

# BEYOND TRADITIONAL ANALYSIS: USING MACHINE LEARNING TO INVESTIGATE INTELLECTUAL CAPITAL DISCLOSURES

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## Abstract

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This research aims to conduct a thorough examination of the practices related to the disclosure of intellectual capital (IC). In the context of the dynamic knowledge-based economy, it is crucial for organizations to recognize the significance of IC. Intellectual capital comprises three key components: internal capital, external capital, and human capital. These elements play a pivotal role in generating value for organizations and positioning them competitively in the market. The current body of literature is constrained in its empirical investigation of IC disclosures and their congruence with organizational strategies. This research utilizes a combination of textual analysis and machine learning techniques, specifically K-means clustering, to examine the practices of IC disclosure. The integration of machine learning techniques facilitates the identification of patterns and interdependencies among diverse IC attributes. Notably, while the current literature has predominantly focused on IC disclosures within established frameworks, it often falls short of empirically exploring patterns and interconnections between different IC attributes. The results of the study indicate a notable emphasis on the disclosure of human capital and provide valuable insights into the different strategic priorities based on the clustering of IC attributes. The insights provided offer significant value to organizations as they facilitate the improvement of transparency and the effective communication of the strategic importance of IC. Furthermore, this study makes a valuable contribution to the existing theoretical framework on IC by identifying the interconnections that exist between various attributes of IC. The utilization of these findings by policymakers and standard-setting bodies can be instrumental in the development of more extensive guidelines for IC disclosures.

**Keywords:** Intellectual Capital, Textual Analysis, Machine Learning, K-Means Clustering

**Authors' individual contribution:** Conceptualization — M.M. and Y.A.; Methodology — M.M.; Formal Analysis — M.M. and Y.A.; Writing — M.M. and Y.A.; Project Administration — M.M. and Y.A.

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## 1. INTRODUCTION

Intellectual capital (IC) is a crucial and indispensable element within organizations, encompassing

intangible assets and resources that facilitate the generation of value and the attainment of a competitive edge. In the context of the ever-evolving knowledge-based economy, the importance of IC has experienced a notable increase. This

encompasses various components such as human capital, which refers to the knowledge, skills, and expertise possessed by individuals within an organization. Additionally, there is *internal capital*, which pertains to the systems, processes, and intellectual property that contribute to the organization's overall value. Lastly, there is *external capital*, which involves the external relationships, networks, and collaborations that enhance the organization's intellectual resources. The existing body of literature on IC disclosure practices and their alignment with organizational strategies is limited in scope. This study aims to bridge the existing research gap by conducting a comprehensive examination of IC disclosure practices in companies listed on the Australian Stock Exchange (ASX 500). To achieve this, advanced methodologies such as textual analysis and machine learning using K-means clustering are employed.

Previous research has delved into the IC and its influence on the overall performance of organizations (Bontis, 1998; Edvinsson, 1997; Guthrie et al., 2004). However, the comprehensive examination of IC in corporate disclosures has not been thoroughly explored. A comprehensive comprehension of how organizations disclose their IC attributes is of utmost importance when it comes to evaluating the strategic value assigned to these intangible assets and assessing the level of transparency in their communication with stakeholders.

In our research, we pose the following questions:

*RQ1: How extensively and in what manner are IC disclosures represented among the companies listed on the ASX 500 in terms of scope and characteristics?*

*RQ2: What specific patterns and interconnections can be discerned between different IC attributes, and how might these connections shed light on the strategic directions and priorities of these organizations in the context of IC?*

This research offers a novel approach to conducting a comprehensive examination of IC disclosures. Notably, the utilization of machine learning algorithms, K-means clustering, is observed in order to effectively identify and analyze patterns within the attributes of IC. Textual analysis is a commonly used method for evaluating IC disclosures. In this context, we employ advanced machine learning techniques, K-means clustering, to identify patterns and relationships within the disclosed information. This integration allows for the identification of complex patterns that go beyond simple disclosure frequencies. It goes a step further by capturing a more profound comprehension of the underlying structure and interconnections.

This research provides a significant contribution to both the theoretical and practical fields. This research contributes to the existing body of IC literature by introducing a novel perspective for examining disclosure practices. Moreover, it uncovers significant patterns and interrelationships among various IC attributes through the application of K-means clustering. The exploration of the strategic significance of IC in the contemporary business landscape serves to deepen comprehension.

The findings of this study offer significant insights for the corporate sector as well as policymakers. Organizations can leverage these valuable insights to enhance their IC disclosure strategies, thereby fostering transparency and facilitating effective communication regarding the significance of their intellectual assets. Moreover, policymakers and standard-setting bodies have the opportunity to utilize this research in order to develop more extensive guidelines for reporting IC. These guidelines can be enriched by incorporating valuable insights obtained from the analysis.

