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Measuring Intellectual Capital in Research Centre: an application of the extended VAIC model

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ABSTRACT

In the contemporary knowledge-driven economy, intellectual capital (IC) is vital for research technology centres (RTC). This study applies the extended VAIC model to evaluate the IC of an Italian RTC. The extended model, incorporating additional dimensions such as relational and innovation capital efficiency, is adapted to the unique needs of RTCs. Utilizing a single case study methodology, financial reporting data, and management insights, the study assesses the value creation of Alpha's IC and management's perception of the effectiveness of the IC measure. Results indicate that most of the value added to Alpha by IC is based on human capital. The perception of the management of the IC measure using the VAIC confirmed some of the limitations of a model based mainly on financial reporting figures. This paper contributes to the literature and practice of measuring IC providing recommendations on how to fill the gap in existing IC measurement for research centres, providing a comprehensive tool for strategic IC management.

Nell'attuale economia basata sulla conoscenza, il capitale intellettuale è fondamentale per i centri di ricerca tecnologica. Questo studio applica il modello VAIC esteso per valutare il capitale intellettuale di un centro di ricerca tecnologica italiano. Il modello esteso, che incorpora dimensioni aggiuntive come l'efficienza del capitale relazionale e dell'innovazione, è adattato alle esigenze specifiche di questi centri. Utilizzando una metodologia di studio di caso singolo, dati di rendicontazione finanziaria e approfondimenti gestionali, lo studio valuta la creazione di valore del capitale intellettuale di Alpha e la percezione del management sull'efficacia della sua misurazione. I risultati indicano che la maggior parte del valore aggiunto ad Alpha dal capitale intellettuale si basa sul capitale umano. La percezione del management riguardo alla misurazione del capitale intellettuale attraverso il VAIC ha confermato alcune delle limitazioni di un modello basato principalmente su dati di rendicontazione finanziaria. Questo articolo contribuisce alla letteratura e alla pratica della misurazione del capitale intellettuale, fornendo raccomandazioni su come colmare le lacune esistenti nella sua misurazione nei centri di ricerca e offrendo uno strumento completo per la gestione strategica di queste risorse immateriali.

Keywords: value-added intellectual coefficient; intellectual capital; IC measurement; IC valuation; Research Technology Centre; knowledge-intensive organisation; Case study

1 – Introduction

In the modern knowledge-driven economy, intellectual capital (IC) has emerged as a pivotal asset, particularly within organisations characterised by intensive research and technology where innovation, knowledge creation, and intellectual contributions are crucial. Over the past decade, various applications of the IC approach in these organisations, as well as in universities have been developed (Leitner, 2005; Sanchez et al., 2009; Secundo et al., 2010; Loyarte et al., 2018). In the context of this study, we will focus on entities referred to as Research Technology Centres (RTC). RTCs have been defined as innovation organisations (Loyarte et al., 2018), the reference is to knowledge intensive or R&D organisations. In the literature, the concept of IC has been less investigated in relation exclusively to research centres, such as Kim and Kumar (2009) and Carayannis et al. (2014). Most studies have analysed research centres in relation to universities – such as Scaringella (2022) – highlighting their complementary roles (Secundo & Elia, 2014; Bisogno et al., 2018). Recognizing the complexity and multifaceted nature of IC, this study aims to apply the extended Value Added Intellectual Coefficient (VAIC) model to assess and analyse the IC of an Italian RTC, aiming to address the critical gap discussed by Loyarte et al. (2018) in the existing IC measurement frameworks for research institutions. The decision to investigate an RTC in the Italian context is based on the observation that this specific aspect has not been sufficiently investigated in the existing literature.

Despite the growing recognition of IC as a critical factor in research institutions, measuring and evaluating its components remain major challenges due to their intangible nature. This study highlights the need for a more effective way to measure IC in RTCs. Veltri and Nardo (2008) argue that social reporting and IC reporting are interconnected, noting that much of the IC-related information is already embedded in corporate reports, such as social reports. This suggests that research centres could enhance IC measurement by leveraging existing tools, thereby reducing fragmentation and improving clarity. IC is crucial for research centres not only for assessment but also for strategic management. Fontana (2013) explored this concept further in his study, examining how IC contributes to urban planning. He found that IC plays a vital role in city governance and value creation. His findings indicate that IC should not be treated as an isolated metric but rather as an integral part of broader institutional strategies. This is particularly relevant for research centres, where effective IC management fosters innovation, attracts funding, and strengthens collaborations.

Loyarte et. al. (2018), in their study, investigate the IC in a research centre, focusing on how it is identified, managed, and utilized within these institutions. According to the literature, Loyarte et al. (2018) highlight that the major challenge in analysing IC for research centres is measuring and evaluating its components due to their intangible nature. The literature on IC measurement has evolved significantly over the past few decades, with various models and frameworks being proposed (Guthrie, 2001; Osinski et al., 2017), while also attracting significant criticism (Dumay, 2009; 2016; Dumay et al., 2018).

Early contributions by Edvinsson and Malone (1997) introduced the concept of the "IC Index" while Stewart (1997) emphasized the strategic management of IC as a critical factor for organizational success. Subsequent research by Bontis (1998) and Andriessen (2004) has expanded on these ideas, exploring the intricate relationships between Human Capital (HC), Structural Capital (SC), and Relational Capital. According to the Loyarte Loyarte of these three main components, Loyarte et al. (2018) use a balanced scorecard approach tailored to the unique context of research institutions to better capture the value of IC. The use of this model and its

results indicate a strong correlation between well-managed IC and the overall performance of research centres, with higher research output, better quality publications, and more significant technological advancements. Loyarte et al. (2018) emphasize the need for strategic management of IC, advocating for its integration into the broader strategic planning processes of research centres. However, the effectiveness of the use of the IC in the management decision making process requires a model to measure the IC able to show the value added by the use and development of intangible assets.

