistically significant in the model. Contrarily to expected, these results are not compatible with the ones obtained by Li and Wang (2014) and Chen *et al.* (2005), who found a positive and strong impact of R&D expenses on return on assets, although being consistent with the study of Guo *et al.* (2012), which revealed a decrease of performance in terms of ROA caused by R&D expenses. The impact of ADV does not correspond to the one assessed by Acar and Temiz (2017), who strongly defend the positive contribution of advertising to return on assets. Nonetheless, the effects of these variables were found to be positive and significant in the prediction of TUR (β = 0.341; t = 5.330; p = 0.005 for SRD and β = 0.114; t = 2.236; p = 0.029 for ADV), not rejecting hypothesis 4 for this variable.

In fact, SRD is the most significant variable to explain TUR. This positive effect reinforces the importance of R&D to performance, being particularly relevant in the technological sector. R&D reflects the innovative activities of the company, which rely on its technology capabilities and are essential to succeed in the technological market. The role of innovation represented by R&D expenses is highly accepted in the literature, with authors defending its positive effect on present and future performance (Ruiqi *et al.*, 2017; Lome *et al.*, 2016; Li and Wang, 2014; Guo *et al*., 2012; Omil *et al.*, 2011; Chen *et al.*, 2005) and their contribution to firm value and value creation (Shakina and Molodchik, 2014; Sridhar *et al.*, 2014; Tanfous, 2013; Gleason and Klock, 2006).

Corroborating the studies conducted by Sridhar *et al.* (2014) and Mizik and Jacobson (2003), a positive relationship was found between SRD and ADV (r = 0.447; p < 0.001). This correlation enhances the relevance of ADV being aligned with SRD in order to magnify the effect of R&D in the creation of competitive advantage for the firm. As verified, ADV contributes significantly to the increase of turnover, which some authors justify by stressing the powerful effect it has on guaranteeing the firms' reputation of well-known and major brands − which is the case in this study − enhancing sales and profits and causing a long-term effect on firm value (Tanfous, 2013; Hanssens and Joshi, 2010).

Table 5 also shows SRD and ADV have a positive and strong correlation with the companies' size (r = 0.703; p < 0.001 and r = 0.557; p < 0.001, respectively), suggesting that larger companies tend to expend more in R&D and advertising.

Hypothesis 3 could not be validated due to the mixed results on Model 3. The model presents the higher explanatory capacity of the three models for turnover (adjusted $R^2 = 90.7\%$) − which is consistent with the observations of Chen *et al.* (2005), who experienced an increase in the explanatory capacity of their model when including R&D and advertising expenses. In spite of the great explanatory capacity, all the independent variables in the model are statistically significant with the exception of BDAC ($\beta = -0.052$; $t = -1.052$; $p = 0.297$) and control variable LEV ($\beta = 0.057$; $t = 1.337$; $p = 0.186$).

Furthermore, while the remaining variables present positive effects on TUR, intangible assets GW and LP are negatively associated with this indicator ($\beta = -0.246$; $t = -4.462$; $p < 0.000$ and $\beta = -0.333$; $t = -4.853$; $p = 0.001$, respectively), which does not allow for the validation of whether the disaggregation of intangibles has a positive impact on performance. Nonetheless, in comparison to the results of Model 2 for turnover, an isolated effect can be noticed regarding GW and LP. These variables were not statistically significant in Model 2, whereas the total amount of the intangibles disclosed in financial position (IA) was ($\beta = -0.238$; $t = -2.584$; $p = 0.014$). Yet, when IA was excluded from the model, these disaggregated measures of intangible assets were found to be significant in the prediction of turnover.

The same conclusion can be taken regarding the human capital proxies. While Model 2 only indicated significance of the variable EMP, Model 3 shows that, when associated with disaggregated intangibles and SRD and ADV, BDSIZE becomes positive and statistically significant in the prediction of TUR ($\beta = 0.172$; $t = 3.334$; $p = 0.001$), reflecting synergetic effects between the variables. This suggests that when the different components of IC are managed together, their synergetic effects increase the performance and profitability of business (Lopes and Ferraz, 2016).

