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Intellectual capital valuation in digital economy: a review of corporate and national perspectives

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Abstract: Intellectual capital (IC) has emerged as a critical driver of organizational value and competitive advantage in the knowledge-based economy. Unlike tangible assets, IC encompasses intangible assets such as human capital, structural capital, and relational capital, which collectively contribute to the innovative capacity and strategic positioning of firms and economies. Despite its significance, measuring intellectual capital poses substantial challenges due to its intangible nature and the lack of standardized valuation methods. This paper aims to provide a brief overview of the components and methods used in the measurement of intellectual capital at both corporate and national levels.

1 Introduction

In contemporary academic theory and practice, there are various approaches to valuing intangible assets. The methods for measuring and valuing different types of intangible components of intellectual capital (IC) depend on the analyst's definition of the intangible asset, and the specific objectives of the analysis. The definition of proxy indicators representing intangible IC components is primarily determined by the scope of economic research. Consequently, macroeconomic approaches to valuing intangible IC components focus on different goals and use different proxy indicators than microeconomic methods.

Many scholars view intellectual capital (IC) as a combination of intangible assets held by individuals, companies, institutions, communities, and regions, which are the primary source of intellectual potential.

At the corporate level, intellectual capital can be defined as a combination of intangible assets that enable a company to function [1,2]. From a strategic perspective, the concept of IC can provide answers to key questions regarding the sources of future profitability [3]. Moreover, in terms of corporate innovation activities, intellectual capital can be viewd as the primary dynamic force driving innovation and economic performance in the knowledge economy [4].

Additionally, IC is characterized as collective wisdom and energy, posing challenges in both quantification and management. In synthesis, corporate intellectual capital stands as a pivotal and intricate asset shaping organizational operations, strategic trajectories, and innovative capabilities, notwithstanding the complexities inherent in its quantification and management [5].

The definition of intellectual capital at the national level is quite similar to that at the corporate level, however with a focus on different objectives. The macroeconomic significance of intellectual capital stems from the fundamental goal of every government, which is to provide favorable conditions for economic growth and enhance the overall welfare of its population. Therefore, at the macroeconomic level, national intellectual capital is perceived as a crucial factor that determines the wealth of nations, positively impacting productivity and the competitiveness of the country. National intellectual capital encompasses intangible assets embodied in individuals, businesses, institutions, communities, and regions, representing a fundamental source of wealth, prosperity, and the most important wellspring of a country's productivity in the contemporary knowledge economy context [6]. Unlike corporate intellectual capital, which primarily consists of human and structural capital, which further include customer, organizational, innovative, and process capital [7], national intellectual capital is defined in terms of four main pillars: human capital, market capital, process capital, and renewal capital [6,8]. Some authors include financial capital as an additional pillar of national intellectual capital [9], which comprises indicators like GDP, external debt, industrial production by major branches, and inflation.

It is necessary to note that measuring intellectual capital (IC) is challenging due to its intangible nature and the lack of standardized methods for quantification and comparison. The complexity of this phenomenon makes accurate measurement difficult at both the corporate and national levels. Additionally, obtaining precise data on IC can be tough, and integrating these metrics with traditional financial reporting framework poses further issues. However, a brief classification of methods for measuring IC will be discussed further in this paper.

2 Methods for measuring IC

Measurement of intellectual capital is crucial for understanding which intangible assets drive economic growth and innovation. The information obtained reveals strengths and weaknesses in human capital, infrastructure, and institutional frameworks, guiding policy-making and investment decisions. Evaluating intangible capital helps not only enterprises but also regions and nations enhance their competitiveness and adaptability in the global environment. It promotes sustainable development by identifying areas that require improvement, such as education, research and technology, thereby ensuring long-term prosperity and resilience.