This research paper is structured as follows. Following the Introduction, Section 2 proceeds to offer a comprehensive analysis of the literature pertaining to IC and its disclosures. Section 3 provides an explanation of the research methodology, focusing on the implementation of textual analysis and the utilization of K-means clustering as a machine learning technique. Section 4 of the research paper provides a detailed examination of the findings and analysis pertaining to IC disclosure practices and the various patterns observed in IC attributes. The final section of the paper, Section 5, concludes the paper, summarizing the findings, discussing the contributions and implications of the research, acknowledging the limitations, and suggesting avenues for future research.

## 2. LITERATURE REVIEW

### 2.1. Intellectual capital

The history of IC is a subject of great significance in the field of knowledge management and organizational studies. It encompasses the evolution and development of the concept of IC over time.

The concept of IC has undergone significant evolution throughout its history, and it is now widely recognized and referred to as knowledge. According to Sullivan (2000), *knowledge* is regarded as the primary catalyst for IC. The notion of IC is not a recent development, as organizations have long recognized the significance of leveraging inventive concepts and the expertise of their workforce to gain a competitive edge. Scholars, professionals, and experts in the field of strategy have extensively deliberated on the significance of IC. Drucker (1959) was among the first to discern a significant transition from a manufacturing-centric economy to a service-oriented one. He observed that companies were undergoing a transformation, wherein they were increasingly assuming the role of knowledge creators. According to Drucker (1959), it is imperative for a company to possess knowledge, particularly in relation to its human resources, in order to effectively engage in long-term company planning. He posits that company knowledge can be categorized into two distinct types: 1) the *collective knowledge* of the entire organization, encompassing its strategic directions, goals, and expectations; and 2) the *individual knowledge* possessed by the top management, including their decision-making processes, commitments, and diligent efforts.

In his work, Teece (1986) explains the intricacies of formulating a business strategy and implementing a mechanism to effectively capitalize

on innovation in order to generate profits. Teece (1986) posits that an innovation comprises a specific body of technical knowledge that is comprised of both codified and tacit elements. In their work, Sveiby and Riesling (1986) provide comprehensive insights and practical guidance on effectively managing intangible assets. Its profound impact was felt within the intellectual circles of Sweden, leading to the emergence of a noteworthy movement known as the Swedish Communities of Practices (CoP). This movement, which flourished in the mid-1980s, focused on conducting extensive research pertaining to the intricate domains of knowledge management and the measurement of IC.

In 1988, Sveiby authored a publication titled *"The New Annual Report"* wherein he introduced the notion of *knowledge capital*. In 1988 (English version — in 1990), he authored a work *"The Invisible Balance Sheet"*, wherein he presented a theory aimed at quantifying IC (Sveiby, 1990). This theory involves the categorization of IC into three distinct components, namely customer capital, individual capital, and structural capital. In 1997, Sveiby made a significant contribution to the field of IC with the publication of his work titled *"The New Organizational Wealth: Managing & Measuring Knowledge-Based Assets"* (Sveiby, 1997). In this work, Sveiby (1997) delves into effective management and quantification of knowledge-based assets in organizations. The tripartite framework proposed by Sveiby (1997) encompasses three key components: external capital, internal capital, and the competence of individuals.

In recent years, the field of IC research has experienced significant growth and attention from both practitioners and academics. This heightened interest has led to a substantial increase in the number of studies conducted on this topic (Brüggen et al., 2009; Guthrie et al., 2004; Muttakin et al., 2015; Oliveira et al., 2006; Striukova et al., 2008; Whiting & Woodcock, 2011).

## 2.2. IC identification and disclosures

The process of identifying IC involves recognizing and categorizing the intangible assets within an organization that contributes to its overall value and competitive advantage. IC encompasses a wide range of elements, including but not limited to knowledge, expertise, and patents.

In order to fully comprehend the concept of IC, it is essential to first establish a comprehensive understanding of knowledge within the business context, as highlighted by Edvinsson and Sullivan (1996). According to them, business knowledge can be classified into two categories: codified knowledge and tacit knowledge. *Codified knowledge* refers to information that is clearly defined and can be readily transferred, thereby allowing for relatively simple replication if not safeguarded by intellectual property legislation. In contrast, the transferability of *tacit knowledge* is hindered by its inherent difficulty in being precisely defined. In IC, tacit knowledge frequently encompasses process knowledge within manufacturing enterprises and relationship knowledge within service-oriented organizations. According to Drucker (1993), tacit knowledge can be defined as a form of expertise that cannot be effectively articulated through verbal

or written means. Furthermore, according to the research conducted by Saint-Onge (1996), it is argued that tacit knowledge plays a pivotal role as a strategic asset within an organization, influencing the cognitive processes and behaviors of its members. The interaction between different types of knowledge is of utmost significance.