This study aims to fill the gap identified by Loyarte et al. (2018), applying the extended VAIC model to the IC components which incorporates additional IC dimensions that are particularly relevant to research centres. The VAIC model, initially developed by Pulic (2000), provides a robust framework for evaluating the efficiency of value-added by IC within organizations. Pulic's model focuses on three primary components: Capital Employed Efficiency (CEE), Human Capital Efficiency (HCE), and Structural Capital Efficiency (SCE). However, its conventional application has primarily focused on corporate environments, with limited adaptation to the unique context of research institutions. Bayraktaroglu et al. (2019) expanded the VAIC model by adding relational capital efficiency – in particular, with regard to the relationship with the client, it is defined as Customer Capital Efficiency (CEE) – and innovation capital efficiency – it is defined as Research Development Efficiency (RDE) – thus providing a more comprehensive assessment of IC. Following others (Kim & Kumar, 2009; Secundo et al., 2010; Carayannis et al., 2014; Loyarte et al., 2018), this study applies a single case study methodology and apply propose an integrative approach to adapt the extended VAIC model to the specific needs of an Italian RTC, which we will call Alpha, real name omitted for privacy reasons.

Founded by the Italian state with the aim of promoting research and technological development, Alpha is a predominantly publicly owned company that aims to conduct research in specific knowledge-intensive and high-tech fields. Alpha's main business is R&D. It participates in the main European and international research programmes, collaborates with universities and companies in Italy and other countries. About 350 employees work in Alpha, of whom more than 200 are dedicated exclusively to research and more than 100 are PhDs. The centre has carried out a total of about 100 research projects and experimental activities funded by the European Union and national and international clients. The main business is R&D, with the aim of enhancing the innovative performance of their customers and society. Due to its nature, its financing comes from a variety of sources, from industrial contract projects (usually through competitive tendering) and funded by public administrations (Regional Governments), but it also sees a significant participation of the main national industries in the sector and several SMEs. It is an incubator for knowledge-based spin-offs and aims to respond to the innovation requirements of companies and institutions.

Alpha, and other research centres cannot capitalise their R&D spending according to Italian law or accounting standards. This creates information asymmetries in capital markets because the book value does not reflect assets or future earnings (Lev, 1999). Moreover, the issue is even more relevant when Alpha competes for grants and research funds (Leitner, 2005). Alpha, like other RTCs, needs a model which includes that measure research and innovation otherwise everything at the centre will be deemed as intangible (Loyarte et al., 2018).

The application of VAIC model to this context aims to evaluate if using financial reporting information, supplemented by information provided by the management can offer a more

detailed and accurate assessment of the RTC's intellectual assets and their contribution to value creation.

The importance of IC in the chosen research centre cannot be overstated. Alpha is a knowledge-intensive environment where the primary assets are intangible. HC, encompassing the skills, expertise, and creativity of researchers, forms the bedrock of innovation and scientific advancement for Alpha (Subramaniam & Youndt, 2005). Additionally, Alpha' s SC, which includes the institutional knowledge, processes, databases, and patents, facilitates the efficient execution and dissemination of research activities (Youndt et al., 2004). Relational capital, involving networks and relationships with external entities such as universities, industry partners, and funding agencies, is another crucial component of the IC for Alpha, facilitating collaborative innovation and resource acquisition (Nahapiet & Ghoshal, 1998). The needs to measure Alpha's IC came from the management needs to effectively use these IC components to enable the centre to enhance its research outputs, attract funding, and foster innovation.

Aiming to support Alpha's management in this process, the primary objectives of this research are threefold: (i) to extend and refine the VAIC model for the application in Alpha context, (ii) to empirically evaluate the IC of this prominent Italian research centre and (iii) to provide actionable insights and recommendations for better management and optimization of IC within research it. These objectives are captured in the following research questions: *Is the extended VAIC model adequate to measure the IC of a research centre? Is the IC measure obtained with the extended VAIC model adequate from the management point of view?*

The study's results indicate that the value added by the IC, as measured by the extended VAIC model suggests a positive contribution of IC to Alpha's performance. However, the findings also reveal that only HC seems to have a clear impact on the measurements. The application of the model highlighted that the calculation of IC measurements with publicly available financial information is not satisfactory. The subcomponents of the extended VAIC model do not fully represent the IC of the centre, and management does not believe that these measures capture the investments and efficiency of the centre in the IC. The analysis of this case study shows an opportunity to improve the model with the collection and use of internal data and interaction with the management. This will allow a more accurate calculation of IC.

This study also acknowledges the limitations inherent in using a single case study. While it provides valuable insights into the application of the extended VAIC model in a specific context, the findings may not be generalizable to all research centres. Future research should consider a larger sample size and a diverse range of institutions to validate the model's applicability and effectiveness more broadly.

By addressing these research questions, this study aims to contribute to the academic discourse on IC measurement while offering practical implications for policymakers, administrators, and stakeholders in the research sector. In conclusion, the extended VAIC model represents a significant advancement in the field of IC measurement, offering a more holistic and tailored approach for research centres. Through this study, we aim to shed light on the intricate dynamics of IC in the Italian research context and pave the way for future research and application in similar institutions globally.

The remainder of the paper is organised as follows. *Section* 2 includes the literature review to define the research questions. The research methodology is described in *Section* 3. *Section* 4 includes the empirical results from the application of the extended VAIC model to the analysed RTC. *Section* 5 presents the discussion of the findings, whilst Section 6 includes the conclusions.

2 – Literature review

2.1 – *The Role of IC in RTCs*

IC has been examined in relation to different types of organisations, without any claim to completeness, such as listed firms (Chen et al., 2005; Firer & Mitchell Williams, 2003; Sardo & Serrasquiero, 2017 Smriti & Das, 2018; Chen & Rahman, 2023;), SMEs (Hermans & Kauranen, 2005; Khalique et al., 2015; McDowell et al., 2018; Mahmood & Mubarik, 2020; Demartini & Beretta, 2023), SMEs high-tech (Xu & Li, 2019), knowledge-intensive SMEs (Khalique et al., 2018), new ventures (Hayton, 2005; Zane, 2023), joint ventures (Gavana et al., 2021), family businesses (Greco et al., 2014; Grimaldi et al., 2016), and high and low tech firms (Tseng & Goo, 2005; Martín de Castro & Sápez, 2008; Delgado-Verde et al., 2016; Buenechea-Elberdin et al., 2018). Although, the broad discussion of the importance of the IC for organisations of all kinds, it holds particular significance especially for knowledge-intensive organisations (Petty & Guthrie, 2000; Kianto et al., 2010).