In exploring the methods for valuing intangible assets, several authors provide a comprehensive overview of methods for measuring intellectual capital (IC). They identify and briefly describe 42 approaches to determining the value of intangible assets at both national and corporate levels. These methods are often classified into four categories based on common characteristics. The brief description of the four groups of methods is discussed below [10-12]:

Methods for Direct Intellectual Capital Measurement (DICM) involve valuing corporate intellectual capital through methods based on the monetary estimation of individual intangible components of IC. These components can be valued individually or expressed as an aggregated index. By using selected methods to separately assess each IC component, a company can gain a clearer picture of its intellectual wealth [13,14]. Some authors emphasize that the precise and relatively simple methodology of these procedures allows their application at any level within the organization [15].

Market Capitalization Methods (MCM) derive the value of IC from the existing differences between the market value of the company and its book value. Similar to DICM, MCM represents a monetary approach to valuing intangible assets, allowing for the comparison of companies within the same industry. However, specific methodologies within this group cannot provide a detailed picture of the intangible nature of all components of a company's intellectual capital [13]. Despite the range of understandable and easily applicable methods encompassed by the MCM cathegory, its greatest drawback is that changes in the market value of a company's shares are not entirely under management control, especially during mergers, acquisitions, or short-term economic cycles, which can cause fluctuations in interpreting the real value of the company's IC [10]. Additionally, the authors point out that market capitalization methods do not allow for the comparison of companies of different sizes without excluding the factor of the size of the compared companies.

Return on Assets Methods (ROAM) include methods based on return on assets and methods that calculate the profitability of individual intangible assets of a company. The main advantage of using ROAM methods is their simplicity and clarity, as ROAM procedures are based on traditional accounting principles [14]. This approach is also suitable for testing and comparing different companies within the same industry. However, calculating return on assets indicators often involves a discount factor based on the interest rate or the required rate of return. While this takes into account the time value of money, it also means that the values of these indicators will differ at different points in time. It is worth to highlight one disadvantage of the ROAM approach: it cannot identify which element is the key driver in the value creation process due to the lack of a unified definition of IC. Additionally, ROAM methods do not provide information on how to potentially improve results [10,16].

Scoreboard Methods (SCM) allow for the valuation of intangible assets through specific indicators and indexes calculated for various components of intellectual capital (IC). These methods are highly complex and can be finely tuned to align with the development strategy of a particular company. One of the greatest advantages of these methods is their applicability to companies of any size and in any industry, regardless of how the individual components of intellectual capital are defined within the company [10,14]. The methods encompassed by this approach allow for the capture and valuation of knowledge contained within human capital not only at the microeconomic level but also at the macroeconomic level. This enables the assessment of the quality of education and the individual competitiveness of people in both microeconomic and macroeconomic tasks [6]. A significant limitation of SCM methods is that each company creates its own index that takes into account all the specific aspects of its business activities and environment. As a result, it is very challenging to compare competing companies based on models created using the SCM approach [10].

3 National Intellectual Capital Index (NICI)

One significant method within the scoreboard approaches is the National Intellectual Capital Index (NICI), first introduced by Nick Bontis in his 2004 study [6]. The NICI methodology offers a comprehensive framework for measuring and evaluating intellectual capital (IC) at macroeconomic level, recognizing intangible assets as critical drivers of economic performance and competitiveness of a country. Its methodology focuses on four key components: human capital, market capital, process capital, and renewal capital [6,8].

The method begins with selecting relevant indicators, both quantitative and qualitative, to represent each

category of NICI. Data for these indicators is then collected from reliable sources, including national statistics agencies, international organizations, and academic studies. To ensure comparability, the data undergoes normalization using statistical methods such as z-scores or min-max normalization. Next, the normalized indicators are assigned weights based on their perceived importance and then aggregated to form composite indices for each category of intellectual capital. These weighted and aggregated indicators are then combined to calculate the overall NICI. Subsequently, the resulting indices are analyzed to identify patterns, strengths, and weaknesses in the nation's intellectual capital, which includes examining causal relationships between intellectual capital and economic performance [6,8].

