



LUND UNIVERSITY

School of Economics and Management

Master programme in Economic Growth,  
Innovation and Spatial Dynamics

## National Intellectual Capital: Concept and Measurement

Volha Lazuka

[volha.lazuka.599@student.lu.se](mailto:volha.lazuka.599@student.lu.se)

*Abstract:* Intellectual capital (IC) is a recent area of research that recognizes the importance of intangibles for wealth creation. Currently several IC models have been proposed for a national level. These models are ready to establish how national intellectual capital (NIC) should be optimized and directed to induce economic growth. The main threat from these proposals is whether NIC models are valid to identify economic effects and instrument inter-nation comparative analyses. The potential flaws for their validity are primarily hidden in specificity of emergence and development of NIC approach that has been replicated from micro studies and not yet conceptualized. On the other hand, NIC models are challenged to operationalize the complicated nature of NIC that allows for multi-dimensional interpretation in concepts and measurements. This thesis justifies current NIC models that respond to these conceptual and methodological challenges. The major notion of this justification is that NIC approach may receive solid support from long-established growth theories. The analysis conducted through the chosen validation framework provides insights for future research.

*Key words:* National intellectual capital, economic growth, composite index

### EKHR71

Master thesis (15 credits ECTS)

June 2012

Supervisor: Anders Nilsson

Examiner: Lennart Schön

## CONTENTS

Preface .....	3
List of abbreviations .....	4
List of tables .....	5
List of figures .....	6
List of appendices.....	7
1. Introduction.....	8
1.1    Research problem .....	8
1.2    Research question .....	11
2. Theory .....	12
2.1    Previous research.....	12
2.2    Theoretical approach .....	15
3. Data and methods.....	22
3.1    Methodology.....	22
3.2    Data.....	23
3.3    Analysis techniques .....	27
3.4    Limitations.....	28
4. Analysis.....	30
4.1    Content validity .....	30
4.1.1    Conceptualization of the model.....	30
4.1.2    Operationalization of the model.....	35
4.2    Construct validity .....	42
4.2.1    Reliability .....	42
4.2.2    Convergent validity .....	44
4.2.3    Discriminant validity.....	45
4.2.4    Nomological validity.....	47
5. Conclusion .....	52
References .....	55
Appendix .....	67

## Preface

Human capital theory and empirics has been a traditional field of research at Polotsk State University in my native country for decades. Having joined research community I decided to begin an investigation of the new phenomenon in this area – national intellectual capital. My efforts to examine this topic and discuss it with my research colleagues on conferences resulted in publication of several articles and reports, and encouraged me to study abroad.

With studies at Lund University my research field has assumed a new dimension – more solid and even paradigmic – economic growth and intellectual capital. It appears that courses chosen and lecturers who held them throughout this academic year contributed highly into this thesis from an applied perspective: Lennart Schön on the Economic Growth course that gave theoretical and empirical foundations for Growth Theories; Jonas Ljungberg on the Economics of Innovations course that provided insight into approaches to innovation and its measurement; Anders Nilsson on the Human Capital course that gave the consideration of human capital concept and its interconnection with economic growth; Christer Gunnarsson on the Institutions and Economic Growth course that exemplified perfectly how to analyze and discuss complex intangible phenomenon.

I sincerely thank all lecturers for guidance throughout courses and freedom to fulfill all my inconceivable ideas in papers and discussions. Thank you to my supervisor Anders Nilsson for support and possibility to choose whatever dimension of research and implement it with your valuable advice. I strongly wish to thank Pirjo Ståhle, an expert in the field. Thank you for your interest shown to my research, constructive feedback, and encouragement. I want to express my gratitude to Julianne Stewart-Sandgren, consultant on academic writing at Lund University. Thank you for your invaluable support and warm-hearted help. Thanks to Swedish Institute Visby's Scholarship programme for opportunity to study at Lund University. Thank you to my family and to my closest friends. Your support was essential to cope with the great pressure in completing this thesis overseas.

## **List of abbreviations**

- BERD – business enterprise sector expenditure on research and development
- EPO – European Patent Office
- ESS – European Social Survey
- EU – European Union
- GDP – gross domestic product
- GERD – gross domestic expenditure on research and development
- IC – intellectual capital
- ICT – information and communication technologies
- IMD – International Institute for Management Development
- ISCED – International Standard Classification of Education
- L&E – Lin & Edvinsson
- NIC – national intellectual capital
- OECD – Organization for Economic Co-operation and Development
- PPP – purchasing power parity
- R&D – research and development
- UN – United Nations
- UNDP – United Nations Development Programme
- USPTO – United States Patent and Trademark Office
- WB – World Bank
- WEF – World Economic Forum

## **List of tables**

- Table 1 – Theoretical approaches to intangibles in a macroeconomic perspective  
Table 2 – Numbers of variables in subcomponents of L&E NIC, by type and total  
Table 3 – Descriptive statistics of L&E indices of NIC and its subcomponents  
Table 4 – Mapping of the attributes of the L&E model  
Table 5 – Indicators of NIC in models based on Edvinsson and Malone (1997)  
Table 6 - Contribution of change in sub-indices into change of NIC index in 1995-2008, in average  
Table 7 – Measures of internal consistency of L&E NIC indices and its subcomponents, for average levels in 1995-2008  
Table 8 – Stability of L&E NIC indices for 1995-2008  
Table 9 – Convergence of L&E NIC indices with Global Competitiveness indices for 1998-2008  
Table 10 – Correlation between antecedent economic performance and indices of L&E subcomponents of NIC, average for 1995-2008  
Table 11 – The explanatory power of the L&E indices of NIC in GDP per capita growth regressions

## **List of figures**

- Figure 1 – The NIC model. Applied by Bontis (2005) to a macro level from Edvinsson and Malone (1997)
- Figure 2 – Conceptual scheme of economic attributes of components of NIC as capital goods
- Figure 3 – Contribution of sub-indices to NIC index in the L&E model in 1995-2008, in average across countries, percentage
- Figure 4 – Pattern of convergence between L&E NIC indices and Global Competitiveness Indices, average ranking between 40 countries for 1998-2008
- Figure 5 – Correlation between antecedent economic performance and L&E' NIC measures, average for 1995-2008
- Figure 6 – Correlation between current levels of NIC and future economic performance, (a) levels and (b) rates of growth

## **List of appendices**

Appendix 1 - The L&E measurement model (from Lin and Edvinsson, 2011)

Appendix 2 - Validation of the L&E model (from Lin and Edvinsson, 2011)

## **1. Introduction**

This section aims to motivate the research problem and outline the research question.

### **1.1 Research problem**

Discussing policy implications of their new set of national intellectual capital (NIC) indices Lin and Edvinsson (2011), claim that the proposed measurement model “helps nations identify key intangible factors for future competitiveness and wealth creation” and provides “an abundance of hard-core information for policy-makers” (pp.368-369). In this case, likewise other researchers, which developed measurement schemes for intangibles, authors have preconceived ideas that suggested measures are capable of grasping the dynamics of NIC in connection to economic growth. This claim appears ambitious if one takes into account that all proposed NIC indices have not been validated in a strict accordance to the test theory. However, the validity of NIC measurement models is questionable.

It should first be noted that the intellectual capital (IC) approach emerged more recently in comparison to other long-established growth and intangible theories. Historically, IC was treated as a part of goodwill among other intangibles measured within accounting practices of firms. Inspired with ideas of knowledge-based competence creation for business, academia and practitioners reassessed the distinction of IC with its classification into subcomponents, such as customer-related (external) capital, structural (internal) capital, and human capital (e.g. Sveiby, 1998; Roos & Roos, 1997; Edvinsson & Malone, 1997). A major difference between proposed taxonomies of IC at a micro level tends to have a focus on a particular category of IC and its measurement. Thus, Edvinsson and Malone (1997) highlight the core role of human capital and treat other types of IC as its supporting surroundings. Furthermore, they measure them with their own proposed indicators. In contrast, Roos and Roos (1997) provide an estimation with a single index consolidated from individual indicators while not prioritizing any particular subcomponent of IC.

Macro studies, on IC, emerged about a decade ago by replicating micro measurement models. Originally, research on NIC was initiated by governments of Nordic countries that recognized the possibility to measure hidden values of a nation with micro metrics. Thus, reports on NIC were first proto-typed for Sweden (Rembe, 1999), Denmark and Norway (Malhotra, 2003). Macroeconomic studies adopted not only firm-level measurement models of IC, but also concepts. In its most acknowledged state NIC is defined as being all intangible assets of a nation, which provide a comparative advantage and enhance wealth creation. In addition, two categories of IC is primarily distinguished: human capital and structural capital, corresponding with all thinking and non-thinking intangible factors of economic performance. In parallel to these studies, international organizations, such as OECD, WB, and UN, proposed national intangible assets measurement models. When primarily focusing on particular sectors of economies and investment

flows into structural capital, these models are similar to the original NIC reports in their use of concepts and indicators. This initiative of world and government agencies on NIC research has been captured recently by academia.

Academics conduct macroeconomic research on IC with a primary emphasis on its economic effects. In these studies researchers highlight that concept of NIC is concerned with the application of microeconomic principles of measurements to a macro level in such a way that “it helps to give direction for future economic development” (Andriessen & Stam, 2004, p.11). However, this desire has not been yet realized, since empirical knowledge about effects of NIC on economic growth obtained by scholars is particularly scarce and contradictory. Thus, some studies indicate that IC has a significant impact on economic performance (e.g. Lerro et al, 2005; Cabrita & Vaz, 2006), whereas others argue that dynamics of IC can not be tackled (e.g. Firer & Williams, 2003). It has been suggested that these conflicting results can be referred to flaws in measurement models of IC, which were replicated, and thus inherited from micro research (e.g. Stähle & Stähle, 2012; Aho et al, 2011).

Macroeconomic research on IC as an economic driver appears to have two lines of thoughts while considering growth theories, proposing either embodiment or disembodiment hypotheses. First, embodiment researchers developed augmented production function with capitalization of intangible investments and hence attempted to embody residual into capital or labour (e.g. Corrado et al, 2004, 2009; Piekkola, 2010, 2011). These studies are grounded in deep traditions of measurement of firm-level intangible assets using financial data and their linkage to aggregate productivity (e.g. Baily, 1981; Griliches, 1981). Although categorization of intangible capital can be criticized (e.g. Stähle & Stähle, 2012), on the basis of purely financial data, they provide an adequate technique that has been recently used by satellites of national accounting programmes, which attempt to measure more broadly immaterial investment. It should be noted that under this approach academics do not refer themselves to the IC community, but operate with concepts of intangible capital and intangible investment. Second, disembodiment researchers consider the necessity to separate economic effects of NIC from effects of other traditional factors of production. In this case, dynamics of IC is measured either with numerous separate indicators (e.g. Stähle & Bounfour, 2008) or with composite single index constructed on their basis (e.g. Andriessen & Stam, 2005; Weziak, 2007). Within this approach, measuring IC by means of vast sets of indicators can be seen as a preliminary step in the selection of indicators for specific cases, which then are aimed to be constructed into final single indices. The major notion of this research is that IC, as a manifold phenomenon that includes primarily value-laden (qualitative) attributes, can be measured only with both quantitative and qualitative data. Indeed, this perspective can be seen as prevailing in future research on economic effects of NIC since it offers suggestions how to bridge accounting focus on quantitative monetary assets and investments and reporting focus on qualitative non-monetary values and metrics (Stähle & Stähle, 2012).