These mixed effects do not allow the validation of H3 in order to refute or corroborate the studies conducted by Tanfous (2013) and Lopes and Ferraz (2016).

As expected, the variable SIZE contributes positive and significantly to the prediction of TUR in every model regressed ($\beta = 0.849$; $t = 10.998$; $p < 0.001$ in Model 1; $\beta = 0.881$; $t = 10.196$; $p < 0.001$ in Model 2 and $\beta = 0.745$; $t = 9.969$; $p < 0.001$ in Model 3). These results corroborate the literature by proving that companies with a higher level of assets tend to generate a higher level of turnover, revealing scale effects

(Lopes *et al.*, 2016; Lopes and Martins, 2015; Shakina and Molodchik, 2014; Tudor *et al.*, 2014).

LEV has a positive effect on TUR in models 1 and 2 ($\beta = 0.276$; $t = 3.800$; $p < 0.001$ and $\beta = 0.169$; $t = 2.430$; $p = 0.020$, respectively), suggesting that when the companies use debt to finance their assets, its impact on turnover is higher. The impact on ROA is exactly the contrary, as LEV showed a negative influence on this measure of performance in every model tested ($\beta = -0.682$; $t = -7.525$; $p < 0.001$ in Model 1, $\beta = -0.682$; $t = -7.246$; $p < 0.001$ in Model 2 and $\beta = -0.448$; $t = -5.241$; $p < 0.001$ in Model 3). SIZE was not found to have a significant effect on the estimation of ROA.

5.3.3 Reliability of the models

The reliability of the three models was assessed through statistical inference. Primarily, it is important to verify the normal distribution of the sample and residuals. According to the Central Limit Theorem, as the sample size gets larger, its means tend to a normal distribution. This is especially true in samples whose size is bigger than 30. Considering that the sample in this study consists of 97 observations, it is assumed that it has a normal distribution. Nevertheless, this assumption was verified in each model's histogram and normal P-P plot of regression standardized residual. Regarding the independence of residuals, the Durbin-Watson test was executed, estimating values approximated to 2, proving there is no autocorrelation between the errors. The homoscedasticity of the residuals was assumed due to the fact that they present a normal distribution and the mean of the residuals is zero. From each model's scatterplot is possible to undertake that the residuals' variance is homogeneous. The assumption of the linear relation between the dependent and independent variables on β coefficients was also assessed for the models through the random distribution of the residuals.

Furthermore, the models presented absence of multicollinearity, with Variance Inflation Factor (VIF) assuming values significantly inferior to 10 and tolerance inferior to 1 for each independent variable. This allows concluding that the explanatory variables are not correlated.

5.4 Distribution of the intellectual capital drivers depending on the region

In order to complement the statistical analysis, t-test for equality of means was performed for the different regions. The sample of 25 technological companies consists of 14 companies from North-America (56%), 3 from Europe (12%) and 8 from Asia (32%), which were aggregated into two groups: North-American companies (56%) and non-North-American companies (44%).

Table 19 presents the Levene's test for equality of variances (F) and t-test for equality of means (t).

Table 19 - T-test to compare the equality of means between the variables of North-American companies and the variables from the remaining regions.

Variable	Equality of variances (F)	Sig.	Equality of means (t)	df	Sig.	Hypothesis	Hypothesis test (H_0)
TUR	0.060	0.807	3.746	95	0.000**		Rejected
ROA	8.127	0.005	-1.546	95	0.125		Not rejected
IA	3.507	0.064	2.516	95	0.014*		Rejected
GW	34.691	0.000	7.766	95	0.000**		Rejected
LP	2.631	0.109	2.715	75	0.008**		Rejected
BTRAD	9.039	0.004	1.449	51	0.153		Not rejected
BDSIZE	0.790	0.376	5.825	95	0.000**	H5	Rejected
BDAC	57.543	0.000	0.754	90	0.453		Not rejected
EMP	1.660	0.201	-0.056	94	0.955		Not rejected
SRD	3.576	0.062	4.922	95	0.000**		Rejected
ADV	1.141	0.289	0.640	84	0.524		Not rejected
SIZE	0.040	0.841	4.239	95	0.000**		Rejected
LEV	7.173	0.009	2.441	95	0.016*		Rejected

Notes: *p < 0.05; **p < 0.01; ***p < 0.1.