The notion of IC can be understood metaphorically, as it encompasses various distinct characteristics that are often emphasized. According to Andriessen (2006), the prevailing metaphors in the field of IC are *"knowledge as a resource"* and *"knowledge as capital"*. The metaphor of *"knowledge as a resource"* is commonly referred to as the resource-based view. The utilization of this metaphor serves to illustrate the transformative potential of knowledge in generating value. Moreover, the metaphor of *"knowledge as capital"* that underlies IC is a highly nuanced and advantageous concept. According to Stewart (1991), when knowledge is regarded as a form of capital, it exhibits greater flexibility compared to physical capital.

In their work, Roos et al. (1997) conducted a comprehensive analysis of the theoretical foundations of IC. They identified two distinct streams of thought that have contributed to the development of IC, namely the *strategic stream* and the *measurement stream*. By tracing the origins of IC to these two streams, they shed light on the diverse perspectives and approaches that have shaped the understanding and management of IC. The strategic stream of research places its emphasis on the cultivation and exploitation of knowledge, while also exploring the intricate interplay between knowledge and the generation of value. The measurement stream pertains to the imperative of constructing balanced scorecards, financial scorecards, and human resource accounting. According to Sullivan (2000), there are two distinct perspectives that emerge as primary areas of focus in management: *value creation* and *value extraction*. The primary objective of value creation is to strategically cultivate and enhance a company's IC. The concept of value extraction revolves around the strategic utilization of IC to generate financial gains.

IC is widely recognized as a collection of distinctive assets that possess several key characteristics. These assets are inherently challenging to replicate, requiring significant investments of time and effort for their development. Moreover, they cannot be acquired solely through financial means, as their acquisition involves a combination of various factors. Additionally, these assets have the remarkable ability to be utilized in multiple ways simultaneously, further enhancing their value and significance (Itami & Roehl, 1987; Sullivan, 2000). Hence, within the corporate entities, it is evident that no two entities possess identical assemblages of IC, encompassing knowledge, know-how, management philosophy, skills, patents, trademarks, and copyrights. The distinguishing characteristics that set a company apart from its competitors and are frequently regarded as the primary drivers of competitive advantage. The valuation of IC has often been overlooked by managers and analysts due to the inherent challenges associated with assessing its worth (Itami & Roehl, 1987; Stewart, 1991).

According to Sullivan (2000), the valuation of IC poses challenges due to its indirect nature and the inherent variability in the values assigned by different companies. Sullivan proposes a comprehensive framework encompassing both qualitative and quantitative indicators to assess the value of IC. An illustrative instance can be observed in the distinction between strategic position value, which pertains to qualitative aspects such as company image, and financial value, which pertains to quantitative aspects such as cash flow. Indeed, the significance of IC extends well beyond the quantifiable assets reported in financial statements (Handy, 1989).

IC serves as a fundamental component of an organization, working in conjunction with other forms of capital such as *physical* and *financial capital* (Lynn, 1998). According to Lynn (1998), there is a prevailing lack of familiarity among accountants regarding IC, as they tend to only have a partial recognition of it in the context of intangible assets. The argument put forth by the author provides support for the existing research that highlights the fact that not all items of IC can be classified as intangible assets.

The discourse surrounding IC has become intricate due to the proclivity of individual authors to espouse their own interpretations of IC (Van der Meer-Kooistra & Zijlstra, 2001). The concept of IC is widely acknowledged as a complex and multifaceted construct, posing challenges in its precise definition and understanding (Petty & Guthrie, 2000; Van der Meer-Kooistra & Zijlstra, 2001; Whiting & Woodcock, 2011).

A widely recognized definition of IC is proposed by Klein and Prusak (1994), who describe it as intellectual material that has been formalized, captured, and leveraged to generate a higher-valued asset. However, Stewart (1998) argues that this definition of IC distinguishes between intellectual material and capital. On the other hand, both Stewart (1998) and Van der Meer-Kooistra and Zijlstra (2001) contend that this definition limits the broader scope of the IC concept, which encompasses tacit knowledge and experience that may not be formalized or captured within a company. Van der Meer-Kooistra and Zijlstra (2001) also note that the concept of intellectual material in the aforementioned IC definition lacks clarity. Consequently, Stewart (1998) defines IC as intellectual material, including knowledge, information, intellectual property, and experience, that can be utilized to generate wealth.