While promoting the investigation of dynamics of IC with composite indicators, researchers have achieved diverse results. In their estimation of the IC of the EU, Andriessen and Stam (2005) found no significant correlation between GDP and intangible stocks, but revealed

statistical relations of lower-level subcategories of IC, such as of human and external (relational) capital to economic performance. While also examining EU countries, Weziak (2007) indicated strong correlations between IC and its components with GDP adjusted by the PPP. Similarly, in his study for Arab countries Bontis (2005) demonstrated that NIC measured with proposed index accounts for nearly one-fifth of the financial wealth. However, the results from these studies could be perceived as unreliable as the sample of countries is too small, and in addition, data on indices is cross-national. In this vein, Lin and Edvinsson (2011) recent study stands in a stark contrast, since it appears to be adequate in formal attributes for investigation of economic effects in a promoted perspective. That being so, in their measurement of forty developed and developing countries with longitudinal data they established a significant average correlation of 0,88 between proposed composite NIC indices and GDP per capita. This evidence enabled the researchers not only to propose their NIC indices for further investigation in economic effects of IC, but also for policy elaboration. Moreover, IC academia tends to promote NIC indices for replication and development in economic growth models (e.g. Stähle & Stähle, 2012). Additionally, researchers strongly suggest using Lin and Edvinsson's (2011) indicators as extended versions of traditional measures of economic performance. This claim is not a novel concept for economic science and practice. Other international indicators, developed from studies on a firm level, such as competitiveness indices, were recommended as supplements to national accounts measures. In sum, Lin and Edvinsson (2011) state, "while GDP reflects the present economic situation, NICI40 [NIC indices proposed in the study for forty countries – *the author*] is not only an indicator of future wealth creation capabilities, but also has good explaining power for current financial performance" (p.315).

The notion of using composite indices for economic science and economic policy appear to be ambitious when taking into account that these indices are usually not validated. Furthermore, the reliability and validity of competitiveness indicators due to proposed high social and scientific value has been assumed a priori, however, these also appear questionable. There is a tendency that international agencies and institutes recommend metrics which are constructed with their own collected data and developed measurements. As far as IC indices are concerned, which are promoted nowadays mainly by individual researchers, without proper examination there is a high risk that measures may serve only as descriptive indicators. As a consequence, these NIC indicators are unlikely to be taken into consideration by academics and policy-makers. Moreover, for theory, having proper validation of IC measures can clarify weaknesses and strengths in measurement models, and hence develop NIC approach. For economic policy, sound examination and critics of NIC indicators can insure recommendations elaborated on their basis to be more powerful and adequate. Given all points, it is vital to examine major conceptual and methodological problems when elaborating indicators of IC at a macroeconomic level, which is the aim of this study.

## **1.2 Research question**

What are the main problems when constructing measurement models of NIC?

While questioning in this way the type of study tends to be exploratory.

For the purpose of this study, the L&E measurement model can serve as a perfect subject for a critical examination. According to the research problem, elaboration of conceptual and methodological flaws in measurement models implies that the L&E model should be validated in two aspects: (a) conformity of NIC indices with IC Theory, and (b) construction of NIC indices, especially in their capability to capture the impact of NIC on economic growth. More precisely, while operating with the concept of validity, it should be discussed whether both content and construct validity can be established in the L&E indicators of NIC. Since there are good a priori reasons to suspect problems here, further research question can be formulated as follows:

Is it possible to modify the L&E model to make it valid in order to identify economic effects of NIC and instrument a comparative analysis?

When putting question in this way, the current study aims to justify the whole prevailing perspective on NIC research that operates with composite indices, and, if it is a case, to steer it for a new dimension.

## **2. Theory**

This section aims to review previous research on IC, discuss theoretical approaches, and state NIC theoretical approach.

### **2.1 Previous research**

The theory of IC tends to have a specific history. IC research has primarily evolved from the desires of practitioners, such as Edvinsson and Sullivan (1996) and Brooking (1996), that resulted in the form of popular press articles and books. With the beginning of its elaboration by academia this intangible phenomenon challenged researchers with the task to frame it using established theories. While dealing with national level of interaction between IC and economic growth, IC studies suggest new findings in their unique framework that developing within mutual dynamics of numerous approaches.

Much of the history of IC literature spans over only a few decades. The idea was originating from the human capital theory and the growth theory. Since publication of Solow's augmented production function in 1957 research interest has shifted to untraditional factors of production which are primarily bounded to knowledge capital. Further, *learning curves* of Arrow (1962) strengthened growing recognition that knowledge diffusion is essential for economic performance. Machlup (1962) was among the first to analyze production and distribution of different types of knowledge in connection to wealth creation. The author not only provided estimation of knowledge expenditures in education and R&D, but also distinguished investment in ICT sector (called it *information machines*) and information services, and into networks which are enhanced with expenditures on media of communication (pp.360-361). With this, he anticipated the emergence of the IC concept. Later on the idea was reassessed with the emerged interest to the concept of knowledge economy. Drucker (1993) pointed out the importance and arrival of a society dominated by knowledge resources and their allocation. By the end of the 1990s, references to IC in contemporary business publications were commonplace.

The first stage of investigation of IC focused on the elaboration of its concepts and metrics on a firm and regional level. Researchers first attempted to simplify heterogeneous nature of intellectual capital into unified taxonomies. Even though many taxonomies of IC have been claimed, the Sveiby's (1997) understanding of both structure and content of IC, as consisting with human capital and structural capital, has been primarily developed and commonly-acknowledged by other researchers (Edvinsson & Malone, 1997; Edvinsson, 2005; Andriessen & Stam, 2004, 2005). Whereas human capital was concerned by emerging studies with all human skills which can enhance economic performance, structural capital was bounded to technology and general market conditions essential for wealth creation. Dealing with IC nomenclature, researchers *became obsessed* with measurement problems which were recognized as a primary task according to requirements of business community (Andriessen, 2004, p.56). Although many IC metrics have been elaborated, their underlying taxonomies are analogues of original models. Thus, firm

measurement models were developed on Edvinsson & Malone (1997)'s, then models of IC concerning regions (Viedma, 2003; Robert Huggins Associate, 2002-2005, 2008; Rodriguez & Viedma, 2006) and region clusters (Hervas-Oliver & Dalmau-Porta, 2005) are replicas of their firm level measurements.

During the last decade researchers have worked on the national measurements of IC. While considering IC concept these studies differentiate a lot in proposed framework to examine the phenomenon. Thus, earlier studies which are primarily launched by national governments claim for reporting on IC. On the basis of Edvinsson and Malone's (1997) taxonomy these projects aim also to identify key strengths on the nation in connection to wealth creation. Rembe (1999), for instance, examined strategic factors of Sweden from foreign investment perspective and suggested plan for Sweden's future growth based on IC. Other Nordic governments, such as Denmark or Norway, promoted similar projects with IC measures (Malhotra, 2003). Israeli researchers also recognized success factors of the nation for IC accumulation with measures picked up from international data sources (Pasher, 1999; Pasher & Shachar, 2005, 2007). A recent report on NIC has been made for Poland from the same reporting viewpoint (Boni, 2009). In addition to national governments, several world organizations, such as OECD, WB and UN's agencies, sponsored various measurement projects assessing intangible capital assets of different economic sectors (see Unpan, 2003; EIS, 2006-2011; EU, 2004-2006; OECD, 2006; WEF, 2006b-2008b, 2010; UNDP, 2000; World Bank, 2012). Some of these projects allow for identification of strategic forces of national economies in terms of investment (e.g. OECD, 2001; UNDP, 2000; World Bank, 2001).

A relatively lesser group of macroeconomic studies aim to examine directly IC as an economic driver. A few studies measure economic effects of IC with models originating on a macro level. Thus, Stähle and Bounfour (2008) attempt to grasp the impact of IC using vast relevant indicators for 51 countries. Researchers demonstrate that related indicators of IC had different kinds of effects on a nation's GNP and its annual growth when developmental stages of economies are taken into account (Stähle & Bounfour, 2008). Other studies apply measurement models developed for a micro level. Corrado et al (2009) estimate intangible capital in the US's economy within own extended microeconomic measurement scheme of immaterial investments (Corrado et al, 2004). Pulic (2005) assesses the connection between IC and economic performance for Croatia with financial indicators operating with value added intellectual coefficient produced originally for a micro measurement (Pulic, 2000, 2003). Lev's (2001) methodology focusing on the economic effects of intangibles for companies has been applied to national stock markets (e.g. Colwell et al, 2007). Bounfour (2005a) deploys dynamic micro measurement model of IC (Bounfour, 2000, 2002) with indicators of economic performance for resources, processes, and outputs in the investigation of EU countries. Noteworthy, while estimating economic effects of IC studies originating macro models from a micro level frequently attempt also to compare countries with suggested metrics.

The last group of macroeconomic studies that prevails in NIC research estimates levels of NIC and provides comparative analysis by means of proposed synthetic single indices which are aggregated from numerous individual indicators. Models which also based on microeconomic taxonomies of IC, primarily on Edvinsson and Malone (1997), all contribute to macro research on

IC in their own way. Thus, Bontis (2005) benchmarks Arab countries with suggested IC index constructed with chosen indicators on the basis of classical micro classification. His model that has been studied further in more detail (e.g. Bontis & Wu, 2005) indicates and measures complex interrelations between subcomponents of NIC. Andriessen and Stam (2005) also attempt to estimate NIC of the EU while modifying the Edvinsson and Malone's (1997) model. Researchers also cross-categorize the chosen indicators into assets, investments and effects of IC. As well applying the model for the EU countries, by means of compound indices, Weziak (2007) distinguishes IC effects subject to the type of the economy. In all, while measuring levels of NIC mentioned studies attempt also to investigate its dynamics.