Independent samples t-test compares the means of two independent samples in order to determine whether the population means are significantly different. The null hypothesis of H5 assumes that the mean distribution of the intellectual capital drivers of the North-American region is equal to the mean distribution of the intellectual capital drivers of the remaining regions. Observing Table 19, there is statistical evidence to reject H_0 for the variables TUR, IA, GW, LP, BDSIZE, SRD and control variables SIZE and LEV, proving these variables present different distributions depending on the

region. In fact, these variables display significantly higher means when considering the North-American region, as can be assessed in Table 20.

Table 20 – Comparison of the means between the variables of North-American companies and the variables of the remaining regions.

Variable	North-America	Mean	Std. Deviation
TUR	Yes	10.83784	0.761900
	No	10.21150	0.882317
ROA	Yes	0.09396	0.051335
	No	0.11564	0.085869
IA	Yes	7.69569	1.628825
	No	6.83664	1.714537
GW	Yes	9.47222	0.773362
	No	7.28857	1.890598
LP	Yes	6.20333	1.585115
	No	5.01529	2.211098
BTRAD	Yes	5.20100	1.619942
	No	4.31200	2.855534
BDSIZE	Yes	11.07	2.035
	No	8.79	1.747
BDAC	Yes	14.92655	0.937324
	No	14.61624	2.748181
EMP	Yes	127287.47	118331.135
	No	128981.80	176943.314
SRD	Yes	8.69707	0.748625
	No	7.60414	1.407871
ADV	Yes	6.30537	1.791403
	No	6.04176	2.025706
SIZE	Yes	11.37924	0.771479
	No	10.70331	0.786743
LEV	Yes	0.50624	0.241256
	No	0.40571	0.130042

From the variables that rejected the null hypothesis of H5, it is possible to observe that TUR has a higher mean in the North-American companies (mean = 10.84$) than in the European and Asian ones (mean = 10.21$). Furthermore, all the intangible assets disclosed in companies' financial position, with the exception of BTRAD, reflect

a higher mean for North-America in comparison with the non-American region. Of the human capital proxies, BDSIZE is the only whose distribution is different between regions, with North-American companies having, in mean, 11 directors on the boards and the remaining firms having, in mean, 9 people representing their board of directors. SRD also shows a higher mean in the case of North-American companies (mean = 8.70$) versus the remaining regions (mean = 7.60$), which can reflect a superior investment in research and development from U.S. companies.

6 Conclusion

The general purpose of this study was to identify the impact of intangibles on the performance of the main technological companies in the world, in order to conclude on the contribution of intellectual capital to performance. The specific objectives consisted of (i) investigating the effect of intangibles disclosed in companies' financial position on performance; (ii) examining the effects of disaggregation of intangibles on performance and (iii) evaluating on what extent the characteristics of the board of directors as a representation of human capital contribute to obtain future economic benefits. Furthermore, it was determined whether the distribution of the intellectual capital drivers does depend on the region.

Regarding the analysis of the descriptive measures, the companies that constitute the sample present a turnover with a mean of 10.57$ (standard deviation = 0.87$) and a return on assets of, in mean, 10.34% (standard deviation of 6.89%). The human capital proxies utilized in this study reveal that these companies have, in mean, 10 members on their board of directors, who have a mean annual compensation of 14.79$. The companies have a mean of 128,011 employees. The remaining intangibles present very different means, with GW and SRD presenting the higher values of 8.53$ (standard deviation = 1.75$) and 8.22$ (standard deviation = 1.21$), respectively. The variables with lower means are BTRAD and LP, with means of 4.87$ (standard deviation = 2.19$) and 5.62$ (standard deviation = 2$), respectively. Considering the control variables, it is possible to verify that these companies have a mean of total assets of 11.09$ (standard deviation = 0.84$) and leverage of 46.27% (standard deviation = 20.61%), which means that companies use, in mean, 46.27% of debt to finance their assets.