3.1 Components of National Intellectual Capital Index

The most important component of National Intellectual Capital Index is national human capital. Just as employees, with their unique qualities, create value for a company, citizens contribute to the economic growth of a country. ***The national human capital*** includes knowledge, expertise, intuition, and the ability to achieve national goals, along with values rooted in the nation's culture and philosophy. It reflects the population's capabilities in education, health, experience, motivation, and entrepreneurship, as well as the presence of a skilled labor force and available scientists and engineers. These factors are essential for creating and maintaining a nation's competitive advantage. As the most crucial link in the value creation process, human capital underpins the development of other intellectual assets like R&D and training [9].

The goal of every country is to advance in the global environment, and national market capital reflects the ability of the economy to keep up with global trends. ***National market capital*** encompasses a nation's assets in its relationship with the international market, reflecting its capabilities and successes in meeting global client needs through competitive and high-quality exports [6]. It includes factors such as customer loyalty, openness to globalization, economic resilience, and satisfaction from strategic customers and trading partners. These elements collectively enhance the nation's attractiveness and competitiveness on the global stage [9].

National process capital, which involves the cooperation and flow of knowledge supported by structural intellectual assets like information systems, databases, and national infrastructure, plays a pivotal role in the EU's digital transformation. This synergy is complemented by human capital, encompassing skills, expertise, and knowledge possessed by individuals, further enhancing the effectiveness of digital transformation[9].

By fostering digital infrastructure and investing in areas such as IT skills and communication networks, the European Union (EU) aims to enhance its digital capabilities and competitiveness. These efforts, combined with improvements in technological readiness, cybersecurity measures, and research institutions, align with the EU's objectives to foster innovation and digital resilience across European countries [17].

Another crucial component of national intellectual capital is ***National renewal capital***, which encompasses a nation's investments aimed at bolstering its competitive advantage in future markets and fostering subsequent growth. These investments span areas such as research and development, patents, trademarks, startup ventures, and innovation capacity, driving the nation's advancement and competitiveness [9]. By driving the development of new technologies, processes, and capabilities necessary for digital transformation, renewal capital plays a pivotal role in enabling nations to adapt to the evolving digital landscape and harness the full potential of digital technologies for economic and social advancement.

Therefore, knowing the value of intellectual capital at the macroeconomic level is crucial for identifying key areas of strength and improvement, driving economic growth and innovation. Moreover, this understanding also empowers policymakers and investors to make well-informed decisions, thereby fostering long-term competitiveness and sustainable development within the global knowledge economy.

3.2 Methodology of National Intellectual Capital Index

The NICI index consists of multiple quantitative and qualitative variables. To integrate both quantitative and qualitative variables and compute cumulative indices for the internal constructs of the NICI, several steps are must be undertaken, as expressed mathematically below [6,8]:

The first step (1) involves transforming variables with negative values:

$$\bar{r_{ij}} = r_{ij} + |min\, r_{ij}| + 1 \quad (1)$$

where r_{ij} is the value of the variable *i*, alternative *j*; $min\, r_{ij}$ is the minimum value of the variable *i*, alternative *j*.

This step is crucial, because transforming variables with negative values enhances the reliability, interpretability, and comparability of the NICI calculation process [8].

The second step (2), (3) involves normalizing variables by adjusting them to a common scale, such as between 0 and 1, to eliminate differences in their scales without altering their relationships [8]:

$$r_{ij} = \frac{min\, r_{ij}}{r_{ij}} \quad (2)$$

$$r_{ij} = \frac{r_{ij}}{max\, r_{ij}} \quad (3)$$

where r_{ij} is the value of the variable i, alternative j;
$min\, r_{ij}$ is the minimum value of the variable i, alternative j.
$max\, r_{ij}$ is the maximum value of the variable i, alternative j.