The concept of IC, when referring to knowledge-intensive organisations, is used to cover all the institution's intangible or non-physical assets including processes, capacity for innovation, intellectual property rights patenting and licensing, the tacit knowledge of its members and their abilities, talents and skills, the recognition by society, its network of collaborators and contacts (Swart & Kinnie, 2003: Khalique et al., 2018). In this perspective, IC often constitutes the primary asset as these organisations rely heavily on the expertise, skills, and creativity of their employees to drive innovation, develop new products or services, and maintain competitive advantage.

The main elements identified in the literature as part of IC encompass specific characteristics of research centres. (Loyarte et al., 2018). HC encompasses the knowledge, skills, and expertise of researchers and staff, and it forms the cornerstone of IC in research centres. This is due to inner aim of a research centre, where HC is essential in driving innovative output and scientific contributions (Curado et al., 2011; Secundo et al., 2017). Research centres must invest in training programs, workshops, and collaborative projects to enhance the skills and knowledge base of their researchers. This investment not only improves individual performance but also fosters a culture of continuous learning and innovation. Furthermore, the recruitment and retention of top talent are vital, as these individuals bring unique insights and drive the centre's research agenda forward (Ployhart et al., 2014).

In fostering an effective knowledge management and research activities, a pivotal role is played by the SC, which encompass supportive infrastructure, processes, and intellectual property. In particular the SC includes organizational culture, information systems, patents, trademarks, and research facilities. Effective management of SC ensures that knowledge is systematically captured, stored, and utilized, facilitating efficient research workflows (Kianto et al., 2014). Robust SC supports innovation by providing a stable foundation for research initiatives and fostering an environment conducive to scientific discovery (Kariuki & Kiambati, 2017). For example, a well-maintained database of research publications and patents can significantly enhance a research centre's ability to manage and disseminate knowledge. Additionally, advanced research facilities and laboratories are essential for conducting high-quality experiments and attracting top-tier researchers (Inkinen, 2015). Implementing advanced knowledge management systems also plays a crucial role in ensuring that valuable intellectual assets are effectively utilized and protected (Andreeva & Kianto, 2012).

The relationship with external stakeholders including academic institutions, industry partners, funding agencies, and the broader community is the core of the relational capital in the research centre (Nielsen & Dane-Nielsen, 2010). The relational capital comprehends the reputation, credibility, and ability of the research centre to secure collaboration and funding opportunities. Strong relational capital is essential for fostering strategic alliances, which can enhance the centre's research capabilities and impact (Camps & Marques, 2011). Collaborative networks facilitate the exchange of ideas and resources, contributing to the diffusion of innovation and the practical application of research findings (Lee & Miozzo, 2019; Hwang, 2023). Indicators of strong relational capital include the number of collaborative projects, funding secured from external sources, and the breadth of the centre's professional network.

Despite its significance, the management of IC in research centres faces several challenges. One critical issue is the difficulty in measuring and quantifying IC. Unlike physical assets, IC components such as knowledge and relationships are intangible and harder to evaluate. This lack of clear metrics can hinder effective management and reporting of IC (Sáenz et al., 2009). Additionally, research centres often operate under tight budgets and face pressure to demonstrate immediate results, which can limit their ability to invest in long-term IC development. Addressing these challenges requires adopting comprehensive IC management frameworks that can capture the nuanced value of human, structural, and relational capital (Bontis, 2001). Furthermore, the dynamic nature of research environments necessitates continuous adaptation and learning. As new technologies and methodologies emerge, research centres must remain agile and responsive. This requires fostering a culture of innovation where experimentation and knowledge sharing are encouraged (Du Plessis, 2007). Building such a culture involves not only formal training and development programs but also creating informal networks and communities of practice that facilitate continuous learning and collaboration (Wenger et al., 2002).

Effective management of IC requires significant investment in developing and maintaining these components, as well as overcoming challenges related to measurement and resource constraints. By addressing these issues, the research centres can achieve superior performance enhancing their innovation capacity, improving research outputs, and maintaining a competitive edge in the scientific community. Therefore, the ability to measure IC can help this organizations to efficiently use and leverage the IC. Moving from traditional financial measurements and applying a rational and holistic approach to measure the IC can help research centre to assess the effectiveness of their knowledge management strategies and track improvements over time. However, studies that have specifically investigated the role of the measurement of IC in knowledge-intensive organisations are scarce. Previous studies have focussed on HC measurement (Demartini & Paolone, 2011), the impact of IC on corporate performance (Cohen & Kaimenakis, 2007; Mehri et al., 2013) and government-university-industry R&D partnerships (Carayannis et al., 2014).

2.2 – *IC valuation models*

The interest on managing IC has led to the development of several methodologies to identify and measure intangibles' contribution toward value creation process efficiency (Sveiby, 2010; Osinski et al., 2017). Most of these methods rely on subjective judgments and have been developed by different companies for their internal use, considered to belong to pioneering studies (Veltri, 2007a) (e.g., the Skandia Navigator, the Intangible Assets Monitor; see Edvinsson

and Malone, 1997; Sveiby 1997, 2018). Among the financial valuation methods (Sveiby, 2010), the Value-Added Intellectual Coefficient (VAIC) model is one of the most widely used method by academics and practioners to investigate the measure the IC in different sectors and in both developed and developing countries (Firer & Mitchell Williams, 2003; Chen et al., 2005; Shiu, 2006; Barathi Kamath 2007; 2008; Zeghal & Maaloul, 2010; Laing et al., 2010; Greco et al., 2014; Santosa et al., 2023; Suciati et al., 2024). Applying a value creation approach, the VAIC differs from traditional asset-centric measurements model and stands out for its objectivity (Sveiby, 2010). The original VAIC model was developed by Pulic (2000; 2004) designed to assist managerial decision-making and enhance a firm's potential. Pulic's model offers a standardized and detailed approach to measure the economic impact and the efficiency of IC (Chan, 2009a; 2009b) by appraising the value creation across physical, structural, and human resources (Pulic, 2000). According to Pulic, there are two key resources that create value-added in companies: Capital Employed (CE) and IC. CE includes physical capital and financial capital, whereas IC consists of HC and SC: HC associated with employee expenditures, SC given by the difference between VA and HC; CE in the different configurations analysed previously.