From the Pearson's correlation coefficients it was possible to conclude that the variable TUR is positive and significantly associated with the intangible assets IA and LP, as well as with all the human capital proxies, BDSIZE, BDAC and EMP. It presented the highest positive correlation with the intangible resources SRD and ADV and a strong positive correlation with the size and leverage of the companies. Contrarily, all the intangibles in this study present a negative correlation with ROA. This negative association is also verified in the relation between ROA and the control

variables, SIZE and LEV. The variable SIZE is positively correlated with all the independent variables, reflecting scale effects.

Multiple linear regression models were realized in order to determine which intangibles have a higher impact on the performance of the world's biggest technological companies. Turnover is used as the main indicator of performance, complemented with the variable ROA.

Model 1, which reflects the impact of the capitalized intangibles comprised in the companies' statement of financial position, showed a negative contribution of GW to TUR and of IA to ROA, with the remaining intangible assets not being significant to explain performance. The negative contribution of GW to performance is supported by Heiens *et al.* (2007) and may be due to the assets not translating the economic benefits the firms were expecting.

Model 2 includes characteristics of the boards of directors in order to conclude on the contribution of human capital to performance. EMP showed a positive impact on TUR, confirming the proposition of Shakina and Molodchik (2014), although no significant relation was found between the remaining human capital variables and performance in this model. The aggregated measure of intangible assets (IA) presented a negative impact on TUR and on ROA and no conclusion could be taken regarding the importance of these human capital variables on ROA.

Model 3 embodies intangible assets along with intangible resources (software and R&D expenses and advertising expenses) and human capital, aiming to identify the disaggregated effects of intangibles on performance. In this model, GW and LP presented a significant, although negative, impact on TUR, reflecting isolated effects that were not evidenced in Model 2, where the total amount of intangible assets explained turnover. Similarly, the human capital proxy BDSIZE becomes relevant to estimate TUR, suggesting that when considered alongside disaggregated measures of intangibility, the size of board of directors becomes important to enhance profitability. The original variable BDAC did not display significant results, suggesting it may not be the best proxy for human capital. Although this model's results do not allow the validation of hypothesis 3 regarding the disaggregated influence of intangibles, an isolated effect can be observed for some variables, exhibiting synergetic effects when considered together. Model 3 also includes the variables SRD and ADV, both contributing to financial performance measured through TUR, although SRD displays a negative impact on ROA and ADV is not relevant to measure return on assets.

ROA was found to be negatively correlated with every independent variable in this study. This evidence does not correspond to the ones obtained by Omil *et al.* (2011), who verified that high-profitable firms are strongly focused on managing their intangibles, which leads to a greater impact and increase on return on assets. In fact, for the estimation of this indicator of performance, intangibles appear to be irrelevant or negatively associated, which contradicts the positive impact found by Nadeem *et al.* (2016), Pucci *et al.* (2015), Tudor *et al.* (2014) and Pal and Soriya (2012), although supporting the conclusions of Lopes *et al.* (2016), Lopes and Ferraz (2016) and Bubic and Susaz (2015).

The negative or null effect of intangible assets obtained in the models, especially Model 1, does not reflect the expected results considering the literature (Lopes *et al.*, 2016; Lopes and Ferraz, 2016; Shakina and Molodchik, 2014; Tudor *et al.*, 2014; Tanfous, 2013; Omil *et al.*, 2011; Heiens *et al.*, 2007). Rejection of H1 culminates in the non-validation of the assumption of IAS 38 that intangible assets are associated with future economic benefits (IFRF, 2014), which would be supported if a positive and significant impact on these companies' performance indicators was verified – particularly on turnover. Hence, since there is no intangible asset disclosed on companies' financial position that contributes positively to turnover or ROA in this research, the assumption of IAS 38 cannot be confirmed for the technological sector represented by these companies.