According to Edvinsson and Sullivan (1996), IC can be defined as knowledge that possesses the potential to be transformed into value. The scope of this definition extends beyond the legal framework of innovation and intellectual property, encompassing a comprehensive conceptualization that incorporates ideas, data processes, skills, and computer programs. A widely accepted conceptualization of IC refers to the unaccounted-for disparity between the book value and market value within a company's financial statements (Brennan & Connell, 2000; Edvinsson, 1997; Fincham & Roslender, 2003; de Pablos, 2005).

The variations in the definitions presented can be attributed to the confusion surrounding the terms "*intellectual capital*" and "*human capital*".

According to Andriessen (2006), IC is generated by individuals utilizing their intellectual abilities. Ulrich (1998) argues that human capital, which encompasses skilled and dedicated employees aligned with the organization's objectives, constitutes the IC of a company. He perceives IC at the individual level, where it is determined by the multiplication of competence and commitment. Conversely, Hamel and Prahalad (1994) contend that IC is not confined to the individual level, as it encompasses the amalgamation of skills and technologies that form the core competencies of the organization. Mouritsen et al. (2002) also conceptualize IC at the collective level, representing the knowledge resources of the entire organization.

Based on the aforementioned definitions, it can be inferred that IC transcends mere knowledge and is typically not disclosed in financial statements. The inclusion of intangible assets within the framework of IC aligns with the perspective put forth by Brooking (1996), who posits that IC refers to the collective intangible assets that facilitate the operational capabilities of a company. According to Hall (1992), intangible resources can be classified into two main categories: assets and competencies. These categories are considered crucial drivers of value within companies. Hall (1993) argues that the development of key intangible resources is crucial for companies to achieve sustainable competitive advantage. This is because these intangible resources play a significant role in driving capability differentials, which ultimately contribute to the company's ability to maintain a competitive edge. Therefore, it is imperative for companies to gain a comprehensive understanding of the development of their intangible resources.

### 2.3. IC framework used in this research

According to Miller et al. (1999), IC can be classified into two distinct categories, organizational/structural capital and human capital. Bontis (1998) has made reference to the components of IC, namely: 1) human capital, 2) structural capital, and 3) customer capital, in his conceptualization of IC. He posits that the innovation within an organization is derived from the IC of its employees, thereby asserting that human capital, in terms of its magnitude, serves as the primary driver of this innovation. Structural capital, in the context of efficiency, refers to the knowledge that is embedded within an organization at its internal level. Customer capital, in the context of longevity, refers to the knowledge that is associated with the relationships a company has with external organizations. Customer capital encompasses a range of market relationships, including but not limited to those established with customers, suppliers, and governmental entities. In their taxonomy, Roos et al. (1997) have employed the term "*relationships*" as an alternative to "*customer capital*". According to their argument, it is contended that customer capital should not be regarded as the sole external value driver. The categorization of the company's interactions with external entities, including customers, suppliers, alliance partners, shareholders, and other stakeholders, is commonly recognized within the framework of structural capital.

In addition, Sveiby (1997) posits that the significance of an organization's external relationships should not be undermined due to the absence of a universally recognized definition and measurement standard for this concept. Notwithstanding this, he underscores the feasibility and imperative nature of quantifying these interconnections. In the context of organizational dynamics, it is noteworthy to observe that individuals within a given entity, when engaging in interactions with customers, actively contribute to the establishment and cultivation of customer relationships. These relationships, in turn, play a pivotal role in shaping the organization's image within the market landscape. It is important to acknowledge that this image, although partially attributed to the corporation as a whole, is also influenced by the collective efforts of the individuals involved in customer-facing roles.

In light of recognizing the significance of external relationships, Sveiby (1997) has made a modification to the classification by introducing external capital as a category within the IC. This tripartite framework encompasses external capital, internal capital, and employee competence, mirroring the three IC categories proposed by Lynn (1998). *Internal capital* refers to the valuable assets and resources that are generated or obtained by employees within an organization and are typically owned and controlled by the company itself. Certain components of internal capital possess the potential for legal protection, rendering them eligible for intellectual property rights and subsequently establishing legal ownership by the company. Internal capital refers to the reservoir of knowledge and expertise that remains within an organization's boundaries at the conclusion of a typical workday. It encompasses the collective intellectual assets, skills, and competencies possessed by employees, which are crucial for the organization's operations and long-term success. The IC encompasses various components that contribute to the overall value and knowledge assets of an organization. These components include: 1) the organizational culture, 2) legal structure, 3) manual systems, 4) research and development activities, 5) patents, 6) conceptual frameworks, 7) software applications, and 8) administrative systems.