Vaic model is defined not only as a valuation model, but also strictly as a measure of intellectual capital efficiency (Marzo, 2022). In total, three types of IC and three efficiency measures are considered to calculate the companies value-added. Basing the measurement of IC on publicly available audited quantitative information, the model overcomes the basic problems associated with the difficulties to identify clear measures for the IC elements (Clarke et al., 2011) and facilitates comparison across departments and firms in different sectors and countries (Tan et al., 2007; Maditinos et al., 2011). One of the main advantages is the possibility to assign an economic value to the overall IC and its components (unlike scorecard methods) (Silvestri & Veltri, 2014).

Despite its widespread adoption both in academia and practice (Ho and Mitchell Williams, 2003; Mohapatra et al., 2019; Xu & Li, 2019), several criticisms arise from the application of this model. Several scholars have criticised the measurement of the variables composing VAIC™ index, like the HC (Andriessen, 2004; Chan, 2009a; Marzo, 2022) or the SC (Stahle et al., 2011; Vishnu & Gupta, 2014). Stahle et al. (2011) argue that the VAIC simply measures the operating efficiency (labour and capital efficiency) of a company, and it does not provide a representative measure of IC. Similarly, other scholars criticized its monetary focus which may prevent a holistic management of value-creation strategy (Kok, 2007; Sveiby, 2010; Sydler et al., 2014). Other limitations of the VAIC model have been linked to the use of overlapping variables for calculation of IC and the inability to handle companies with a negative book value of shareholders' equity or negative operating result (Chu et al., 2011). Silvestri and Veltri (2014) addressed the problem of the additive property of the model, which does not consider synergies between different components. Some scholars have criticized the absence of the relational capital component in the model (Veltri, 2011; Vishnu and Gupta, 2014; Nassari & Nasab, 2014; Bayraktaroglu et al., 2019; Bassetti et al., 2020; Ahmad, 2023).

Considering these criticisms, numerous scholars have revised Pulic's model to address its limitations (Iazzolino & Laise 2013; Id., 2021), although criticism of the extended models was not lacking (see Marzo, 2024). Iazzolino and Laise (2013; 2021) have critically discussed the theoretical and methodological foundations of the VAIC model. According to them, Public's model does not suffer from conceptual vagueness (Stahle et al., 2011) but rather it is characterised by a semantic shift. The revision of the model has, therefore, introduced,

alternative measurements of SCE (Nazari & Herremans, 2007; Ahmad, 2023) and some other IC components (Phusavat et al., 2011; Vishnu and Gupta, 2014; Ulum et al., 2014), which were neglected by the original VAIC approach. For instance, Chang (2007) added innovation capital (InVC) and intellectual property capital to capture the totality of IC, while modified the original VAIC model by including two SC sub-components – innovation capital and relational capital – as control variables. Another modified VAIC model including RC is that of Vishnu and Gupta (2014), who considered marketing, selling and advertising expenses as a proxy for RC. Moreover, split SC into two sub-components: customer capital (CC) and organization capital (OR) – further subdivided into process capital and innovation capital (InVC). Similarly, Bayraktaroglu et al. (2019) have extended the VAIC methodology proposed by Pulic to provide more information about the interrelationship among IC components and their role in the organizational success.

However, these studies present inconclusive evidence regarding the effectiveness of the proposed modifications within the original VAIC framework. Hence, further empirical investigations are required to examine the validity of the extended VAIC methodology.

Our study aims to contribute to the IC valuation literature by testing the empirical validity of one of the most recent extensions of VAIC model, the one suggested by Bayraktaroglu et al. (2019). Based on the Turkish manufacturing sector, the study of Bayraktaroglu et al. (2019) highlighted how SCE has a positive impact on firms' profitability and how RDE has a direct impact on firms' productivity. This extended VAIC model not only incorporates additional IC components but also revises the measurement of Value Added (VA), considering proxies for IC components as asset-like investments rather than costs. Specifically, Bayraktaroglu et al. (2019) delineates IC into HC, Structural Capital (SC), and introduces two additional components, Customer Capital (CC) (Bose & Thomas 2007) and Innovation Capital (Chen et al., 2005, Vishnu & Gupta, 2014). In this model, CC has been included as the third IC component while innovation capital is emphasized as sub-component of SC (Edvinsson & Malone, 1997). Sales, marketing, and distribution expenses serve as proxies for CC, while Research and Development (R&D) expenses stand as proxies for innovation capital. Consequently, these expenses are treated as investments rather than costs in measure of the VA. This approach is consistent with prior research (Nazari & Herremans, 2007; Ulum et al., 2014; Nimtrakoon, 2015; Vinshu & Gupta 2014) and provide a more accurate measure of IC than the original VAIC model. These novel components should enhance the evaluation of VA and aligns with the investment-centric perspective (Bayraktaroglu et al., 2019: 413), similar to labor expenditures in Pulic's VAIC model. The calculation of extended VAIC model involves eight steps (compared to five in the original model).

1. The calculation of VA* considers the inclusion of the new components of the model:
   VA= Pulic's VA+ marketing and distribution expenses (labor expenses excluded) +*
   + R&D expenses (labor expenses excluded);
2. The determination of HCE* respects Pulic's formulation, considering the wording of the VA* according to the extended model:
   HCE=VA*/ HC;*
3. The determination of SCE* presents a modification, the calculation is modified for innovation capital as its sub-component, i.e., R&D expenses. SCE is the ratio of SC* (in the new formulation) to VA*:

$$SC^* = VA^* - HC - CC - RD$$
$$SCE^*=SC^*/VA^*;$$

4. The extended VAIC stipulates that the CCE must be considered:
$$CCE=VA^*/ CC;$$

5. The calculation of RDE:
$$RDE= RD/VA^*;$$

6. The determination of Intellectual Capital Efficiency (ICE):
$$ICE^* = HCE^*+SCE^*+CCE+RDE;$$

7. CEE is calculed,
$$CEE^*= VA^*/CE;$$

8. Finally, it is possible to calculate the VAIC* according to the extended model of Bayraktaroglu et al. (2019):
$$VAIC^*= ICE^*+CEE^*.$$

The analysis of the formula of the extended VAIC model appears to be essential for organizations seeking to unlock the full potential of their intangible assets. This is even more relevant for organizations such as research centres.