The third step (4) involves calculating cumulative indices using the Simple Additive Weighting (SAW) method, which is executed as follows [8]:

$$S_j = \sum_{i=1}^{m} \overline{w_{ij}}\, r_{ij} \quad (4)$$

where S_j represents the multi-criteria measurement value of alternative jj.
w_{ij} denotes the weight of variable i.
r_{ij} is the normalized value of variable i for alternative j.

The insights gained from the NICI are invaluable for policymakers, as they help identify areas that need investment and development to enhance national competitiveness. Additionally, the NICI serves as a benchmarking tool, allowing nations to compare their performance against other countries and understand their relative strengths and weaknesses. Businesses and government agencies can also use these insights for strategic planning and investment decisions. However, challenges such as data availability, subjectivity in weighting, and the dynamic nature of intellectual capital can impact the accuracy and applicability of the NICI results. Despite these challenges, the NICI provides a structured and systematic way to measure and analyze the intangible assets that drive a nation's competitiveness [8].

4 Popularity of National Intellectual Capital methodology among researchers

Despite the growing interest in assessing national wealth and intellectual capital, the research area focusing on evaluating IC through the use of NICI methodology is not extensive. This fact is indicated by the number of records of articles in one of the word´s leading database – Web of Science (WoS).

Searching the Web of Science database using keywords like "national intellectual capital" and "national intellectual capital index" as of June 12, 2024, we found only 95 publications addressing these topics covering the period from 2007 to 2024. Looking at the popularity of the topic over the years, we can conclude that the highest number of publications came out in 2014 (40 publications), making up 42.11% of the total records.

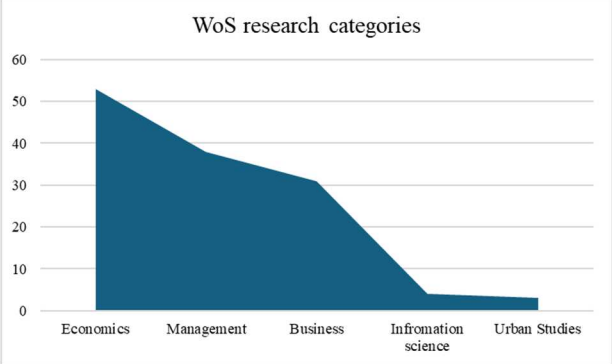

Figure 1 Record count of WoS Categories

The breakdown across various thematic categories reveals that "Economics" leads with the largest share at 55.79%, followed by "Management" at 40.00%, and "Business" at 32.63%. "Information Science" accounts for only 4.21% of publications, while "Urban Studies" makes up just 3.16%. Other categories were comparatively less significant, each contributing less than 2% to the total.

Examining the geographic distribution of individual publications reveals that Finland contributes the highest number with 38 publications, accounting for 40% of the total records. Taiwan follows with 9 publications, representing 9.74% of the records, closely followed by Lithuania and Spain, each with 8 publications. Minor contributors include Vietnam with 5 publications, Romania with 4, and Sweden with 4. Croatia, China, Poland, and the USA each have 3 publications. Other countries have 2 publications or fewer.

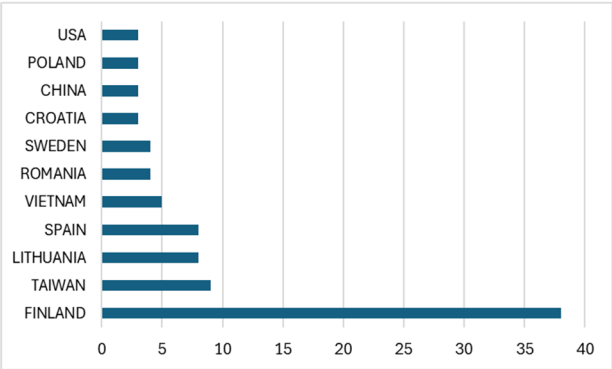

Figure 2 Leading countries in field of NICI research

In the domain of national intellectual capital research, a few authors have emerged as pivotal contributors. Leading figures in this field include Lin C.Y.Y., who has been featured in 43 publications, Edvinsson L. with 41 publications, Beding T. with 35 publications, Chen J. with 32 publications, and Markkula M. also with 32 publications. Notably, the author of the original NICI methodology, Bontis N., has only one publication listed in the Web of Science database.