It appears that projects on measurement of levels of NIC have all resulted into sets of composite indices, which represent a specific group of indicators. According to their construction such indices are the weighed aggregated indicators created out of the raw of individual measures. Further, the nature and scope of composite indices make it possible to provide cross-national and longitudinal comparative analysis, and hence are highly encouraged by international organizations. Several indices tend to be nearly related to the concept of IC and intangibles as a whole, such as: Human Development Index (UNDP), Knowledge Economy Index and Knowledge Index (WB), Economic Competitiveness Index (IMD), Global Competitiveness Index (WEF), Quality of life (Economic Intelligence Unit). All the current NIC compound indices are constructed in the image and likeness of the international composite indicators (Andriessen & Stam, 2005; Bontis, 2005; Bounfour, 2005a; Lin & Edvinsson, 2011; Weziak, 2007). Although these indices have been accepted enthusiastically by policy-makers and practitioners, academics are concerned with the lack of underlying theoretical grounds, thus implicitly having questioned the validity of composite indicators (M'Pherson & Pike, 2001; Malhotra, 2003; Stähle, 2006).

The development of valid measurement of IC has become the major challenge for all studies on IC, especially when economic effects are aimed to be examined. The assessment of the validity of the measurement method on the microeconomic level has shown to be done by using replication. By using this method validation of human resource indicators with micro data have been discussed and examined successfully by Gardner and Wright (2009), Carper (1976), Hartman (1992), Flamholtz (1972), Capelli (2012). Recent attempts to estimate the validity of the IC method applied to microeconomic data tend to be similar. Thus, Aho et al (2011) evaluate the validity of the Stewart's (1997) method with longitudinal data in the national stock exchange market. Having replicated measurement method for financial data of Finnish companies, researchers demonstrate conceptual and methodological problems in the IC stock measured within the Stewart's framework. With the same data and validation methodology, Stähle et al (2011) analyze the validity of the Pulic's method. In addition to running the analysis of replication results, study discusses the construction of indicators and their conformity with IC concepts.

The validation of macroeconomic measures of IC is considerably scant. Operating on a national level, researchers frequently confine themselves at most to brief analysis of reliability (e.g. Weziak, 2007; Firer & Williams, 2003). In this vein, the study of Stähle and Stähle (2012) stands in a contrast, since it examines the validity of the Corrado's measurement methodology appealing to the concepts of IC and discussing overall accuracy of the model. In their framework,

researchers further demonstrate that some IC measurement models, such as of Lev or Corrado, albeit have constraints, may be successfully applied to a national level, whereas others, such as of Pulic or Stewart methodologies, are not valid at any level of implementation (Stähle & Stähle, 2012; Stähle, 2008; Stähle, 2012b). Tellingly, validation of composite indexes of NIC has not been initiated recently or conducted by international organizations (Stähle, 2012a). Reading to date has shown only a single attempt to address validity problems of aggregated human resource indicators in their connection to the growth theory (Muhsam, 1970). However, this was on the first stages of the popularization of composite indices. Furthermore, some recent independent scholars from Institutional Economics have included brief discussions of validity of compound indicators (Thomas, 2008; Kurtz & Schrunk, 2006), although not in any great detail. According to Malhotra (2003), the avoidance of validation of international indicators should be especially questioned when they are used for prediction. In overall judging of studies on IC dynamics, this vacuum of validation studies may impede research in the field since conceptual and methodological flaws are not revealed in the models (Stähle, 2008).

Appealing to the validity of proposed measures of NIC researchers in general are not sufficed with their theoretical grounds, and still claim for the stage of empirical search and conceptualization (e.g. Malhotra, 2003; Stähle, 2008). It seems to have been justified when to take into account a short period of investigation on the concept on a macroeconomic level. However, all mentioned IC studies might acquire more solidity in a Growth Theory perspective.

## 2.2 Theoretical approach

While matching IC approach to Growth Theories it is important to note that IC studies commonly bounded this concept with intangibles. In turn, this connection to intangibles could not but refer IC spectrum to the concept of knowledge. In a micro perspective, Edvinsson & Malone (1997), for instance, argue that “IC is intangible kind of assets”, and propose the use of IC, knowledge capital and intangibles as synonyms (p.3). Applying to the concept at a macro level, Andriessen and Stam (2005) define NIC as “all intangible resources available to a country or a region...which in combination are able to produce future benefits”. Similarly, NIC is regarded as knowledge assets which represent national competences and capabilities vital for economic growth (e.g. Malhotra, 2003). These definitions underline also another notion of research line on IC – the understanding of knowledge capital as a source of economic growth.

The consideration of NIC as an economic driver has been replicated from a micro level studies. Roos and Roos (1997) state, that “the IC system affects the long-term earning capability of the business” (p.419). In addition, it is argued that knowledge and information have become the business’s primary raw material and its most important outcome (Stewart, 1997, p.x). In the same manner, in a macroeconomic perspective, researchers claim that intangible capital, and more precisely, its accumulation, is essential for economic growth (e.g. Malhotra, 2003; Bontis, 2005). According to Andriessen and Stam (2005), the concept of NIC applies the principles of IC measurement and management on a macroeconomic level, in a way that it defines future economic

development. However, the consideration of IC Theory within other intangible theories enables more broad theoretical and empirical dimension of IC and economic growth to be built.

As Bounfour (2005b) states, the intangible thematic implies that researchers are in a *patchworking* context of theories that reflects the transversal nature of the concept (p.5). More precisely, from a macroeconomic perspective, researchers appear to plunge into long-established theories for the intangible dimension of economic growth; all approaches are distinguished originally by Neoclassical Theories and Evolutionary Theories (Table 1). Although research on IC tends to echo with all approaches to intangibles, three of them appear to prevail in studies on NIC: (i) intangible investment approach and (ii) endogenous theories, both based on neoclassical economics, and (iii) national innovation system approach developed from evolutionary economics. In all, these approaches applied to IC Theory seem to reflect a methodological position of a researcher in the Growth Theory framework.

Table 1 – Theoretical approaches to intangibles in a macroeconomic perspective

Approaches to intangibles	Main authors/contributors	Main expressed views
Human capital theory	Becker, 1961, 1975; Kendrick, 1976; Schultz, 1969, 1971; Bartel, 1991, 1992; Goldin, 2001; van Leeuwen & Foldvari, 2008; van Leeuwen, 2007; Ljungberg & Nilsson, 2009	Human capital is considered as a strong complement to investment in physical capital. Individuals are regarded as investors, especially in education in a long-term perspective. Human investment is important contributor to the economic performance via human skills.
Technical change and innovation theory	Pasinetti, 1981; Berstein, 1989; Solow, 1957; Arrow, 1962; Mansfield, 1968, 1977; Griliches, 1957; Sherer, 1980; Soete & Patel, 1985; Freeman & Perez, 1988; Mohnen & Lepine, 1991	Technical change is a cumulative process. Some studies underlined the incremental nature of innovation and the existence of strong differences among sectors. They also provided clear evidence of the impact of innovation on productivity. Other studies emphasize discontinuities in technological change.
Intellectual/intangible investment	Caspar & Afrait, 1988; Buiges et al, 2000; Dosi, 1984; Machlup, 1962; Nakamura, 1999, 2001, 2003; Corrado et al, 2004, 2009; OECD, 1998; Khan, 2001; Basu et al, 2004; Lev, 2001; McGrattan & Prescott, 2000, 2006	The efficiency of the firm/nation is dependent upon intellectual investment. Intangible investments can be approached by considering several aggregates such as R&D, market research, and vocational training. Intangibles either treated as consumption or underestimated by traditional firm/nation accounting systems.

New growth theories/Endogenous growth theories	Romer, 1986, 1990, 1996; Lucas, 1988; Mankiew et al, 1992; Grossman & Helpman, 1991; Barro & Sala-i-Martin, 1995; Jones, 2005; Arnold, 2005	Knowledge accumulation is the basic source of growth. This progresses through human capital accumulation or innovation via R&D. Knowledge is produced with increasing returns to scale. Knowledge includes several items, such as human capital, organizational capital, pieces of physical capital and technical change.
Evolutionary theories	Nelson & Winter, 1982; Dosi, 1988; Amendola & Gaffard, 1988; Carlsson & Taymaz, 1991; Silverberg & Verspagen, 1998; Malebra, 1999; Silverberg, 2001	Routines are the central focus of a firm's behavior. Institutions are of importance. Firms are governed by learning processes rather than by optimization. Innovation is a cumulative, that is incremental, process. Development process is cyclical.
National innovation/knowledge systems approach	Nelson, 1993; Dosi, 1988; Carlsson, 1995; Edquist, 1997; Nelson & Rosenberg, 1994; Mowery, 1984; Lundvall, 1992; Furman et al, 2002; Smedlund & Pöyhönen, 2005; North & Kares, 2005; Heusler & Schedl, 2005; Karlsson & Martinez, 2005	Innovations are driven by context-dependent factors. Actors and institutions, especially government policy, the university's system and the intellectual policy protection, play a decisive role in this process. Innovation process is nonlinear. Nation-specific approaches to innovations are diverse. In the latest replication the core of the system being knowledge.
IC theory, NIC approach	Bounfour, 1998, 2004; Edvinsson & Malone, 1997; Pike & Roos, 2000; Lin & Edvinsson, 2008, 2011; Lev, 2001; Pulic, 2003; Malhotra, 2000, 2003; Andriessen, 2004; Andriessen & Stam, 2004; Stähle , 2006; Bontis, 2001, 2005; Alexander, 2006; Cabrita & Vaz, 2006; Stähle & Bounfour, 2008	IC is the major economic driver with a long-term effect. Subcomponents of IC, which are human capital and structural capital (infrastructure, institutional environment and innovation), contribute to economic growth through mutual interaction. Dynamics of IC is dependent on the developmental stage of the economy

Source: own modification of Bounfour (2005b), pp.6-7; OECD (1999)

The research on IC appears to have two methodological lines of thoughts within the Neoclassical view: considering technological change as either embodied or disembodied in tangible capital. The embodiment argument is exploited within the approach on intangible investments. Noteworthy, the traditional embodiment hypothesis implies that technological shift is capitalized in goods, and hence its effect can be captured while qualifying capital (e.g. Jorgenson, 1966, 2001). In a similar manner, within the IC framework researches consider the presence of additional stock of capital - intangible capital - and add its effect to traditional estimates of capital contribution, which are tangible. As a result, the inclusion of intangible assets makes a significant difference in the observed patterns of economic growth, in particular, between capital deepening and total factor productivity (e.g. Corrado, 2009; Lev & Zarowin, 2003). In addition, this literature builds upon previous work that has linked economic growth to stock market performance (e.g. Baily, 1981; Hall & Hall, 1993) and constructed firm-level intangible stocks using financial data (e.g. Griliches, 1981; Cockburn & Griliches, 1988; Hall, 1993). Even though this approach is developed mainly in micro models (Corrado, 2004; Pulic, 2000; Lev, 2005), the impact of different types of intangibles on regional and national levels have been captured partially in models proposed by the growing literature (e.g. Basu et al, 2004; Khan, 2001; Nakamura, 2001).