According to our discussion our *Research Question* is presented below.

RQ1: *Is the extended VAIC model adequate to measure the IC of a research centre?*

2.3 – *IC measure and management perception*

IC measurement serves as a strategic tool for management, offering tangible insights into the organization's intangible assets and guiding resource allocation decisions (Edvinsson & Malone, 1997). By quantifying HC through metrics such as skills inventory, employee turnover rates, and training investments, management gains a nuanced understanding of the organization's talent pool and its potential for innovation and growth (Mubarik et al., 2018). Similarly, the measurement of SC, including patents, proprietary technology, and organizational processes, enables management to identify areas for optimization and investment (Choo & Bontis, 2002). Relational capital measurement, encompassing customer relationships, supplier networks, and brand reputation, provides valuable insights into the organization's market positioning and external competitiveness (Choo & Bontis, 2002). However, the impact of IC measurement extends beyond operational decision-making to strategic planning and organizational culture. Effective IC measurement challenges traditional performance metrics and encourages management to adopt a more holistic approach to value creation (Kong, 2015). By quantifying the value derived from different components of IC, management can prioritize investments in talent development, innovation initiatives, and strategic partnerships (Kong, 2015). Moreover, IC measurement fosters a culture of accountability and transparency within the organization, setting performance expectations and incentivizing employees to contribute towards the organization's intangible asset base (Edvinsson & Malone, 1997). By providing insights into Human, Structural, and Relational Capital Efficiency, the extended VAIC model enables management to make informed decisions, foster a culture of innovation, and enhance organizational performance.

According to this assumption our Research Question is a s follow:

RQ2: *Is the IC measure obtained with extended VAIC model adequate from the management point of view?*

3 – Research method

This study uses a qualitative methodology based on a single case study, because there are no other cases available for replication (Loyarte et al., 2018).

Although the case study methodology has received criticism for lacking rigour (Yin, 1994), there are several advantages to using case studies. First, the examination of the data is most often conducted within the context of its use (Yin, 1994), that is, within the situation in which the activity takes place. Second, the detailed qualitative accounts often produced in case studies not only help to explore or describe the data in a real-life environment, but also help explain the complexities of real-life situations which may not be captured through experimental or survey research (Azzone & Manzini, 2008).

The complex nature of IC makes the use of the case study research method particularly suitable (Mouritsen, 2006). This method allows a holistic and in-depth investigation of a complex phenomenon in the context of real life in which it takes place, especially when it is not possible, or even desirable, as in this case, to separate the phenomenon from the context (Yin, 2003; Chiucchi, 2009). The main approaches followed for this case study are the instrumental case study, i.e., it analyses a more general problem to refine a theory (Stake, 1995) and theory-practice-oriented case study (Dul & Hak, 2008). The process followed in our approach to the case study supports the criteria of qualitative research with an interpretive-constructivist perspective: credibility, transferability, dependability and confirmability (Guba & Lincoln, 1994: 114). In our work we have applied the accepted theoretical phases of a case study (Eisenhardt, 1989; Scapens, 1990; Ryan et al., 2002; Yin, 2003; Eisenhardt & Graebner, 2007; Chiucchi, 2012; Taylor et al., 2015): (i) formulation of research questions; (ii) selection of cases; (iii) preparation to work in the field; (iv) collection of data; (v) analysis of data; and (vi) communication of research results. The chosen target is an Italian RCT which provides a typical example for answering our research questions. An RTC clearly represents a case where the IC requires adequate model for its measurement, able to capture the complexity of the intangible assets and the technological bets that are crucial to the survival of the RTC in the private, public, international, and diversified markets.

The use of the Italian RTC. which is called Alpha, as our case study is valid for the present work because the centre is developing a new method for valuing and reporting intangible assets. The analysis of this case will help the researchers to identify new meanings, different interpretations, new models of the phenomenon being studied, and new solutions to a given problem (Eisenhardt, 1989). The application to our RTC of the extended VAIC, as a business-economic valuation model of IC, is a challenge which opens the opportunity to contribute to the literature on the measurement and valuation of IC of RTCs. The application of the VAIC model is used to highlight the intangible assets that our RTC possesses and to critically reflect on the IC measure generated. The discussion of our results clarifies strengths and weaknesses of the VAIC model for these complex business realities and recommends possible developments of IC measures. Our approach overcomes one of the most limitations of the (single) case study (Ryan et al., 2002) because it assures the transferability of our results from one context to another, that is, to the adequacy with respect to the degree of comparability of different contexts (Lincoln & Guba, 1985).

The research process is based on different sources of evidence for data collection and analysis. Firstly, a semi-structured interview with a delegated manager of the preparation of the annual reports (in the organisational unit of the administrative management) of the chosen Italian RTC and, secondly, the analysis of the Italian RTC annual reports (2016-2022), as well as analytical and verification accounting documentation.

The interview is one of the most relevant sources of information for a case study (Yin, 2003) and in general is one of the most important methods of collecting qualitative data (Qu & Dumay, 2011). Our interview lasted about two hours, with the same person there and, in addition, there was a further informal exchange of information via email.

The second source of evidence is the analysis of documentation. Content analysis is a method of encoding the text of a written text according to selected criteria (Krippendorff, 2019). The analysis of the content of annual reports is a technique that has been used in IC research specifically to understand the aspect related to its reporting (Guthrie et al., 2004). In our work the analysis of the content of annual reports (and additional analytical accounting documentation) has been carried out to apply the chosen theoretical framework and practically apply a valuation of IC according to the extended VAIC methodology (Bayraktaroglu et al., 2019).