Based on the framework presented above, it is evident that the presence of external capital introduces an element of uncertainty. This uncertainty has the potential to impact reputations and relationships, leading to possible changes over time. External capital refers to a range of intangible assets that contribute to the overall value and success of a company. These assets encompass various elements such as well-established brands, strong customer loyalty, a favorable company reputation, and robust supplier relationships. These factors play a crucial role in enhancing a company's competitive advantage and long-term sustainability in the marketplace. Employee competence refers to an individual's capacity to effectively navigate and perform in diverse situations, and it is inherently tied to the individual possessing it. This valuable attribute cannot be owned or controlled by anyone other than the individual themselves. The enhancement of employee competence can be

achieved through a combination of training and practical experience, which can then be effectively transferred through active engagement in various activities. Employee competence encompasses a range of essential attributes that contribute to their overall effectiveness and performance within an organization. These attributes include: 1) creativity, which enables employees to generate innovative ideas and solutions; 2) know-how, which refers to the practical knowledge and expertise acquired through hands-on experience; 3) previous experience, which provides employees with valuable insights and lessons learned from past roles and responsibilities; 4) learning, which involves the continuous acquisition of new knowledge and skills; 5) formal training, and education.

Sveiby's (1997) tripartite framework has gained significant traction in the field of IC research and is frequently referenced in various studies (Abeysekera & Guthrie, 2005; Guthrie et al., 2004; Li et al., 2012; Meritum, Project, 2002; Petty & Guthrie, 2000; Steenkamp & Northcott, 2007; Sujana & Abeysekera, 2007; Wagciengo & Belal, 2012; Whiting & Woodcock, 2011). These studies employed Sveiby's framework to explore and analyze different aspects of IC. Several research studies employ varying terminology that bears resemblance to the tripartite framework proposed by Sveiby (1997). Relational capital and customer capital are occasionally employed as alternative terms for external capital within IC. Organizational capital, also known as structural capital, is commonly recognized as a form of internal capital within an organization. The concept of employee competence also referred to as the *competence of individuals*, is occasionally employed as a substitute for the notion of human capital. As noted by Hussini (2004), the utilization of the concept of "internal capital" serves as a valuable tool in discerning the disparities between intra- and extra-organizational entities. In contrast, it is important to note that external capital encompasses a wider scope than customer capital. Furthermore, it is crucial to recognize that human capital extends beyond the mere aggregation of individual competencies, as highlighted by Hussini (2004).

This research employs the established IC framework proposed by Guthrie et al. (2004) to analyze IC. This framework is aligned with Sveiby's tripartite framework, which classifies IC into three categories: internal capital, external capital, and human capital. According to Beattie and Thomson (2007), the categorization of IC can be expanded into various subcategories, which they perceive as distinct types of information. This research employs the term "IC attributes" to denote the various categories of information encompassing the aforementioned elements. The framework for IC elements, initially proposed by Brooking (1996), has been further refined by the Australian Society of CPAs and The Society of Management Accountants of Canada (1999). This modified framework was then integrated with the framework developed by Guthrie and Petty (2000). The resulting IC framework encompasses three categories, each comprising a set of attributes. Specifically, the framework encompasses: 1) six attributes within internal capital, 2) seven attributes within external capital, and 3) five attributes within human capital.

**Table 1.** Intellectual capital framework

<i>Internal capital</i>	<i>External capital</i>	<i>Human capital</i>
1. Intellectual property 2. Management philosophy 3. Corporate culture 4. Management processes 5. Information/networking systems 6. Financial relations	7. Brands 8. Customers 9. Customer satisfaction 10. Company names 11. Distribution channels 12. Business collaborations 13. Licensing agreements	14. Employees 15. Education 16. Training 17. Work-related knowledge 18. Entrepreneurial spirit

Source: Guthrie et al. (2004).

### 3. RESEARCH METHODOLOGY

This research aims to examine the IC disclosures within the 2015 annual reports of the ASX 500 companies. A comprehensive analysis was conducted on the complete set of annual reports sourced from the official website of the Australian Securities Exchange. The selection of the 2015 annual reports serves as a robust sample for IC research due to its relevance and representation of IC practices in the region during that period. Our methodology incorporates textual analysis and K-means clustering to thoroughly investigate the structure and characteristics of IC disclosures.

According to Krippendorff (2004), textual analysis is a research methodology that enables the generation of reliable and accurate conclusions from data by systematically categorizing the data into distinct categories based on predetermined criteria. This approach allows for a comprehensive examination of the data within its specific context, facilitating the extraction of meaningful insights. The definition of content analysis was subsequently refined in 2004, emphasizing that the data used in this method encompass texts or other forms of meaningful material (Krippendorff, 2004).