Another, disembodiment, approach regards knowledge as a fundamental determinant of economic growth that can be added within the production function independently from other factors. This approach is highly exploited by the Endogenous Growth Theories. In this case, knowledge is proxied by schooling or learning-by-doing (Lucas, 1988) or R&D investments (Romer, 1990, 1994; Jones, 2005). Recent endogenous models have been developed for multi sector economies. Thus, Romer's (1990) model has three sectors: a technology producing sector, an intermediate goods producing sector where capital goods are produced, and a final output sector. In the first sector human capital that is not used directly in the sector producing final output uses technology as a set of institutions to create new technologies (van Leeuwen, 2007, p.32). Similarly, the IC Theory claims for the taxonomy of IC and interrelatedness of its subcomponents (e.g. Lev, 2001; Bounfour, 2005a; Stähle, 2008). That being so, IC is a multi-level hierarchy that consists of human capital and structural capital; in the latter market capital (networks), process capital (infrastructure), and renewal capital (innovation) can be further distinguished (Bontis, 2005; Andriessen, 2004; Edvinsson & Malone, 2008). Further, the indication of interrelations between these subcomponents of IC appears to be similar to the Romer's model. In this vein, Bontis (2005) provides empirical estimations of these links and discusses them as follows:

Human capital is the pre-eminent antecedent for the intellectual wealth of a nation. As a nation's citizens codify their knowledge into the systems and processes of a country, those structural capital assets can then be renewed for the future by investing in R&D. A feedback loop further develops a nation's human capital. Eventually, the codified knowledge base of a nation can be marketed within the global and domestic economies. As the human capital continually develops, a nation's ability to market its intellectual wealth will result in a higher financial well-being.

(Bontis, 2005, p.131)

In a similar manner, Edvinsson (2005) suggests the idea of *IC multiplier*: there exists a multiplier effect for the future earning capabilities as a result of combination of the human capital with structural capital (p.29). In parallel to this, when highlighting the exponential value of multiplying knowledge Bounfour and Edvinsson (2005) refer to the Romer's *law of increasing marginal utility* (p.170). As to external effects of IC, embodiment and disembodiment approaches are particularly different in underlying theoretical assumptions.

In addition to the view on technological change, neoclassical approaches applied in NIC studies differentiate in theoretical assumptions concerning IC attributes. Within traditions of neoclassical economics, both endogenous and intangible investment theories see interrelated processes as separable by clear cause and effect; in addition, economic growth is assumed as ordered and steady state phenomenon (Verspagen, 2005, p.488). However, approaches are different in their view on attributes of innovation or knowledge. Thus, the New Growth Theories assume increasing (constant) returns to scale and nonrivalry and partial excludability of some components of knowledge capital (e.g. Romer, 1994). Further, knowledge spillovers are possible due to the nonrivalry and partial excludability of some types of knowledge, in particular, its technological component (Romer, 1990). In contrast, these external effects of knowledge are not possible within the approach on intangible investments. As Hulten (2000) argues, much of the R&D effort of any private firm goes to improving the quality of the firm's products, not the productivity of its production function (p.25). Another argument is that many subcomponents of IC, such as brand equity and organizational and human competences, are firm-specific and valuable, because the firm is able to exclude other competitors from using them (Corrado et al, 2009). Therefore, the approaches can be differentiated by basic assumptions and, as a result, their empirical implications. Nevertheless, the underlying traditions of Neoclassical Theories define a single research outcome within these approaches, that is an existence of a functional dependency between IC and economic growth.

Evolutionary, or Neo-Schumpeterian, approach suggests for researchers a worldview characterized by complex causal mechanisms, context-specificity and, hence, turbulent growth patterns (e.g. Lundvall, 2005; Freeman, 2002). In innovation literature, this approach has been developed within the systemic view – the concept of National Innovation Systems that appears to resemble with IC studies. Thus, Hervas-Oliver et al (2011) compare IC reports and studies on National Innovation Systems, in particular, European Innovation Scoreboard reports. The researchers conclude that two fields overlap strongly in used indicators. In addition, research on region's and city's knowledge systems, e.g. Smedlund and Pöyhönen (2005) or Heusler and Schedl (2005), appear to be similar to innovation systems studies, such as Howells (2005) or Edquist (2005), mainly in their either holistic approach or accent on learning processes. Notwithstanding these observations, reading to date has shown that trajectories for IC approach in comparison to innovation system approach are different. Thus, whereas innovation systemic studies attempt primarily to identify driving forces of innovation, IC studies focus on the overall linkages between knowledge and economic growth (e.g. Stähle, 2006; Malhotra, 2003). In addition, although earlier research on innovation systems implies high consideration of a mesoeconomic level, in the recent innovation reports there is more accent on micro entities, such

as small and medium enterprises, finance and micro activities (EIS, 2008). In a different manner, IC reports highlight the macro perspective (e.g. Rembe, 1999; Pasher & Shahar, 2005). These distinctions are likely to result from the continuous attempts of IC scholars to find and build sound theoretical grounds for macro empirical analyses.

All told, a pairwise comparison of the NIC approach, in its framework presented in current literature, with other approaches on intangibles has shown that it corresponds more with the New Growth Theories due to the following considerations:

- Scholars regard IC as a determinant of economic performance (e.g. Malhotra, 2003; Bontis, 2005); additionally, the accumulation of IC is of importance (Malhotra, 2000; Bounfour, 2005b). IC stock is seen as a decisive factor for current and future economic prosperity (e.g. Andriessen & Stam, 2005; Mouritsen et al, 2005).
- Due to the intangible nature of IC it is difficult to measure. Consequently, it is difficult to measure relationships between IC and economic growth (e.g. Malhotra, 2003; Ståhle, 2008).
- The impact of IC is characterized with multiplier effect (Edvinsson, 2005; Bounfour & Edvinsson, 2005). In this case, market capital (networks) amongst other subcomponents of IC defines the scope of positive externalities (Bounfour & Edvinsson, 2005).
- IC is presented as a relatively homogenous and ordered phenomenon (e.g. Malhotra, 2003; Ståhle & Bounfour, 2008). In this complex structure human capital is a core (Bontis, 2005); human capital influences economic growth through supportive surroundings – structural capital (Bounfour, 2005a, b; Bontis, 2005).
- IC is likely to affect the rates, but not the levels of economic growth (Ståhle, 2006; Ståhle & Bounfour, 2008). Moreover, IC might influence economic growth through its dynamics, that is with growth rates of IC (Malhotra, 2003).
- Since IC is considered as a long-term phenomenon (Ståhle, 2006) it should be largely unaffected by short-term fluctuations in growth. However, there exist attributes of IC, e.g. general education, which saturate over longer periods of time than attributes which are bounded to time and context, e.g. technical knowledge (Ståhle & Bounfour, 2008).
- Even through the interrelations between IC and economic performance might be context-specific and nonlinear (Malhotra, 2003; Ståhle, 2008), if developmental stages of economies are considered, the role of IC as a driver can be determined in a function with economic growth (Hofman, 2005; Manuelli & Seshardi, 2010; Ortiz, 2006; Ståhle & Bounfour, 2008).

In this vein, the IC scholars are challenged to develop further theoretical models inherited with the Endogenous Growth Theories. Thus, in current growth models human capital and R&D appear to be facilitators of technological change, rather than factors of production (van Leeuwen, 2007, p.30). Moreover, Romer's model, that is likely to ground IC model, still assumes an existence of competitive market of innovations (Romer, 1990). Further, although in the Jones's (2005) extended model there exists monopolistic competition in the intermediate-goods sector, since innovators are protected from imitation by patents, under these assumptions the long-run growth appears to depend only on exogenous parameters, in particular, the rate of population growth (Jones, 2005). Arnold (2005) developed Jones's model for the case of multi-country open economy and explained its transitional dynamics, but the exogenous character of the technological change still has been remained unsolved. All these assumptions are not applicable within the NIC approach. Therefore, development of the production function based on IC measures is in need of further implementation by researchers.

Overall, the short period of research on IC and the scope of early studies create some impediments for research on a national level. When macroeconomic IC theory is not fully conceptualized, micro-to-macro replication of measurement models questions the validity of metrics proposed. When regarded in a Growth Theory perspective, the concept of NIC acquires more solidity. Although the IC Theory will more probably be developed within several research dimensions, this thesis approaches NIC concept and metrics in an Endogenous Growth Theory perspective. To put it differently, while validating L&E methodological model it is assumed that NIC indices are to be used for assessing the dynamics of IC in connection to economic performance, and in addition, its economic effect can be separated from effects of other tangible factors. In other words, it is considered the disembodiment hypothesis that underlies examined measurement model.

### **3. Data and methods**

This section aims to justify for the methodology, discuss the data, outline analysis techniques, and state limitations of the research.

#### **3.1 Methodology**

A specified research question requires producing an analysis in the current study in validation framework. As stated, the current study aims to discuss conceptual and methodological problems in measurement models of NIC, and thereby establish ways to improve them. The L&E model has been chosen for thorough examination, primarily since it represents the prevailing perspective on IC research on a macro level. According to main foci of NIC approach, the L&E model should be justified in two aspects: (a) conformity of NIC indices with IC Theory, and (b) construction of NIC indices, both in their capability to capture the impact of NIC on economic growth and to tackle a comparative analysis.

Measurement literature provides a broad scope of alternative procedures for validation. These procedures have been often framed as different types of validity, among which content, criterion, convergent, and construct validity are mostly acknowledged (e.g. Carmines & Zeller, 1979; King et al, 1994, p.25). Scholars name more than thirty types of validity which techniques are diverse and entangled (e.g. Adcock & Collier, 2001). Following Bollen (1989, p.197), since measurement validity requires extensive methodological analysis, it is reasonable to specify the focus of investigation. In this vein, the outlined research problem implies that types of evidence of validity should be found in an Endogenous Growth Theory perspective.