In fact, the intangibles that were found to positively influence performance are not under the assumption of IAS 38 since they do not meet the capitalization criteria to be considered intangible assets. These are represented by the skills, knowledge, experience and talent of the human factor in the company, displaying the importance of human capital in this sector. Nevertheless, the intangibles that contribute the most to explain financial performance are the advertising and R&D expenses. In point of fact, the variable SRD is the most significant variable to explain turnover. Thus, as expected for a sector which is highly dependent on the innovative activities of the company, R&D represents a major contribution to the organization since it allows the company to create a competitive advantage that is expected to be translated into higher levels of performance. The vital contribution of R&D to financial performance and value creation

of technology-intensive companies is strongly accepted in the literature (Ruiqi *et al.*, 2017; Lome *et al.*, 2016; Li and Wang, 2014; Shakina and Molodchik, 2014; Sridhar *et al.*, 2014; Tanfous, 2013; Guo *et al*., 2012; Omil *et al.*, 2011; Gleason and Klock, 2006; Chen *et al.*, 2005), reflecting the importance of structural and innovation capital in this sector. Furthermore, results show that advertising expenses are greatly correlated with R&D expenses in this sample, which, aligned with its positive effect in the increase of turnover, corroborates the studies of Sridhar *et al.* (2014) and Mizik and Jacobson (2003) that reinforce the role of advertising in magnifying the effect of research and development activities in enhancing performance.

As expected, the size of the company contributes to turnover, corroborating the literature by proving that companies with a higher level of assets tend to generate a higher level of turnover, revealing scale effects (Lopes *et al.,* 2016; Lopes and Martins, 2015; Shakina and Molodchik, 2014; Tudor *et al.,* 2014).

Complementarily, this paper assesses whether the distribution of the intangibles (intellectual capital drivers) depends on the region of the company by dividing the sample in two groups and comparing the means of the North-American region with the remaining regions. Results suggest that the distribution of intellectual capital is different among regions for the variables IA, GW, LP, BDSIZE and SRD, as well as for the performance indicator TUR and control variables. In fact, these variables present higher means for the North-American region, which indicates that, in mean, U.S. companies have higher levels of IA, GW and LP, their boards are generally constituted by more members and they tend to invest more in R&D activities. American companies also present a higher mean regarding the size and turnover of the business, implying that American companies are bigger than European and Asian ones, and have higher levels of profitability.

The present dissertation corroborates the importance of intangibles in constituting a competitive advantage, resulting in superior financial performance for the firm. These intangibles were used as a proxy of intellectual capital, which is proven to be a vital resource of any knowledge-intensive company, which is the case of the technological firms under analysis. With the variable SRD being the most significant in

this study, the results reinforce the importance of structural and innovative capital in the technological sector, with human capital also representing a considerable factor.

This study contributes to the literature by increasing the knowledge of intangibles and their contribution to organizational performance. Furthermore, in spite of the several studies conducted in the past, this research innovates by analyzing the technological sector represented by the major companies in the world. The results allow concluding on the contribution of intellectual capital to these companies' financial results, with special focus on human capital and innovation capital, which complements the literature and provides new information on this topic.

6.1 Limitations

Although intellectual capital represents 'the sum of all of the intangible and knowledge-related resources that an organization is able to use in its productive processes in the attempt to create value' (Kianto *et al.*, 2014), IC's disclosure on financial reports is still very incomplete, which limited the information capable of being collected from the companies' reports. Thus, some independent variables present several missing values, which is particularly the case of BTRAD and LP, and some had to be combined in order to avoid this issue.

Moreover, the fact that the data had to be manually collected restricts the size of the sample, which can be enlarged by adding more years to the research. A different limitation that arises from the previous one is that, although every collected data was revised more than twice in order to guarantee the reliability of the study, there is always the possibility of error when collecting the information.

The fact that this study compares the results with previous investigations that utilized different methodologies or dependent variables can constitute a limitation, although providing a general appraisal of IC's effect on performance.

6.2 Further research

Regarding suggestions for future research, it would be interesting to explore other variables as intangibles and human capital proxies in order to determine if it would originate different results for this sample. Moreover, the study would benefit from an analysis over a longer period in order to conclude on the impact of intellectual capital on future performance.

7 References

Acar, M. & Temiz, H. 2017. Advertising effectiveness on financial performance of banking sector: Turkey case. ***International Journal of Bank Marketing***, 35 (4): 649-661.