The methodology employed in this research involves the utilization of textual analysis as a means of measurement. Specifically, the process entails the manual enumeration of meaning units to determine their frequency of occurrence. The primary unit of analysis for coding in this study is the sentence. This choice is based on the understanding that sentences offer a more comprehensive, dependable, and significant source of data compared to the isolated examination of individual words (Milne & Adler, 1999). Similarly, Abeysekera (2011) employs sentence count as a metric to assess the extent of IC disclosures in his study. In certain instances, when a sentence contains multiple IC attributes, all pertinent attributes are systematically identified and categorized. This study employs the absolute frequency approach, which is derived from Krippendorff's (2004).

Furthermore, we employ K-means clustering, a widely used technique in unsupervised machine learning, to classify these disclosures into separate clusters based on their inherent characteristics. The K-means algorithm is highly advantageous for this specific task due to its ability to uncover patterns within extensive datasets through the process of grouping data points based on their similarities. While current literature largely centers on IC disclosures using existing frameworks and textual analysis, it frequently lacks depth in the empirical examination of patterns and relationships among various IC attributes.

Machine learning, a branch of artificial intelligence, empowers systems to acquire knowledge and improve their performance autonomously, without relying on explicit

programming. In the context of unsupervised learning, the algorithm operates autonomously, devoid of explicit directives, and is entrusted with the responsibility of identifying intricate patterns and interconnections inherent in the input data. The K-means clustering algorithm is a well-established technique in the field of unsupervised learning. It is particularly effective in partitioning datasets into separate clusters that do not overlap. Each data point is assigned to a unique cluster, ensuring clear affiliation (Jain, 2010). It is important to acknowledge that although non-machine learning analyses provide alternative approaches for studying these datasets, they may not possess a comprehensive understanding of the intricate, non-linear relationships and hidden patterns that exist within the data (Hastie et al., 2009; James et al., 2013). Moreover, the importance of utilizing textual analysis in corporate disclosures and machine learning is emphasized by Li (2010), and Nasukawa and Yi (2003).

The usage of K-means clustering as the method for analyzing IC disclosures is justified by a multitude of factors. First and foremost, it is important to note that IC disclosures are known for their multi-dimensional nature. They encompass a wide range of attributes and types of information, as outlined in the literature reviews. K-means clustering has gained significant recognition for its exceptional efficacy in handling multi-dimensional data and extracting significant clusters by leveraging the inherent properties of the data (Hartigan & Wong, 1979). Furthermore, the utilization of K-means clustering for the examination of IC disclosures embraces a data-driven methodology. This is of utmost importance due to the fact that IC encompasses intangible assets and value drivers that may not be easily observable. K-means clustering is a powerful technique that can reveal the hidden structures and relationships within IC components. This method is particularly valuable as it can uncover insights that may be missed by traditional analysis approaches. In addition, the process of clustering IC disclosures can provide valuable insights into the diverse strategies employed by organizations to structure and manage their intellectual assets.

### 4. RESEARCH RESULTS

#### 4.1. Textual analysis

This research conducts a comprehensive textual analysis as a preliminary measure to critically assess the attributes and extent of IC disclosures within the ASX 500 companies. In Table 2, we observe the utilization of Guthrie et al.'s (2004) IC framework to present a comprehensive overview of the disclosure frequency of different IC attributes in the annual reports.

**Table 2.** Textual analysis results using Guthrie et al.'s (2004) IC framework

<i>Internal capital</i>	<i>Disclosures</i>	<i>External capital</i>	<i>Disclosures</i>	<i>Human capital</i>	<i>Disclosures</i>
Intellectual property	138	Brands	160	Employees	4,896
Management philosophy	147	Customers	152	Education	1,217
Corporate culture	94	Customer satisfaction	68	Training	281
Management processes	48	Company names	229	Work-related knowledge	5,562
Information/networking systems	1,003	Distribution channels	510	Entrepreneurial spirit	54
Financial relations	97	Business collaborations	237		
		Licensing agreements	28		
<b>Total</b>	<b>1,527</b>	<b>Total</b>	<b>1,384</b>	<b>Total</b>	<b>12,010</b>

According to the findings presented in Table 2, it is evident that human capital stands out as the most significant category, constituting a substantial 81% of the overall disclosures. In comparison, internal capital and external capital account for 10% and 9% respectively. The results of this study align with existing literature that underscores the significance of human capital as a critical element of IC (Andriessen, 2006; Bontis, 1998; Edvinsson, 1997; Hussi, 2004). The findings presented in Table 2 provide a comprehensive overview of the predominant attributes disclosed within the category of human capital. It is evident that work-related knowledge, employees, and education emerge as the most commonly reported factors in this category.