According to the specificity of the research problem, two types of validity should be examined: content validity and construct validity (e.g. Churchill, 1979; Locke, 2011; Stone-Romero, 2002). First, content validity depends on the extent to which the proposed model captures the entire domain of a construct and includes nothing irrelevant (Carminez & Zeller, 1979). To estimate the content validity implies a mapping both between a theory and a more specific definition of the construct (conceptualization) and between the description and specific indicators chosen to measure that concept (operationalization). To provide the evidence for construct validity, its four aspects must be examined, namely: reliability, convergent validity, discriminant validity, and nomological validity (Bohrnstedt, 1970; Cronbach, 1971; Carmines & Zeller, 1979; Adcock & Collier, 2001). Reliability refers to the extent to which a measuring procedure yields the same results on repeated trials, thus considers the stability of the measures across time; prerequisite for stability is concerned to be internal consistency of the construct (Churchill, 1979). Its establishment is considered as necessary, but not sufficient conditions of construct validity (e.g. Kirk & Miller 1986, p.20). Convergent validity is concerned with the extent to which the measure correlates with other constructs designed to measure the same phenomenon. Discriminant validity is regarded with the degree to which measures of conceptually distinct constructs differ, that is the extent to which the measurement is uncorrelated with other variables with which in theory it

should not be correlated. Nomological validity refers to the construct's ability to correlate with other theoretically related constructs, thus variables with which in theory it should be correlated.

In all, the logic of design within different types of validity enables parallel investigation of NIC from its theoretical foundations, that is content validity, to empirical grounds in its connection to economic growth, that is nomological validity, in addition to other aspects. Moreover, different techniques within types of validities act as alternative measurements, and thus make it possible to control for a single outcome. Therefore, the chosen framework provides the most appropriate solution to the research problem.

### 3.2 Data

The sources used in the current study are secondary and the criterion for data selection is availability and representativeness. Data on NIC indexes, which validity is directly examined, are drawn from Lin and Edvinsson (2011). Data consist of NIC indices and its sub-components, both indices and rankings, - NIC, and human capital, market capital, process capital, renewal capital, financial capital - for 40 countries for 1995-2008 (see Appendices 1 and 2). The methodology of L&E is a representative of Sveiby's taxonomy of IC, which dominates in the literature on IC and its measurement. Since it represents the prevailing perspective on NIC measurement, thus generalizations are possible. Moreover, it is the single source of longitudinal data on NIC indices.

According to the L&E methodology, NIC indices are constructed as composite indices. Authors of the model selected the balance number of variables for each of the four types of capital - seven variables each, excluding financial capital that was measured with one variable (see table 2). Both quantitative and qualitative indicators are used in the L&E study (14 versus 15). The distribution of both types of data across different subcomponents is not even: for construction of market capital, for instance, six qualitative indicators are used out of seven, whereas both human and renewal capitals are constructed mainly with quantitative indicators. Data with qualitative ratings were drawn by authors of the model with original units of measures which are based on a scale of 1-10. To provide integration with qualitative data, quantitative measures were benchmarked by authors, that is the ratio of the absolute value relative to the highest value of each quantitative variable was calculated and multiplied by 10 to transform the number into a 1-10 score. This procedure was repeated for all numerical indicators of subcomponents of IC, including financial capital, which was originally presented by the logarithm of GDP per capita adjusted by the PPP.

Composition procedures for sub-indices and overall indices of NIC are not discussed in detail in the L&E. Thus, authors do not provide enough information about construction of each subindex. However, according to their view and logic of overall composition, it can be supposed that sub-indices were either benchmarked or averaged in the L&E study. If to suppose that indices were summated first, and then again divided by the highest level within each sub-index, their levels should reach 10 at maximum. As descriptive statistics indicates (see table 3),

subcomponents of IC measured with the L&E indices do not exceed 9, excluding financial capital. That being so, authors of the model calculated final sub-indices as simple averages of individual indicators within each sub-category. As a consequence, even if levels of sub-indices should vary in interval from 0 to 10, the highest levels are not achieved in the L&E since original indicators differentiate strongly across countries. In other words, within the L&E composition, a country can be matched, for instance, with 10 units of human capital index only if all seven indicators which constructed this index reach their highest levels for this particular country. Further, overall NIC indices are constructed as unweighted sums of all sub-indices and correspondingly can variate from 0 to 50. All given, constructed in a mentioned way L&E NIC index and its sub-indices are measured in synthetic units with own authors' scale.

Table 2 – Numbers of variables in subcomponents of L&E NIC, by type and total

Subcomponent of NIC	Quantitative	Qualitative	Total
Human capital	5	2	7
Market capital	1	6	7
Process capital	2	5	7
Renewal capital	5	2	7
Financial capital	1	-	1
Total	14	15	29

Source: L&E methodology

The descriptive data on indices can offer some evidence of measurement weaknesses in the L&E model resulted from their construction (see table 3). As could be seen, overall NIC indices increase in average levels over time as well as majority of sub-indices. Among others, human capital index increases most strongly. In contrast, market capital index tends to decrease slightly across time. In addition, levels of sub-indices are not relatively equal: financial capital is evidently overstated, whereas renewal capital is measured as a lowest. The latter is a direct consequence of composition procedure on the sub-index's level: indicators which construct renewal capital index differentiate stronger between countries, whereas indicators of other types of IC tend to be more harmonic. Further, it is indicated that indices are dispersed differently across countries: in average renewal capital indices are more variated; both market and financial capitals tend to average more across countries. In all, these provide some evidence of methodological and conceptual problems in the L&E model.

For the assessing of content validity of the L&E model the classic and recent literature on IC are used, for example: Edvinsson and Malone, 1997; Andriessen and Tissen, 2000; Andriessen, 2004; Andriessen and Stam, 2005; Bontis, 2005; Bounfour, 2005; Malhotra, 2000, 2003; Marr and Starovic, 2005; Stähle and Bounfour, 2008.

Table 3 – Descriptive statistics of L&E indices of NIC and its subcomponents

	NIC*		Human capital		Market capital		Process capital		Renewal capital		Financial capital	
	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
1995	27,841	5,218	5,224	1,112	5,742	0,950	4,512	1,649	3,257	1,789	9,106	0,775
1996	28,650	5,506	5,391	1,136	5,851	0,982	4,686	1,648	3,624	1,970	9,099	0,761
1997	28,628	5,323	5,325	1,123	5,740	0,925	4,929	1,524	3,541	1,954	9,092	0,755
1998	29,623	5,524	5,914	1,057	5,651	0,966	5,158	1,558	3,784	2,067	9,088	0,762
1999	30,210	5,599	5,932	1,027	5,842	0,964	5,548	1,619	3,781	2,059	9,105	0,761
2000	30,265	6,013	6,222	1,290	5,575	0,974	5,646	1,625	3,702	2,049	9,121	0,756
2001	30,376	6,326	6,370	1,353	5,682	1,055	5,659	1,625	3,653	2,102	9,119	0,751
2002	30,464	6,104	6,386	1,302	5,579	1,033	5,559	1,621	3,811	2,123	9,129	0,743
2003	30,519	5,984	6,416	1,279	5,693	1,052	5,497	1,640	3,763	2,054	9,149	0,729
2004	30,921	6,022	6,415	1,260	5,602	1,021	5,409	1,567	3,832	2,060	9,164	0,716
2005	30,962	5,917	6,530	1,232	5,642	1,048	5,717	1,574	3,895	2,100	9,178	0,699
2006	30,814	5,911	6,467	1,225	5,601	1,062	5,573	1,521	3,960	2,123	9,203	0,684
2007	30,724	5,975	6,581	1,240	5,491	1,111	5,508	1,436	4,000	2,079	9,222	0,668
2008	30,790	5,882	6,706	1,224	5,350	1,117	5,395	1,422	4,113	2,105	9,227	0,654
Mean	30,056	5,807	6,134	1,204	5,646	1,019	5,343	1,574	3,765	2,045	9,143	0,730
Max	42,640	-	8,956	-	8,727	-	8,436	-	8,478	-	10,000	-
Min	18,225	-	3,160	-	3,019	-	1,575	-	0,949	-	6,759	-
N	40	40	40	40	40	40	40	40	40	40	40	40

\* NIC index is defined in the model as a sum of Human capital index, Market capital index, Process capital index, Renewal capital index, and Financial capital index.

In sections 3.3 and 3.4 NIC index is adjusted with exclusion of financial capital index to avoid tautology.

For the investigation of convergent validity of NIC indices, the IC literature on a macro perspective suggests two groups of similar measures which are considered to estimate intangible capital (Hervas-Oliver & Dalmau-Porta, 2007; Stähle, 2006). The first group is NIC indices based primarily on Edvinsson and Malone (1997) nomenclature, such as Bontis (2005), Andriessen and Stam (2004) among others. The second group is national competitiveness indices published by international organizations, such as WEF's Global Competitiveness Index or IMD's Economic Competitiveness Index. Although competitiveness indicators are not fully identical to measures of NIC, they resemble a lot in data sources and principles of composition (Stähle, 2006). In the current study, for assessing convergent validity of L&E NIC indices, one index from both groups of IC and national competitiveness composite indices was chosen. First, Weziak's indicators of NIC for EU countries was chosen (Weziak, 2007), since it is a single study with available measures of IC overlapping with the L&E data. Other studies either examine out-of-scope countries (e.g. Bontis, 2005) or provide only illegible illustrations of results (e.g. Andriessen & Stam, 2004; Bounfour, 2005a). The Weziak's study with available data allows for cross-national comparison with L&E measures for 18 countries in 2004. From the second group, the Global Competitiveness Index was chosen, since it enables to cover a broader scope of countries and observations in comparison to other data banks. Data on Economic Competitiveness Index from IMD reports, for instance, covers the whole sample only from 2004 (compare IMD, 2003 with IMD, 2004). In this case, the data on Global Competitiveness indices captures proper observations from 1998 till 2008 for the whole L&E sample of 40 countries (WEF, 1998-2008). According to specificity of analysis techniques, from the above data bank, rankings and levels are estimated.

In the examination of discriminant validity and nomological validity, additional data on economic growth measures is needed due to the following considerations. For the examination of discriminant validity it is supposed that the IC should not correlate with antecedent economic performance. As proposed by Stähle (2006), NIC is a long term phenomenon, and hence it should be largely unaffected by short-term fluctuations in growth. Additionally, when the measurement model uses qualitative data, if the dynamics of IC captured with the model's indices may be perception-biased, thus overly influenced by recent economic performance, as supposed by Lall (2001) or Glaeser et al (2005). As far as nomological validity is concerned, it is considered that NIC should correlate with future economic performance, and its effect should be distinguished from other factors in the model. Further, the IC is likely to affect the rates, but not the levels of economic growth (Stähle, 2006; Stähle & Bounfour, 2008); in addition, IC might influence economic performance through dynamics, that is with its rates of change (Malhotra, 2003). Hence, nomological validity of L&E NIC measures is tested in their predictive power for future economic performance in log-log and log-linear models. As suggested by measurement literature, control variables should be included in the model (e.g. Ragin, 1987, p.58). In accordance with theoretical statements, initial level of economic growth is used as a control variable. Data on economic growth measures has been drawn in the current study from WB, since this database covers variables for all elements of the sample. As suggested by Growth Theory literature, GDP per

capita adjusted by the current PPP for all 40 countries (1995-2008) are captured. Rates of growth of GDP are calculated by the researcher with log formulas.