4 – Application of the Extended VAIC to the Italian RTC "Alpha"

The interview and content analysis of accounting documentation allowed the application of the theoretical framework. The analysed annual reports were tracked down by Alpha's website, while the additional analytical accounting documentation was shared by the delegated manager of the preparation of the annual reports after the interview date. The model has been implemented in Alpha over several years (2016-2022), so that this tool can be judged meaningful and useful.

The aim was to encourage the emerging of a medium-long term trend of the various coefficients taken into consideration by the model for a more effective analysis of the same.

The choice to start from 2016 (and not earlier) is essentially due to the change implemented by D.Lgs. 139/2015 for the criteria for allocating Research and Development expenses, which impacted on the 2016 annual reports. The financial statements prior to 2016 provide for a different allocation of these expenses, which we know to play a fundamental role of the adopted evaluation model. The choice of the starting year depended, therefore, on needs dictated by the homogeneity of the data analysed.

The Pulic model, in its original formulation, requires a modest degree of discretion in the choice of values to be considered (Vishnu, Gupta, 2014), consequently also the extended Vaic model follows the same. In general, in order for the VAIC methodology to work properly, the model requires adjustments to the pure balance sheet data, making reclassifications and using enterprise-specific and detailed information, which is not always disclosed in publicly available financial statements (Dzenopoljac et al., 2017).

We analyze below the implementation process, proposing the individual phases implemented.

The first phase involved the calculation of the starting data to structure the model. In the formulation of the extended VAIC, the proposing authors (such as Vaic's Pulic) start from the determination of the added value. The calculation of VA implies the identification of the components that need to be predetermined.

HC is representative of the employees-related costs incurred by the enterprise. The total value has been assumed from item B9 of the Income Statement of Alpha's financial statements. The data considered are the total labor expenses, including wages and salaries, social security contributions, provision for severance pay and other costs.

CC, according to the notion of the model, is given by the sum of the advertising and distribution expenses incurred by the enterprise. In Alpha, the individual cost items identified in the analytical economic and financial situations of the enterprise were evaluated, to understand in the analysed seven years which items were addressed to this type of activity. By doing so, the intention was to consider, under the heading relating to distribution, the expenses incurred for representation, while for advertising the expenses of advertising and the expenses incurred for exhibitions and fairs. These expenses were allocated in the income statement under the heading "costi per servizi diversi". The total of these items has been represented in a single value (for year).

Innovation capital (RD), representative of research and development expenses (net of labor expenses), deserves further study.

Among the others, Alpha produces research as a final product. Indeed, in the income statement there are specifically identified the revenues from research in the value of production. For this reason, a specific analysis has been carried out to consider only the R&D expenses incurred by Alpha to develop in-house research, the so-called self-financed research which falls within the notion of innovation capital.

The total value of these investments considered additional expenses, those incurred for employees training, booked in the income statement. The choice is essentially due to the consideration that it is a type of investment attributable to R&D, as confirmed by the interview. In addition, the enterprise is equipped with researchers, among the investments supported there is the expense of the related publications, indeed these investments have also been calculated in the overall determination of the innovation capital. For these reasons, the result is representative of the total sum (for each year) of the above items.

SC, as shown in the model, was calculated as the difference between VA (which we will clarify the determination below) and the two components of IC (HC and CC), considering the innovation capital subcomponent. Therefore, in this sense, the simple subtraction was made.

Capital employed (CE) was criticized in the original model and, consequently in the extended model. This is essentially due to the fact that in the formulation of the model the choice of Pulic and his successors in outlining the reference perimeter of the "capital employed" was not clear. This has provoked different configurations of the same in the literature. The configuration taken into consideration, in line with the extended model adopted, is that of Chen et al. (2005) in which the CE is given by the sum of the assets recorded in the balance sheet minus intangible assets.

Once the starting point was outlined with the data necessary to develop the model, the next step involved the determination of the VA to calculate the individual efficiencies.

The formulation of the VA* provides that the following components are added to the operating result (Output-Input): depreciation and amortization, expenses related to employees, advertising and distribution expenses and research and development expenses. These components are not considered expenses, but rather investments made by the company.

Subsequently, the HCE (VA/HC), the SCE (SC/VA), the RDE (RD/VA), the CCE (CC/VA) – understood as client capital – and, finally, the ICE (HCE+SCE+RDE+CCE) and CEE (VA/EC),

was determined. Finally, the VAIC was determined according to the Bayraktaroglu et al. (2019)'s Extended Vaic model. The results of the model application are shown in Table 1.

By observing the importance of each coefficient in the composition of the VAIC, we can identify the component which those that play a major role in the creation of value of the IC for Alpha: HC. This implies that the structure of wealth generation of Alpha is strongly linked to the human factor. In the literature several authors have pointed out that human resources are the hard part of IC in any company (Roslender & Fincham, 2001; Chen et al., 2004), however it is the component that can disappear when employees leave the company (Bontis, 1999; Laghi et al. 2022).

A higher value of VAIC indicates an efficient use and proper management of each capital included, with the positive result of a greater value created by the business. The overall trend of the Extended VAIC is over 1, which shows how the Ic contributes to the value of the Alpha.

Table 1 – Alpha's Extended VAIC (Our elaboration)

Indicators	2022	2021	2020	2019	2018	2017	2016
HCE	1,08	0,78	1,11	1,22	0,98	1,22	1,05
SCE	0,07	< 0	0,10	0,18	< 0	0,17	0,04
CCE	0,01	0,01	0,01	0,01	0,01	0,01	0,01
RDE	0,01	0,01	0,01	0,01	0,03	0,01	0,01
ICE	**1,16**	**0,49**	**1,21**	**1,40**	**0,95**	**1,39**	**1,09**
CEE	0,19	0,14	0,19	0,22	0,19	0,22	0,18
Extended VAIC	**1,34**	**0,62**	**1,39**	**1,61**	**1,14**	**1,60**	**1,26**

5 – Discussion of the results

To fully understand the meaning of the results in Table 1, we need to analyse the different efficiency measures and their trends over the period of analysis. The discussion of these results is based on the application of the VAIC reference values (so-called reference parameters) (Pulic, 2008) and the relative degrees of judgment: much worrying, worrying, relatively good performance, good performance, successful performance (see Table 2). The use of these parameters facilitates the valuation of productivity of the different components of IC.