Amadieu, P. & Viviani, J.-L. 2010. Intangible effort and performance: The case of the French wine industry. ***Agribusiness***, 26 (2): 280–306.

Andriessen, D. 2004. ***Making sense of intellectual capital: Designing a method for the valuation of intangibles.*** Oxford: Elsevier Butterworth-Heinemann.

Assaf, A. G., Josiassenb, A., Mattilac, A. S. & Cvelbard, L. K. 2015. Does advertising spending improve sales performance? ***International Journal of Hospitality Management***, 48: 161–166.

Barney, J. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17 (1): 99-120.

Bubic, J. & Susak, T. 2015. ***The impact of intangible assets on financial performance of Croatian companies.*** Paper presented at the Ninth International Scientific Conference on Economic and social Development, Istanbul.

Buenechea, M., Sáenz, J. & Kianto, A. 2016. ***Exploring the role of human capital, renewal capital and entrepreneurial capital in innovation performance in high-tech and low-tech firms.*** Paper presented at the International Conference of Theory and Application in the Knowledge Economy, Aveiro.

Cesaroni, F. M., Del Baldo, M., Demartini, P. & Paoloni, P. 2015. Entrepreneurial, renewal and trust capital of Italian firms: insights from an empirical study. ***International Journal of Management, Knowledge and Learning***, 4 (1): 69-89.

Chen, J., Zhu, Z. and Xie H. Y. 2004. Measuring intellectual capital: A new model and empirical study. ***Journal of Intellectual Capital***, 5 (1): 195-212.

Chen, M.-C., Cheng, S.-J. & Hwang, Y. 2005. An empirical investigation of the relationship between intellectual capital and firms' market value and financial performance. ***Journal of Intellectual Capital***, 6 (2): 159-176.

Edvinsson, L. and Malone, M. 1997. ***Intellectual capital: The proven way to establish your company's real value by measuring its hidden brainpower***. London: Judy Piatkus Limited.

Erikson, T. 2002. Entrepreneurial capital: The emerging venture's most important asset and competitive advantage. ***Journal of Business Venturing,*** 17 (3): 275-290.

Forbes. 2017. World's 25 Biggest Tech Companies in 2016, available at https://www.forbes.com/pictures/57462056a7ea4353698e2b4b/worlds-25-biggest-tech-co/#24acdb030a7d (accessed 25 October 2017).

Gan, K. & Saleh, Z. 2008. Intellectual capital and corporate performance of technology-intensive companies: Malaysia evidence. ***Asian Journal of Business and Accounting***, 1 (1): 113-130.

Gleason, K. I., & Klock, M. 2006. Intangible capital in the pharmaceutical and chemical industry. ***The Quarterly Review of Economics and Finance***, 46(2): 300-314.

Grant, R. 1996. Toward a knowledge-based theory of the firm. ***Strategic Management Journal,*** 17: 109–122.

Guo, W. C., Huo, S. R., & Chien, W. J. 2012. A study on intellectual capital and firm performance in biotech companies. ***Applied Economics Letters***, 19(16): 1603-1608.

Hall, R. 1992. The strategic analysis of intangible resources. ***Strategic Management Journal***, 13 (2): 135-144.

Hanssens, D. M. & Joshi, A. 2010. The direct and indirect effects of advertising spending on firm value. ***Journal of Marketing***, 74: 20–33.

Heiens, R., Leach, R. T. & Mcgrath, L. C. 2007. The contribution of intangible assets and expenditures to shareholder value. ***Journal of Strategic Marketing***, 15: 149-159.

Hussinki, H., Ritala, P., Vanhala, M. & Kianto, A. 2017. Intellectual Capital Profiles and Financial Performance of the Firm. In J. Guthrie, J. Dumay, F. Ricceri & C. Nielsen (Eds.), ***The Routledge Companion to Intellectual Capital***: 450-462. London.

Ilmakunnas, P. & Peikkola, H. 2014. Intangible investment in people and productivity. ***Journal of Productivity Analysis***, 41: 443–456.

Inkinen, H., Kianto, A., Vanhala, M. & Ritala, P. 2017. Structure of intellectual capital - an international comparison. ***Accounting, Auditing & Accountability Journal***, 30 (5): 1160-1183.