Sample is consistent throughout the current study. However, as could be seen, for convergent validation procedures with Weziak (2007)'s NIC indexes the number of elements in the sample must be changed (cut) to the available overlapping items (to 18 items in this case).

The problem of missing data is handled with extrapolation. Since L&E sub-indexes of NIC are not provided for Ireland for 2008 and 2009, they are extrapolated with previous data.

### 3.3 Analysis techniques

In this research quantitative (exploratory) research strategies are used. Data analysis procedures are quantitative; the study has longitudinal and cross-national components.

Content validity is estimated with metaanalysis of (a) a mapping between IC theory and a more specific definition of the NIC index proposed by the author (its description) and (b) a mapping between the description and a specific operationalization of the concept. The examined indices are mainly compared with Bontis (2005)'s model that is regarded as commonly acknowledged in macroeconomic literature on IC. In addition, operationalization is examined with comparison to Weziak's (2007) indicators that share the same basic IC taxonomy and further examined in construct convergence with the L&E model. Moreover, macro measurement models and discussions of Andriessen and Stam (2005), Malhotra (2003), Stähle and Bounfour (2008) are considered, as well as classical micro models, such as Edvinsson and Malone (1997).

For the examination of construct validity different correlation and regression techniques have been chosen to solve the research problem efficiently. In addition, they are selected according to the specificity of L&E indices.

Reliability is assessed with correlation coefficients in two aspects - cross-national (internal consistency) and cross-temporal (stability). The measurement literature suggests assessing internal consistency by means of different correlation coefficients, such as Cronbach's alpha (Churchill, 1979; Carmines & Zeller, 1979; Cronbach, 1971), Pearson's item-to-total correlations and item-to-item correlations (Hair et al, 1998; Smith, 2005a; Westen & Rosenthal, 2003). Cross-temporal reliability could be measured with Pearson's correlations between observations (Luce et al, 1990). In addition, as Churchill (1979) suggests, when the construct has several dimensions, correlation can be estimated for the first-level measures; when they are reliable the internal consistency of the whole construct is secured. In the current study, all four analysis techniques will be used to estimate the reliability of L&E NIC indices. According to Hair et al (1998), inter-to-total correlations should exceed 0,50, inter-item correlations, cross-temporal correlations and Cronbach's alpha should exceed 0,70.

Convergent validity is examined with Spearman's ranking correlation between NIC index and Global Competitiveness indices and Weziak (2007)'s indices for overlapping countries, likewise this technique is applied, for instance, in Archibugi and Coco (2005). Following suggestions of measurement literature, e.g. Feinstein and Thomas (2002, p.86), ranking correlation coefficient is used, since (a) although ranks have been allotted to data which was originally measured on an interval scale, the point of interest lies in their rank; (b) the margins of error is so large in interval data, and it is advisable to confine attention to its ranking. According to Hair et al (1998), correlation coefficients should exceed 0,70.

In the investigation of discriminant validity, the L&E indices are assessed in their correlation with antecedent economic performance. Recent or antecedent economic performance is stated as average of previous two years calculated into logarithms (e.g. Kurtz & Schrunk, 2006; Glaeser et al, 2005). The Pearson's linear correlation coefficient is used that should not exceed 0,50 (Hair et al, 1998). Following the Growth Theory literature, GDP per capita adjusted by the PPP is used as an indicator of economic performance. As can be seen in table 3, L&E measures of NIC have, in their composition, an index of financial capital that is operationalized with GDP per capita. To avoid tautology this sub-indicator is excluded from NIC and hence called *adjusted NIC indices*. With this modified structure, NIC measures conform to considerations of the IC Theory in a growth perspective. Noteworthy, this resembles with procedures made by researchers on IC studies dealing with composite measures (e.g. Andriessen & Stam, 2005; Bontis, 2005).

Examination of nomological validity is of particular importance, since the relationship of IC with economic growth is assessed, as proposed by the IC literature. Within this estimation, nomological validity of L&E NIC measures are tested in their predictive power for future economic performance for 1995-2008 in log-log and log-linear simple and multiple regression models. Initial level of economic growth is included additionally as a control variable. As proposed by growth literature, economic performance is measured with GDP per capita adjusted by the PPP, and levels of GDP are calculated into logarithms. Likewise in the examination of discriminant validity, L&E NIC measures are adjusted. To meet the requirements of nomological validity the correlation should have positive sign, be significant, and the model should have high explanatory power.

### 3.4 Limitations

The study has two (2) limitations, which are stated as follows.

First, the research on the validity of macroeconomic measures of NIC is data-driven. As mentioned, the L&E is the single source of longitudinal data on countries' IC indices. As Ståhle (2012b) claims, some micro measurement models (Lev, 2001; Corrado, 2004) are conceptually different, and thus may be successfully applied to a national level. Formation of these databases on NIC indicators is time-consuming due to their methodological specificities. It should be noted, however, that most cross-national data banks on NIC indexes all share the same taxonomy of IC –

Edvinsson and Malone (1997)'s, that is used in the L&E NIC indexes. In addition, as it shown, even though these models may suggest proper measurements for effects of intangible capital on economic performance, the L&E model conceptualizes NIC more adequately (Ståhle, 2008). Thus, validation of L&E methodology has its own more grounded justification. Extension of other measurement schemes to a national level can be done in future research.

Second, validation of NIC measures is conducted in a particular perspective – of the Endogenous Growth Theory. In this vein, while establishing validity the current study is searching for particular evidence amongst others that proposed measures are capable to tackle the impact of NIC on economic performance. The scope of the current research enables to examine only the validity of L&E NIC indexes by inserting it into the Growth Theory methodology framework. However, it is evident that assessing the mutual dynamics of IC and economic performance requires additional investigation, but within another particular research problem. This, certainly, could be extended to the investigation of causality in future research.

## **4. Analysis**

This section aims to validate the L&E measurement model in a Growth Theory perspective. According to the specificity of the theoretical approach, both content validity and construct validity are examined.

### **4.1 Content validity**

This sub-section aims to estimate content validity of the model in two aspects: conceptualization and operationalization of the model.

#### **4.1.1 Conceptualization of the model**

The L&E conceptual model is discussed from a critical review of models and proposals of measurements established in the IC Theory and the Endogenous Growth Theory.

The L&E model proposes own definition of NIC that resembles conceptually with definitions established in the literature. Thus, according to the model, “NIC is comprised of the knowledge, wisdom, capability, and expertise that provide a country with a competitive advantage over other countries and determine its potential for the future growth” (p.3). Further, the authors use terms NIC and nation’s invisible wealth as synonyms (p.2). In this case, in the L&E model, intangibles of the country are specified in a way, as Andriessen and Stam (2005) suggest: the principles of IC as a micro entity from Edvinsson and Malone (1997) is applied to a macro model. That being so, researchers assume that IC micro models act in a similar way on a nation and international level. In addition, paralleled to other definitions, such as of Bontis (2005) or Malhotra (2003), the definition in the L&E model highlights the understanding of NIC as a source of relative advantage and economic growth. These economic effects of NIC are possible through the NIC constitution.

In the literature there is a rather unified understanding about structure and components of NIC. The taxonomy of three – human capital, market capital and organizational capital – is commonly established (Ståhle, 2008). These subcomponents are encapsulated into the multi-level hierarchy; Bontis’s (2005) modification of the micro model of Edvinsson and Malone (1997) has been applied to the most of macro models (see figure 1). As could be seen, IC is broken into human capital and structural capital; the latter is divided into market capital and organizational capital, which again is divided into renewal capital and process capital. Further, financial capital, that is analogous to physical capital in growth theories, is regarded as a part of national wealth in addition to IC. This hierarchical order of subcomponents of IC establishes interrelations between them. As Bontis (2005) empirically shows, human capital is likely to influence economic performance directly, whereas market capital affects through other subcomponents of IC; the latter impact can be essential if both process and renewal capitals are significant (p.131). In general,

hierarchy of subcomponents of NIC or their interrelatedness is usually presumed in the measurement model.

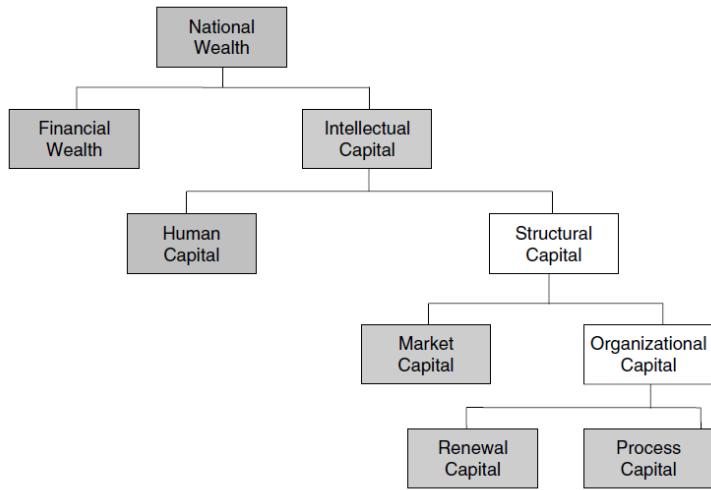


Figure 1 – The NIC model. Applied by Bontis (2005) to a macro level from Edvinsson and Malone (1997)

Source: Bontis (2005), p.115

The L&E model constitutes NIC and interconnection between its subcomponents in overall accordance to the established macro classification, but some of them are considered inadequately. Thus, in the L&E five types of IC are assumed: human capital, market capital, process capital, renewal capital, and financial capital. Primarily, it could be judged, that the inclusion of financial capital into the list of subcomponents of IC is completely inadequate either from theoretical viewpoint or from common sense. The authors inconsistently motivate their choice of the financial capital as a subcomponent aiming to present *more comprehensive coverage* and indicating that “advanced countries create national value through improved GDP per hour worked” (pp. 3, 16). In their further discussion, it is proposed that NIC index can serve as an extension of GDP measure or other commonly used economic indicators (p.315). All these notions appear to be completely misleading, if used definitions and basic assumptions of the model, all as measuring intangibles, are regarded. Further, the IC hierarchy is not considered clearly in the L&E model. However, it is briefly mentioned in accordance with IC theory that human capital represents key factors of economic performance that acts through renewal capital, and structural capital sustain and increase the output of human capital (p.4). Therefore, although the consideration of financial capital among subcomponents of NIC tends to be conflicting, with this adjustment, the L&E model’s taxonomy of IC corresponds to the established view in the theory.