The emphasis on work-related knowledge, specifically, highlights the significance that organizations are attributing to the practical skills and expertise exhibited by their employees. This observation reflects an understanding that possessing such knowledge is crucial for fostering innovation and maintaining a competitive edge. Moreover, the comprehensive disclosure pertaining to employees can be interpreted as indicative of the organization's dedication to an employee-centric approach, a highly esteemed attribute among diverse stakeholders.

Internal capital disclosures, although relatively limited in number, continue to hold substantial importance for organizations. According to the findings presented in Table 2, it is evident that information/networking systems exhibit the most significant number of disclosures within this particular category. This observation underscores the significance that organizations attribute to digitalization and information management, a notion that resonates with existing literature on the pivotal role of internal capital in harnessing organizational knowledge and resources (Lynn, 1998; Sveiby, 1997).

In the category of external capital, it is worth noting that distribution channels and business collaborations emerge as prominent attributes. The inclusion of disclosures pertaining to these attributes underscores the significance of strategic alliances and market penetration within modern business landscapes.

Moreover, the utilization of textual analysis offers invaluable insights into the prevalence of different IC attributes. This, in turn, facilitates a more analytical exploration of the subject matter. The utilization of quantitative data pertaining to the frequency of IC disclosures is of paramount importance in comprehending the subject matter. However, it is imperative to delve deeper into the connections and interdependencies that exist among these various attributes.

Subsection 4.2 will comprehensively explore this particular aspect using K-means clustering. By employing the K-means clustering technique, we aim to unveil the unique patterns and characteristics of IC attributes. These distinct characteristics may potentially indicate varying strategic orientations and emphases within the context of IC. The utilization of clustering techniques in the analysis of IC attributes enables the identification and understanding of the relationships and interdependencies that exist among different IC attributes.

#### 4.2. K-means clustering analysis

Following textual analysis in subsection 4.1, we then proceed to conduct a K-means clustering analysis with the objective of discerning patterns within 18 IC attributes. The utilization of K-means clustering analysis offers a robust methodological framework for effectively identifying and discerning patterns within the IC attributes. This approach surpasses the conventional examination of textual analysis, which solely focuses on the frequency of disclosures. In this section, we present an analysis of the outcomes derived from the application of K-means clustering technique on 18 IC attributes.

The K-means clustering analysis yielded a set of outcomes that unveiled three clusters, as depicted in Table 3 below.

**Table 3.** K-means clustering results

<i>IC categories</i>	<i>IC attributes</i>	<i>Cluster</i>
Internal capital	Information/networking systems	1
Human capital	Education	
Human capital	Employee	2
Human capital	Work-related knowledge	
Internal capital	Intellectual property	3
Internal capital	Management philosophy	
Internal capital	Corporate culture	
Internal capital	Management processes	
Internal capital	Financial relations	
External capital	Brands	
External capital	Customers	
External capital	Customer satisfaction	
External capital	Company names	
External capital	Distribution channels	
External capital	Business collaborations	
External capital	Licensing agreements	
Human capital	Training	
Human capital	Entrepreneurial spirit	

The analysis reveals three different clusters, each characterized by a unique combination of IC attributes. The incorporation of attribute clustering enhances our comprehension of IC disclosures.

Cluster 1 encompasses two IC attributes, namely information/networking systems, which fall under the category of *Internal capital*, and

education, which is classified as *Human capital*. The findings of this cluster indicate a potential for a mutually beneficial relationship between the organizational systems for information management and employee education. From a theoretical perspective, it is crucial to emphasize the significance of integrating knowledge management systems with the advancement of human capital (Grant, 1996). The significance of education in harnessing information and networking systems for organizational learning and innovation is emphasized.

In practical terms, organizations have the opportunity to enhance their IC by strategically allocating resources toward both information systems and employee education. By cultivating an environment that prioritizes knowledge sharing and continuous learning, companies can effectively leverage this insight to bolster their IC.

Cluster 2 pertains to the inclusion of employee and work-related knowledge attributes within the category of *Human capital*. The observed clustering can be attributed to the inherent connection between employee presence and the accumulation of work-related knowledge within the organizational context. The statement posits that there is theoretical support for human capital theories, which highlight the crucial role of employees' knowledge in enhancing organizational value (Becker, 1964).

Based on our findings, it is recommended that practitioners in the field of human resources prioritize the acquisition and retention of employees who possess valuable knowledge and expertise. This is particularly important in light of the observed cluster. The preservation of knowledge is of utmost importance in the establishment and long-term maintenance of IC.