International Financial Reporting Foundation (IFRF). 2014**.** International Accounting Standard No. 38: Intangible Assets. Available at http://www.ifrs.org/IFRSs/Pages/IFRS.aspx (accessed 20 October 2017).

Kaufmann, I. & Schneider, Y. 2004. Intangibles: a synthesis of current research. ***Journal of Intellectual Capital***, 5 (3): 366-388.

Kianto, A., Andreeva, T. & Pavlov, Y. 2013. The impact of intellectual capital management on company competitiveness and financial performance. ***Knowledge Management Research & Practice***, 11: 112–122.

Kianto, A., Hurmelinna-Laukkanen, P. & Ritala, P. 2010. Intellectual capital in service- and product-oriented companies. ***Journal of Intellectual Capital***, 11 (3): 305-325.

Kianto, A., Ritala, P., Spender, J.-C. & Vanhala, M. 2014. The interaction of intellectual capital assets and knowledge management practices in organizational value creation. ***Journal of Intellectual Capital***, 15 (3): 362-375.

Kogut, B. & Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. ***Organization Science***, 3(3): 383–397.

Laureano, R. M. 2011. ***Testes de hipóteses com o SPSS: O meu manual de consulta rápida.*** Lisbon: Edição Sílabo.

Lev, B. 2001. ***Intangibles: Management, Measurement, and Reporting***. Washington: Brooking Institution Press.

Li, H. & Wang, W. 2014. Impact of intangible assets on profitability of Hong Kong listed information technology companies. ***Business and Economic Research***, 4 (2): 98-113.

Lome, O., Heggeseth , A. G. & Moen, Ø. 2016. The effect of R&D on performance: Do R&D-intensive firms handle a financial crisis better? ***Journal of High Technology Management Research***, 27: 65–77.

Lopes, I. T. & Ferraz, D. P. 2016. The value of intangibles and diversity on boards looking towards economic future returns: evidence from non-financial Iberian business organisations. ***International Journal of Business Excellence,*** 10 (3): 392-417.

Lopes, I. T., Ferraz, D. P. & Rodrigues A.M.G. 2016. The drivers of profitability in the top 30 major airlines worldwide. ***Measuring Business Excellence***, 20 (2): 26-37.

Lopes, I. T., & Martins, M. M. 2015. ***Intangibles as source of effective returns in the Iberian stock exchange markets.*** Paper presented at **the** European Conference on Knowledge Management, Kidmore End**.**

Maditinos, D., Šević, Z. and Tsairidis, C. 2010. Intellectual capital and business performance: an empirical study for the Greek listed companies. ***European Research Studies Journal,*** 13 (3): 145-167.

Mashayekhi, B. & Bazaz, M. S. 2008. Corporate governance and firm performance in Iran. ***Journal of Contemporary Accounting & Economics***, 4 (2): 156–172.

Mayer, R. C., Davis, J. H. & Schoorman, F. D. 1995. An integrative model of organizational trust. ***Academy of Management Review***, 20 (3): 709-734.

Mizik, N. & Jacobson, R. 2003. Trading off between value creation and value appropriation: The financial implications of shifts in strategic emphasis. ***Journal of Marketing***, 67: 63–76.

Nadeem, M., Gan, C., & Nguyen, C. 2016. ***Intellectual capital and firm performance: Static or dynamic estimation: Evidence from the UK.*** Paper presented at the 8th European Conference on Intellectual Capital, Italy.

Nath, S. D., Islam, S. & Saha A. K. 2015. Corporate board structure and firm performance: The context of pharmaceutical industry in Bangladesh. ***International Journal of Economics and Finance,*** 7 (7): 106-115.

Oanda. 2018. OANDA's currency calculator, available at: https://www.oanda.com/lang/pt/currency/converter/ (accessed January 15th, 2018).

Omil, J. C., Lorenzo, P. C. & Liste, A. V. 2011. The power of intangibles in high-profitability firms. ***Total Quality Management***, 22 (1): 29–42.

Pal, K. & Soriya, S. 2012. IC performance of Indian pharmaceutical and textile industry. ***Journal of Intellectual Capital***, 13 (1): 120-137.