Within the L&E model, subcomponents of NIC are defined mainly with an extension of attributes which are commonly used in the literature. The choice of a broad set of indicators in overall corresponds to the theoretical view that IC has a complicated nature (e.g. Bounfour, 2005b; Malhotra, 2003). On account of this, it is assumed that even if indicators strongly correlate they are added up since all contribute to IC in different aspects. In this vein, although Bontis’s (2005)

definitions of human capital, market capital, process capital, and renewal capital are adopted in the L&E model, extension of their attributes tends to be grounded (see table 4). However, it creates situation when attributes of IC can be matched in a considerably different way between its subcomponents. As could be seen, human capital is precised more broadly in the L&E in comparison to the Bontis's (2005) definition. In contrast to the L&E model, values and norms are considered by Bontis (2005) as market capital. That being so, in the attributes of market capital, the L&E model highlights the international orientation of national networks, whereas Bontis (2005) originally proposes the importance of national intra-relationships. Hence, the Bontis's framework of market capital covers laws and market institutions, whereas the L&E model regards them as attributes of process capital. Besides these intra-economy elements, process capital is attributed by both models with infrastructure or ICT systems. The definition and attributes of renewal capital as innovations is adopted from Bontis (2005) to the L&E model without modification.

Table 4 – Mapping of the attributes of the L&E model

Subcomponent of NIC	Attributes
Human capital	Knowledge*, education*, wisdom, expertise, intuition, ability to realize national tasks and goals*, values, philosophy, health, experience, motivation, and entrepreneurship
Market capital (networks)	National loyalty*, openness to globalization, nation's flexibility and adaptability, resilience of economy, and satisfaction of strategic partners and customers*
Process capital (infrastructure)	Information systems*, hardware*, software*, databases*, laboratories*, national infrastructure*, knowledge transfer, legal environment for entrepreneurship, the ease to establish a business, quality management system, and agricultural productivity
Renewal capital (innovation)	Basic research, patenting*, trademarks, start-up companies, scientific articles*, patenting*, expenditure on R&D*, and capacity for innovation*
Financial capital	GDP*, external debt, industrial production by major branches, and inflation

Source: own mapping of the L&E model with the Bontis (2005) model

\* the attribute overlaps with Bontis (2005)

Noteworthy, both models attribute financial capital inadequately to theoretical assumptions. As can be seen, both Bontis's and L&E models overlap in matching it to GDP. As L&E argue “it is most common measurement of financial wealth” (p.20). This notion tends to be not only wrong, but tautological and misleading, since authors provide output metrics for financial

wealth that is further regarded as an outcome in models. Moreover, L&E consider financial capital with other attributes, which are not only output measures in growth models (industrial production) or constraints on economic policy (inflation), but indicate particularly flows than stocks. In a similar manner, Bontis (2005) notes that financial capital should also capture health, poverty, and gender empowerment. With this, in their desire to provide adequate conceptualization, researchers appear to be lost and misguided among long-established traditions of wealth and growth estimation. Therefore, although models adopt mainly acknowledged definitions and attributes of subcomponents of IC, the mapping indicates the arbitrary character of their choice. As a consequence, as Marr and Starovic (2005) claims, the NIC measurement results can not be compared and generalized. However, as far as a Growth Theory perspective is concerned, the grounds for distinction between subcomponents and, as a result, their metrics, might be more powerful.

The consideration of economic attributes of capital goods within the Endogenous Growth Theory framework, which are rivalry and excludability, enables researchers to place disperse metrics of NIC in a sound way. As endogenous theories regard it, in terms of public economics, a purely rival good has the property that its use by one firm/nation precludes its use by another; meanwhile a capital good is excludable if the owner can prevent others from using it (Romer, 1990). Following Romer (1993), the subcomponents of national capital have been inserted into the two-dimensional scale of rivalry and excludability (see figure 2). Obviously, as could be seen, human capital has economic attributes of a private good, since it is purely rival and highly excludable. In this case, IC scholars, e.g. Roos (1997) or Malhotra (2000), succeed human capital theorists assuming that human capital is inherently tied to persons (e.g. Becker, 1975; van Leeuwen, 2007).

High	Rival	Non-rival
Degree of excludability		
High	Human capital	Organizational capital (prescriptive attributes)
Low	Market capital (prescriptive attributes)	Structural capital (propositional attributes)

Figure 2 – Conceptual scheme of economic attributes of NIC components as capital goods  
Source: own proposal in the Romer's (1993) framework

For other components of IC, it is helpful to use the Mokyr's (2000, 2005) distinction between prescriptive and propositional knowledge. The former is concerned with techniques and rules of thumb; propositional knowledge explains why things work in the way they do, thus could

be traced to general knowledge. Within these notions, structural capital has intrinsic attributes which could be regarded as propositional ones, and accordingly can not be traded or owned, such as basic R&D, legal systems, or market institutions. Noteworthy, even though some attributes of market capital, such as norms and values, are country-specific, they should be treated as non-rival and non-excludable. In this case, Stewart (1997)'s notion that "market capital can not be owned" refers to its propositional attributes (p.143). Further, prescriptive metrics of renewal capital and process capital represent the core of nation's technological activities. In this vein, these subcomponents can be regarded in their higher-order component, that is organizational capital; all attributes of incremental processes, such as ICT or investments in innovations, should be referred to prescriptive organizational capital. As Edvinsson and Malone (1997) claim, this capital can be owned and thereby traded (p.11). In connection to Endogenous Growth Theories, in the Ljungberg's (2004, p.4) statement, only with an accumulation of propositional attributes of structural capital, prescriptive structural capital will eventually generate diminishing returns. However, since propositional metrics of structural capital as well as market capital are low-excludable, for generating technological change, prescriptive organizational capital that can be charged is particularly important.

Representatively, the recent empirical findings on economic effects of IC appear to support the proposed conceptual distinction between its propositional and prescriptive attributes. Thus, while examining developed economies Bergheim (2005) has found that the capability of IC to further advance economic growth may weaken or even vanish over time. Ståhle and Bounfour (2008) have indicated the same phenomenon of *saturation* of IC drivers in the investigation of developed and developing countries with extensive data. Similarly, Hervas-Oliver and Dalmau-Porta (2007), in the study on OECD countries, indicate that technological and business factors contribute for development of IC in a short period, whereas educational and networking factors do not, and thus might matter for a longer period. These findings are illuminating evidence that the role of propositional and prescriptive attributes of IC in sustaining economic growth differentiates over time. Thus, prescriptive drivers can not be transferred and repeated unrestrictedly with the expectation that they enforce the creation of national wealth at constant rates. In turn, this challenges economies for continuous enhancement and renewal of propositional NIC attributes.

Given all points, the L&E model replicates definitions and major statements of IC Theory. However, some notions of the model tend to be confusing in its overall consideration. Thus, since in a high resemblance with the theory the role of IC is highlighted, the constitution of financial capital as a subcomponent of IC is misleading. Further, although interconnection between components of IC is regarded by the model in line with the theory, their attributes have been chosen arbitrarily. The latter tends to be resulted from conceptual vagueness of definitions used not only in this model, but in the theory as a whole. In this vein, if economic attributes of capital goods within the Endogenous Growth Theory framework are considered, which are rivalry and excludability, the grounds for distinction between subcomponents and, as a result, their metrics, are becoming more powerful.

#### **4.1.2 Operationalization of the model**

The operationalization of the L&E model is examined from a critical review of measures of NIC and its components established by literature on Human Capital Theory, Innovation Theory, and, in particular, by the NIC approach.

The indicators for the L&E model have been chosen arbitrarily, while the measurement procedures for commensurability in general have been conducted. As L&E state, the selection of indicators comprised two rounds: in the first round, variables that were used at least two times in relevant studies, such as international and national reports, IC studies, and databases, were matched to the IMD World Competitiveness Yearbook; in the second round, the focus group has been expertized by Taiwanese researchers and finalized in the set of 29 indicators (p.18). It should be stated, indicators of market capital are supported with the fewest number of relevant studies, thus matched either by the L&E expert group or the theoretical studies of Malhotra (2000, 2003). Further, according to L&E's description of measurement principles, since there existed two types of data – qualitative and quantitative, - the data with absolute values has been normalized by dividing to the highest value and multiplied by 10 to transform into a 1-10 score, likewise the original view of data with qualitative ratings (p.21). That being so, in the M'Pherson and Pike (2001) statement, the procedure of normalization used in the L&E models does not conform to the standard normalized-scale reduction that usually is implemented with minimum and maximum scores. However, even though normalization as well as selection run by the L&E model tends to be arbitral, the final L&E indicators are commensurate. As M'Pherson and Pike (2001) further state, while satisfying the principle of commensurability, indicators should be also distinct and complete, thus should not allow for double-counting.

The use of broad and unspecified definitions of components of NIC leads to the indistinct choice of indicators in NIC models which can be matched to different subcomponents of IC. As mentioned (section 2.3), for illustration, it is reasonable to compare L&E's indicators with the Bontis's (2005) model and the Weziak's (2007) model (see table 5). As a comparison shows, although all models share the analogous definitions, their chosen IC attributes tend to differentiate considerably. Thus, with definition of human capital in terms of knowledge, education, and competencies in realizing national tasks, researchers choose not only education measures, such as literacy rate or higher education enrollment, but also other metrics of well-being, such as health, tolerance and happiness. Within the conceptual vagueness of process and renewal capitals attributed to infrastructure and capability for innovation, indicators for these subcategories, such as patents or mobile phone subscribers, obviously overlap in models. In contrast, the indicators of market capital which defined most broadly as internal and external country's relational networking diverge strongly: from institutional indicators of globalization, trust and norms in Weziak (2007) and L&E to innovation indicators of patenting in Bontis (2005). This creates the problem of double-counting. In the Weziak's this problem appears to be even explicit: the same indicators of patents in process and market capital are obviously repeated in the model.