Table 2 – Parameters of judgment of the original VAIC (Source: Pulic, 2008)

HCE	SCE	ICE	Judgement
≤1	0	≤1	Much worrying
1,13	0,12	1,25	Worrying
1,44	0,31	1,75	Relatively good performance
1,62	0,38	2	Good performance
≥ 2	≥ 0,5	≥2,5	Successful performance

The table, provided by Pulic (2008) on the basis of the original VAIC, considers the ICE as the sum of only HCE and SCE. In the extended VAIC the parameters must be extended considering that for the value of the ICE, the CCE and RDE are considered. The parameters have, therefore, been expanded. It was assumed, on the basis of the calculation formulas

applied, that the value of innovation capital and client capital (since the ratio is on expenditure to VA) have the same reference values as SC (calculated in the same way).

The parameters for the ICE shall be established by adding up their individual values. In this way, the weight of each component compared to the ICE remains unchanged. Table 3 shows the reference values as for our calculation in line with the extended VAIC.

Table 3 – Parameters of judgment of the extended VAIC (Source: own elaboration)

HCE	SCE	RDE	CCE	ICE	Judgement
≤1	0	0	0	≤1	Much worrying
1,13	0,12	0,12	0,12	1,49	Worrying
1,44	0,31	0,31	0,31	2,37	Relatively good performance
1,62	0,38	0,38	0,38	2,76	Good performance
≥ 2	≥ 0,5	≥ 0,5	≥ 0,5	≥3,5	Successful performance

5.1 – *Human Capital Efficiency (HCE)*

HCE indicator measures staff productivity and how much HC contributes to the creation of value attributable to IC. In the case in question, the HCE for Alpha has an average value of 1,06 with fluctuations observable in the years 2019 and 2021.

Comparing our result with the reference values, we see that the trend can be assessed as worrying (see Table 4).

Table 4 – Rating of Alpha's HCE (Source: own elaboration)

	2022	2021	2020	2019	2018	2017	2016
HCE	1,08	0,78	1,11	1,22	0,98	1,22	1,05
rating	worrying	much worrying	worrying	Relatively good performance	much worrying	Relatively good performance	worrying

A rating classified as worrying indicates that Alpha does not create enough value to ensure business development, and some inputs are not sufficiently covered, as well as some liabilities towards stakeholders (Pulic, 2008). In 2019 and 2017. Alpha presents relatively good performance. However, this result does not guarantee long term safety. Looking at the financial performance, although Alpha has liquidated all its liabilities, there is not enough left for future business investments (Pulic, 2008).

Supported by our interview and the documentation collected, it emerged that over the years Alpha has implemented a policy of increasing human resources with the aim of providing the centre with high skills and knowledge human resources. The HCE in 2019 and 2017 represents the maximum peak (albeit low) but in reality, there have been no significant investments in HC compared to other years, what has changed positively is rather the VA, which has impacted on the two values. Differently, 2021, influenced by the problems related to the Covid-19 pandemic, represents the minimum peak of HCE. In this case, the figure cannot be considered explanatory of the efficiency of HCE as it is subject to effects of exogenous causes.

The HCE in Alpha is, however, the component of IC best managed by the enterprise. These results are in line with what was observed in the interviews and documentation. The enterprise

invests in its employees and in its management report has a dedicated paragraph to human resources, although it is still weak in terms of information.

The management approach to HC shows how employees are not considered a cost incurred but rather a real investment that increases knowledge in Alpha. The centre encourages the participation of its employees through internal and external training programmes aimed at improving their skills. In particular, Alpha invests in its workers also thanks to the establishment of scholarships. The application of the VAIC shows its limit on this component because the value of HCE considers the added value of employees seen as a whole, without carrying out an in-depth analysis of other important investments attributable to HC. This aspect represents a strong limitation of the applied model, which should be further adapted to the context analysed and assign to the calculated value other possible values attributable to the skills and knowledge applied by HC.

It must be noticed that a useful approach would be to separate the added value by individual department and identify the departments of Alpha which add (or destroy) value for this component of the IC. This will offer a holistic analysis of the contribution to the value of the various departments to the VA by HC, trying to understand the causes that determine the lower contribution of others.

5.2 – *Structural Capital Efficiency (SCE) and Innovation Capital Efficiency (RDE)*

The SCE is the indicator which clarifies the share of added value created thanks to the contribution of SC. In this case, SCE for Alpha has an average value of 0.03, which is significantly low (much worrying) (see Table 5).

Table 5 – Rating of Alpha's SCE (Source: own elaboration)

	2022	2021	2020	2019	2018	2017	2016
SCE	0,07	< 0	0,10	0,18	< 0	0,17	0,04
rating	*much worrying*	*much worrying*	*worrying*	*worrying*	*much worrying*	*worrying*	*much worrying*

This measure shows investments in building corporate culture, information and technological systems, intellectual property (patents, copyrights and trademarks), management processes and organizational learning skills that create value for the centre. The low level of Se contribution appears to be in line with the limitation of the approach followed in the formula to determine the SCE which confirms various criticisms advanced by the doctrine (Stahle et al., 2011; Vishnu & Gupta, 2014; Nimtrakoon, 2015; Bassetti et al., 2020).

Specific components should be provided to determine it and not consider it as a variable inversely proportional to HC. In addition to the choice of additional components, a different formula could be envisaged, for example, considering (as in the case of HCE and CEE) the VA in the numerator (VA/SC), as suggested by Vinshu and Gupta (2014).

The trend of RDE, as considered in the VAIC extended model, is a subcomponent of SC and is determined on the basis of the expenses incurred for R&D.

In the case of Alpha, it should be noted that implementation has shown a negative contribution over the years, which, according to model's evaluation parameters, is considered highly concerning. Comparing our result with the reference values, we notice how the value appears negligible (see Table 6).