Cluster 3 exhibits a remarkable level of diversity, as it encompasses a wide array of attributes pertaining to *Internal*, *External*, and *Human capital*. The third cluster serves as a theoretical demonstration of the intricate and multifaceted characteristics inherent in IC, showcasing the interdependencies and interconnectedness among its diverse attributes. The statement highlights the adoption of an integrated approach to IC, which is in line with the viewpoints put forth by Integrated Reporting (2021).

Based on a pragmatic standpoint, it is recommended that companies embrace a comprehensive strategy for the management and disclosure of IC. This approach acknowledges the interconnectedness of different attributes within the IC framework. The implementation of this approach has the potential to yield more extensive and significant IC disclosures, as well as enhance the strategic alignment of internal resources.

The integration of textual analysis and K-means clustering makes a substantial contribution to the existing body of IC knowledge. From a theoretical perspective, the identification of these clusters offers valuable insights into the interconnectedness among various IC attributes. This research endeavor enhances the depth of comprehension regarding the landscape of IC disclosure, thereby facilitating the advancement of more comprehensive theories pertaining to IC.

From a pragmatic standpoint, this analysis provides actionable insights for corporate disclosures and management. One notable example involves the recognition of the significant role that knowledge management systems play in conjunction with education, as evidenced by Cluster 1. In light of this understanding, organizations have the opportunity to strategically align their internal resources in order to effectively foster the development of human capital. Furthermore, it is crucial to comprehend the comprehensive perspective embodied in Cluster 3. In doing so, organizations can aim to adopt integrated reporting practices that take into account the intricate dynamics and interconnectedness among various types of capital.

In addition, it is worth noting that regulatory bodies and standard-setting organizations have the ability to leverage these valuable insights in order to develop comprehensive guidelines for reporting IC. The implementation of this approach has the potential to cultivate enhanced levels of transparency and uniformity in the manner in which organizations communicate their IC. Consequently, this could result in stakeholders making more well-informed decisions.

In summary, this study provides a comprehensive and thorough investigation into IC disclosures using a combination of textual analysis and K-means clustering techniques. Through the identification and analysis of clusters of IC attributes, this research significantly contributes to the theoretical advancement of the field. By delving into these clusters, valuable insights are gained that can be applied to enhance corporate reporting and management practices. Subsequent investigations can expand upon these discoveries to delve deeper into the dynamics of IC within the ever-changing business environment.

## 5. CONCLUSION

This research undertook a comprehensive investigation into the IC disclosure practices of ASX 500 companies. Through the utilization of advanced techniques such as textual analysis and K-means clustering, this study effectively shed light on the patterns and interconnections that exist within the IC attributes. The results of this study highlight the significant role of human capital disclosures and shed light on the patterns in which IC attributes are grouped together, indicating varying strategic focuses.

This study expands upon the existing body of literature by drawing upon the works of Guthrie et al. (2004), Bontis (1998), and Edvinsson (1997). This study aims to provide further insights into the disclosure practices and clustering patterns of IC. This study makes a valuable contribution to the existing theoretical framework on IC by shedding light on the interconnections between different attributes of IC. These interrelations hold substantial implications for the overarching theoretical constructs of IC.

From a pragmatic perspective, the research offers valuable insights that can inform corporate disclosures and management practices in order to improve IC disclosures. The results of this study have the potential to offer valuable insights to



organizations seeking to enhance their IC disclosures. By achieving more equitable and comprehensive disclosures, organizations can promote transparency and effectively communicate the strategic significance of their intellectual assets to stakeholders.

Nevertheless, it is imperative to acknowledge that this study is not without its limitations. The data utilized in this study was obtained solely from ASX 500 companies. It is important to acknowledge that this approach may have certain limitations in terms of the generalizability of the findings to diverse geographical and industry contexts. Moreover, the study primarily centered its investigation on the frequency of IC disclosures.

Future studies may extend the scope of this study by conducting a comprehensive analysis of IC disclosures across diverse geographical regions and industries, with the aim of identifying and

comparing distinct patterns and clustering tendencies. Moreover, conducting a qualitative inquiry into the content of IC disclosures has the potential to provide profound insights into the characteristics of such disclosures.

This study underscores the significance of IC as a complex and fluid concept within a constantly changing business environment. The cultivation of a more profound comprehension and consciousness regarding IC disclosures can ultimately lead to a higher level of informed strategic decision-making, improved allocation of resources, and the amplification of organizational value creation. By engaging in a systematic and rigorous process of investigation and analysis, we can strive towards a future in which the significance of IC is not only acknowledged but also efficiently leveraged for the advancement of both organizations and society at large.

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