Pucci, T., Simoni, C. & Zanni, L. 2015. Measuring the relationship between marketing assets, intellectual capital and firm performance. ***Journal of Management and Governance***, 19: 589–616.

Ruiqi, W., Wang, F. Xu, L. & Yuan, C. 2017. R&D expenditures, ultimate ownership and future performance: Evidence from China. ***Journal of Business Research***, 71: 47–54.

Salehi, M., Enayati, G. & Javadi, P. 2014. The relationship between Intellectual Capital with Economic Value Added and Financial Performance. ***Iranian Journal of Management Studies***, 7 (2): 259-283.

Sánchez-Segura, M., Ruiz-Robles, A., Medina-Dominguez, F. & Seco, A. A. 2014. ***Smart intangible knowledge assets valuation***. Paper presented at the European Conference on Knowledge Management, Kidmore End**.**

Sardo, F., Serrasqueiro, Z. & Alves, H. 2018. On the relationship between intellectual capital and financial performance: A panel data analysis on SME hotels. ***International Journal of Hospitality Management***, 75: 67–74.

Scott, W. R. 2012. ***Financial accounting theory***. Toronto: Pearson.

Shakina, E. & Molodchik, M. 2014. Intangible-driven value creation: supporting and obstructing factors. ***Measuring Business Excellence***, 18 (3): 87-100.

Sharma, S. & Dharni, K. 2016. Measurement, management and reporting of intangible assets: A review. ***Journal of Commerce & Accounting Research***, 5 (4): 56-69.

Sheikh, N. A., Wang, Z. and Khan, S. 2013. The impact of internal attributes of corporate governance on firm performance: Evidence from Pakistan. ***International Journal of Commerce and Management***, 23 (1): 38–55.

Sonnier, B.M. 2008. Intellectual capital disclosure: high-tech versus traditional sector companies**.** ***Journal of Intellectual Capital***, 9 (4): 705-722.

Sridhar, S., Narayanan, S. & Srinivasan, R. 2014. Dynamic relationships among R&D, advertising, inventory and firm performance. ***Journal of the Academy Marketing Science***, 42: 277–290.

Sveiby, K. E. 1997. ***The new organizational wealth: Managing & measuring knowledge-based assets.*** San Francisco: Berrett-Koehler Publishers.

Tanfous, M.B. 2013. The contribution of intangibles to value creation. ***Journal of Business Studies Quarterly***, 5 (1): 43-75.

Tseng, C. Y. & Goo, Y. J.J. 2005. Intellectual capital and corporate value in an emerging economy: empirical study of Taiwanese manufacturers. ***R&D Management***, 35 (2): 187-201.

Tudor, A.T., Dima, S., Dima, B. & Ratiu, R.V. 2014. The linkage between intangibles and profitability. ***Annales Universitatis Apulensis Series Oeconomica***, 16 (1): 283-293.

Uadiale, O. M. 2010. The impact of board structure on corporate financial performance in Nigeria. ***International Journal of Business and Management***, 5 (10): 155-166.

Wang, Y.-C., Tsai, J.-J. & Lin H.-W. W. 2013. The influence of board structure on firm performance. ***The Journal of Global Business Management***, 9 (2): 7-14.

Zhang, M. 2013. The impact of internally generated goodwill on financial performance of firms. ***The Journal of Applied Business Research***, 29 (6): 1809-1814.

8 Appendix

The Forbes' ranking 'World's 25 Biggest Tech Companies in 2016' (Forbes, 2017) that constitutes the sample in this research is the following:

1. Apple
2. Samsung Electronics
3. Microsoft
4. Alphabet
5. IBM
6. Intel
7. Cisco Systems
8. Oracle
9. Hon Hai Precision
10. Taiwan Semiconductor
11. Hewlett-Packard Enterprise
12. Qualcomm
13. Alibaba
14. SAP
15. Facebook
16. Tencent Holdings
17. EMC
18. Amazon
19. HP
20. Ericcson
21. Baidu
22. Nokia
23. SK Hynix
24. Tata Consultancy Services
25. Texas Instruments