Table 6 – Rating of Alpha's RDE (Source: own elaboration)

	2022	2021	2020	2019	2018	2017	2016
RDE	0,01	0,01	0,01	0,01	0,03	0,01	0,01
rating	*much worrying*	*much worrying*	*much worrying*	*much worrying*	*much worrying*	*much worrying*	*much worrying*

According to the extended VAIC model and its basic concepts, the result obtained in our case would imply that the innovation capital of Alpha does not add value to the centre, but for the specific activities carried out by Alpha, it is clear how innovation capital is the core of the business. This indicator is the one that caused the greatest concern during the interview, where it is clarified how a significant share of the activities of Alpha is oriented towards research and development, which represents a distinct final output of the business cycle. This consideration implies that the search for Alpha can be found, as a positive component, in sales revenue and, as investments made, in costs broken down by kind in the income statement . In Alpha distinguishing R&D activity from everything else is very complicated; almost all investments are made in R&D, which, as mentioned, is the centre's core business.

The limitation of the trend of the IC component is closely related to the specific characteristics of the RTC and its activities. A possible solution could be to consider this subcomponent as a fundamental part of SC. It would be advisable not to subtract it from the SC and to represent it, for the extended model, implicitly in the HSE value, providing specific additional information through analytical-narrative data.

5.3 – *Customer Capital Efficiency (CCE)*

The CCE reveals how much it contributes to the creation of value attributable to IC. In this specific instance, the CCE for Alpha has an average value close to 0, remaining negatively constant.

Comparing our result with the reference values, we notice how, as for RDE, the value appears negligible (see Table 7).

Table 7 – Rating of Alpha's CCE (Source: own elaboration)

	2022	2021	2020	2019	2018	2017	2016
CCE	0,01	0,01	0,01	0,01	0,01	0,01	0,01
rating	*much worrying*	*much worrying*	*much worrying*	*much worrying*	*much worrying*	*much worrying*	*much worrying*

It is interesting to note that in this case there was a different reaction from the interviewee. The value seems to be in line with the activity carried out by Alpha, with respect to both advertising and distribution costs.

For marketing expenditure, the enterprise does not invest in advertising as the sector in which it operates, and the activities carried out by it do not require such investment. Alpha maintains moderate and constant advertising expenses, as well as related expenses attributable to fairs and exhibitions.

For these reasons, the efficiency of Alpha's relational capital shows a low contribution to added value. The choice to use advertising and distribution costs as a proxy, both for the specific characteristics and for the sector to which Alpha belongs, does not allow a real awareness of the relational capital of the same.

5.4 – *Intellectual Capital Efficiency (ICE)*

In conclusion, after the analysis of the individual coefficients, we analyze the ICE of Alpha (see Table 8).

Table 8. Rating of Alpha's ICE (Source: own elaboration)

	2022	2021	2020	2019	2018	2017	2016
ICE	1,16	0,49	1,21	1,40	0,95	1,39	1,09
rating	worrying	much worrying	worrying	worrying	much worrying	worrying	worrying

The analysis presents a much worrying/worrying trend, which allows us to believe that Alpha, according to the model implemented, does not create enough value to cover the expenses incurred. This opens room to an in-depth discussion on the adoption of the VAIC model for the IC of Alpha. It is necessary to underline that the reliability (both of the indicators of ICE and of its components), is strongly influenced by the ability of financial reporting figures to represent the complex company resources employed in the enterprise, resulting from internal choices but, even more, to criteria for allocating the elements (assets, liabilities, expenses and revenues).

6 – Conclusions

The implementation of the extended VAIC model in Alpha aimed to assess its effectiveness in highlighting the added value of IC in an Italian RTC and to determine whether management considered this measure adequate. The enterprise showed a consistent trend with overall VAIC indicators exceeding 1, primarily driven by the HC component. This trend enabled the company to quantify IC efficiency and prompted a reflection on IC investments and their recognition in financial statements. However, the VAIC model revealed limitations in accurately representing the true value and potential of the RTC's IC. Specifically, the model's components and their lack of interaction posed challenges. The dynamic interplay between IC components is crucial for strategic advantage, especially for high-tech companies. The data used in the model, derived exclusively from company accounts, are limited by stringent national financial statement criteria.

One of the key contributions of this study is its extension of IC measurement to research centres, a context that has been largely overlooked in the existing literature. Unlike traditional firms, RTCs operate in an environment where research and innovation outputs are the primary sources of value. However, financial reporting standards do not allow for the capitalisation of R&D spending, leading to information asymmetries in financial disclosures. This reinforces the argument by Veltri and Nardo (2008) that IC measurement should be integrated with social and non-financial reporting, rather than relying solely on financial statement figures.

The extended VAIC model struggled with assessing innovation capital and relational capital, which appeared almost non-existent in Alpha's context. The method used for these components was not useful, indicating a need for more tailored analyses. Consequently, the extended VAIC model did not sufficiently capture Alpha's IC value. While it served as a historical tool for added value creation, it failed to provide significant insights for forecasting and strategic decision-making process, including showing specific IC component identification and investment choices. Discussions during interviews confirmed the interpretation of the results of this case study and highlighted the need for additional information to be retrieved and included in the

model for the IC measure to be considered suitable by the management. Overall, while the VAIC model measures a company's intellectual capacity to exploit resources, it fell short in providing a comprehensive view of Alpha's IC.

From a practical perspective, the study underscores the importance of strategic IC management in research centres. Effective IC measurement can enhance an organisation's ability to secure funding, foster collaborations, and drive innovation. However, our findings reveal that the extended VAIC model does not fully capture relational and innovation capital, suggesting that additional non-financial metrics should be incorporated to provide a more comprehensive evaluation of IC in RTCs.

This study is not without limitations. The single case study approach provides in-depth insights but limits the generalisation of findings. Future research should explore cross-country comparisons of RTCs to assess the impact of institutional and regulatory differences on IC measurement. Moreover, further studies could integrate qualitative data from interviews and alternative performance measurement models, such as the Balanced Scorecard or Integrated Reporting frameworks, to enhance the accuracy of IC assessment in research centres.

Finally, given the increasing role of big data and artificial intelligence in corporate reporting, future research should investigate whether machine learning techniques can be leveraged to develop more dynamic IC valuation models that integrate financial, social, and operational data.

By addressing these challenges and research avenues, this study contributes to the ongoing academic and managerial discourse on IC measurement in knowledge-intensive organisations, paving the way for more refined and strategic approaches to intellectual asset management in research institutions.

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