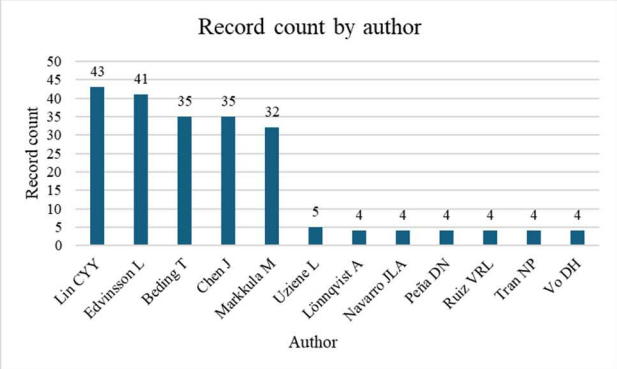

Figure 3 Leading authors in field of NICI research

Interesting findings from some notable publications point out that national culture, described as the intentional efforts of people to manage their surroundings and reduce uncertainty, can significantly influence the intellectual capital of countries [18]. Moreover, national human capital is regarded as the most crucial component of national intellectual capital, driving a country's economic performance and prosperity .[19,20]. Additionally, studies indicate that the Nordic countries may have higher values of national intellectual capital compared to other OECD countries [21]. Overall, the findings highlight key areas for improvement across multiple countries: enhancing university-enterprise cooperation, employee training, intellectual property rights protection, fostering a fair business competition environment, and investing in basic research. Strengthening specific aspects like patents, business R&D, and transparency in government policies is crucial for promoting development and fostering innovation, which in turn stimulates GDP growth [22].

Despite the valuable insights provided by the NICI methodology, its complexity and significant data requirements have limited its popularity among researchers [6]. Additionally, the lack of standardization in defining and measuring components of intellectual capital across different countries or regions complicates cross-country comparisons [13]. Moreover, the inherent intangibility of intellectual capital makes it challenging to measure the individual components of NICI with traditional metrics [16]. Nevertheless, NICI can still offer valuable strategic insights for policymakers and governments capable of implementing it effectively.

5 Conclusion

In today's knowledge-driven global economy, the measurement of intellectual capital is essential for understanding the intangible assets that fuel economic growth and innovation. This paper has briefly discussed the role of intellectual capital at the macroeconomic level and provided a brief description of several methods for its measurement. The main contribution of our paper lies in explaining the key components of national intellectual capital and methods for its measurement.

The discussed methods, including Direct Intellectual Capital Methods (DICM), Market Capitalization Methods (MCM), Return on Assets Methods (ROAM), and Scoreboard Methods (SCM), offer diverse approaches to evaluating the intangible components of intellectual capital. Each method has its strengths and limitations, but together, they provide a comprehensive framework for assessing intellectual capital at different levels.

One particularly valuable method discussed in this paper is the "National Intellectual Capital Index", which focuses on assessing intellectual capital at the macroeconomic level. This approach serves policymakers, enabling economies to adapt to digital advance, and drive economic and social progress. Therefore, it is essential for governments to prioritize enhancing digital infrastructure, investing in IT skills, and fostering innovation to strengthen national digital capabilities and competitiveness.

We specifically examined the popularity of the NICI method among researchers and discovered that its complexity poses a barrier to its extensive adoption among researchers. Based on this paper, we see an opportunity for further research aimed at precisely quantifying the components of NICI and conducting a study offering novel practical insights in this topic.

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