Table 5 – Indicators of NIC in models based on Edvinsson & Malone (1997)

Component of IC	L&E model (2011)	Bontis (2005)	Weziak (2007)
Human capital	Skilled labor*; Employee training*; Literacy rate; Higher education enrollment; Pupil–teacher ratio; Internet users per capita; Public expenditure on education/GDP	Literacy rate; Tertiary schools per capita; Primary teachers with required qualifications; Tertiary students per capita; Cumulative tertiary graduates per capita; Male grade 1 net intake; Female grade 1 net intake	Life satisfaction*; Subjective health*; Tolerance*; Happiness*; Human resources in science and technology; Employment in high-tech service sectors; Total researchers per capita; Employment in high-tech sectors; Internet subscribers; Individuals' level of computer skills; Computer-based workforce; Internet-based workforce; Students at ISCED levels 5-6; Graduates ISCED 5-6; Participation in any learning activities; Doctorate students in science and technology fields
Market capital	Corporate tax*; Cross-border venture*; Openness of culture*	High-tech exports; Patents USPTO per capita; Meetings hosted per capita	Inflow of students/total students; Patent applications EPO per capita; Patents USPTO per capita;

Table 5 continued

Market capital (continued)	Globalization*; Transparency*; Image of country*; Exports of goods/GDP		High-tech exports/total exports; Four indicators of trust from ESS*; Four indicators of norms from ESS*;
Process Capital	Business competition environment*; Government efficiency*; Intellectual property rights protection*; Capital availability*; Computers in use per capita; Convenience of establishing new firms*; Mobile phone subscribers per capita	Telephone mainlines per capita; Computers in use per capita; Internet hosts per capita; Internet users per capita; Mobile phones subscribers per capita; Radio receivers per capita; Television sets per capita; Newspaper circulation per capita	Patent applications EPO per capita; Patents USPTO per capita; Broadband penetration rate; Enterprises having access to the Internet; Mobile phone subscribers per capita; Patents EPO per capita
Renewal capital	BERD per capita; Basic research*; GERD/GDP; R&D researchers per capita; Cooperation between universities and enterprises*; Scientific articles per capita; Patents per capita (USPTO + EPO)	Book imports/GDP; Periodical imports/GDP; GERD/GDP; Ministry employees in R&D per capita; University employees in R&D per capita; Tertiary expenditure/ public education funding	Private expenditure on education/GDP; Public expenditure on education/GDP; Tertiary expenditure/ public education funding; GERD/GDP; Expenditure on Information Technology/GDP
Financial capital	GDP per capita PPP	GDP per capita	Not included

Source: own constitution

\* Qualitative indicator

Although all discussed models are problematic in double-counting, indicators chosen for L&E NIC subcomponents appear to be more sound in their contents, as compared to other models. Thus, within the L&E model, likewise in other ones, the indicators for human capital and renewal capital can be highly interdependent, such as literacy rate, enrollment ratios and skilled labour, or BERD/GERD and basic research. However, in comparison to other schemes, the L&E model suggests relatively equal numbers of both input and output indicators for each NIC category. In this case, although human capital is estimated with broad output measures of literacy and skills (van Leeuwen, 2007), they are complemented with input measures on investments in education. In a similar manner, highly criticized output indicators of patenting are amplified with input measures on expenditures on R&D or number of researchers which are seen as more harmonized across countries (e.g. Smith, 2005b; Kleinknecht & Reijnen, 1993; Jones, 2002). Additionally, metrics for process capital in the L&E model are not skewed to ICT, as it is done in other models with such indicators as computers or telephones in use. Although the presence of *internet users* in human capital as a measure of communication skills tends to be unsound, the desire of the authors of the L&E model to cover with it much more than the spread of the ICT, likewise in similar measurement models, tends to be theoretically grounded. However, this has been solved in the model with an extensive use of qualitative indicators.

As could be seen in comparison to other models (see table 5), the L&E study proposes balance numbers of indicators of each type – both qualitative and quantitative, and thereby differentiates with a more broad use of qualitative metrics. The choice of qualitative measures appears to be justified by the theory, since it is considered that IC comprises primarily value-laden characteristics (Stähle & Stähle, 2012). Thus, L&E market capital, for instance, is estimated with six qualitative indicators out of seven. In addition, the L&E model even uses qualitative measures of basic research and skilled labour instead of quantitative metrics which can be found in the data sources, e.g. employment in high-tech sectors or training and development participation rates. For a comparison, whereas the Weziak's model proposes relatively few qualitative measures of happiness or trust, the Bontis's model suggests only financial and industrial indicators. However, due to the original specificity of qualitative indicators, there appear additional methodological problems with their use. Thus, Stähle (2012b) argues that macroeconomic qualitative indicators available for IC research are lacking in reliability. Further, as Glaeser et al (2005) point out, the majority of qualitative indicators suffer highly from subjective bias, and thus being overly influenced by recent economic performance. Moreover, some international indices, such as government efficiency or globalization, which are chosen by the L&E model, originally represent composite indices constructed from diverse data sources which differentiate subject to the country. Besides the mentioned problem of double-counting in various sets of indicators used for composition of these indices, they may not allow for a reliable comparison of countries over time (Lall, 2001). Therefore, although the use of qualitative measures conforms to the theory, this creates methodological distortions in the model.

The way in which the L&E final indices and sub-indices are calculated does not conform to the model's theoretical assumptions. Thus, the final composite indices of NIC are constructed in the model through the use of the 1:1 summation, as it done, for instance, in Bounfour and Edvinsson (2005) or Marr and Starovic (2005). This practice tends to have deep theoretical implications, albeit not in the IC Theory, but applied within Innovation Theory: it is assumed that various components of knowledge are complementary and not substitutes (e.g. Antonelli, 2003). That being so, summing of different indicators in the L&E model is adequate, but only within considerations of the Innovation Theory. Another solution to the composition of sub-indicators that proposed by the empirical literature, but does not correspond to any theory, is benchmarking, that is estimation of specific metrics relatively to the highest score or value (e.g. Bontis, 2001). The common sense in using benchmarks can be stated as follows (Lall, 2001): some aspects of IC can only be assessed in comparison between countries and reference to actual practice. In line, as Stähle (2008) argues, this procedure is acceptable when dealing with only a few metrics, but with a large number of indicators the comparison becomes diffuse. Therefore, it appears inadequate to apply benchmarking to all indicators, as it has been done in the L&E model on the first stages of construction of NIC indices. Additionally, averaging of sub-indicators that further conducted in the L&E model can not be justified neither with theory nor with practice. Taken all, sophisticated procedure of composition of L&E's NIC indices appears to be arbitrary and artificial from established grounds.

Furthermore, within applied composition techniques, L&E indices in their output levels also conflict with theoretical assumptions. As indicated, in the L&E model both statements on the role of human capital as a core factor and structural capital as supporting surroundings are underlined. However, the contribution of sub-indices of IC to overall index does not indicate any empirical evidence for this in the L&E model (see figure 3). As could be seen, share of human capital is not the highest and equals to share of market capital or process capital. Additionally, when the Bontis's (2005) taxonomy is applied, structural capital that defined as a sum of renewal, process, and market capital exceeds human capital more than 2,5 times in average across countries. Moreover, evidence emerges that share of renewal capital in comparison to other ones is considerably understated. This tends to be inconsistent with the model's notion on renewal capital as a determinant of innovation capability that sustains future economic performance. Likewise with levels and shares of NIC and its subcomponents, composition and selection procedures applied in the L&E predefine a particular dynamics of indices.

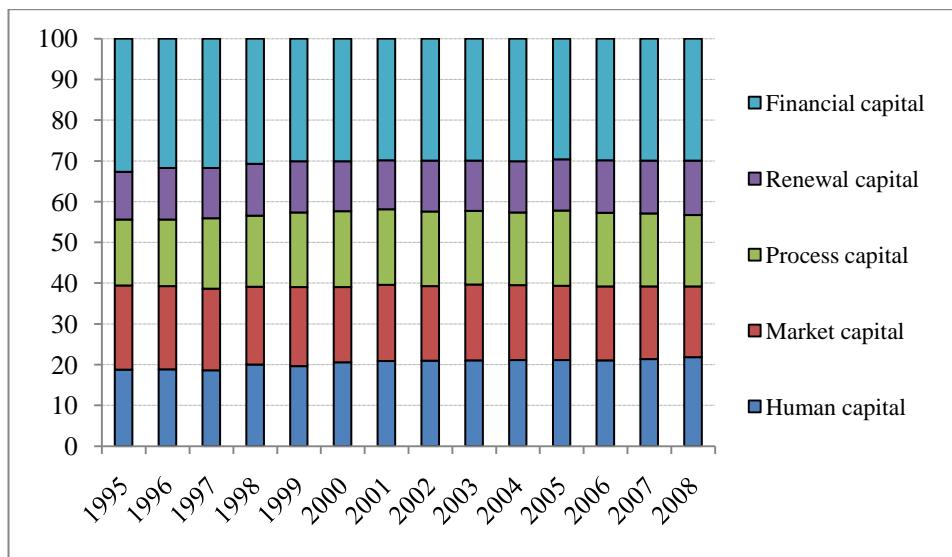


Figure 3 – Contribution of sub-indices to NIC index in the L&E model in 1995-2008, in average across countries, percentage

Source: own calculations

Also, the dynamics of components of NIC measured within the L&E model is questionable from IC Theory. Although NIC is stable in trajectories during the period across countries, subcomponents of IC contribute differently into its change (see table 6). As could be seen, human capital index accounts for a half of the change in NIC index in average. Further, a change in financial capital, measured with the L&E index, leaded to the lowest increase of the final index in comparison to effects of other components. The most remarkable evidence is that market capital decreased and correspondingly contributed negatively to the change in NIC, whereas other sub-indices had positive impacts. In cope with shares in overall indices, this dynamics of sub-indices provides illuminating evidence that levels and trajectories of NIC are predetermined by authors' construction of the L&E model. On account of this, in Stähle's (2006) view, it should be questioned whether the right elements – indicators – are being emphasized or processed in a right manner in the model.

Table 6 - Contribution of change in sub-indices into change of NIC index in 1995-2008, in average

	Absolute change, units	Relative change, per cent
Human capital	1,482	5,06
Market capital	-0,392	-1,34
Process capital	0,883	3,02
Renewal capital	0,856	2,92
Financial capital	0,121	0,41
NIC, total	2,950	10,07

Source: own calculations

This discrepancy between the underlying theory and model's suppositions creates impediments for interpretation of results on the basis of its indices. In this case, the critique of the Edvinsson and Malone (1997) may be relevant: the tool of multiple summated indicators does not provide any insight into cause-and-effect relationships between indicators (Andriessen, 2004, p.351). That being so, without proper theoretical grounds it is impossible to generate prescriptions for policy-makers, as the L&E model aims to do, since within vast set of indicators the emphasis on relation of some aspects to economic growth can be chosen only arbitrarily. In this vein, two ways to solve this problem of theoretical clarity could be proposed by IC research. One solution is to implement a holistic approach, that is done within national reports on IC (e.g. Pasher & Scharar, 2007). Another way is to narrow the perspective of IC to its aspects, such as investment in knowledge (e.g. Khan, 2005) or ICT (e.g. Masuyama, 2005). From the IC Theory view, these aspects are hardly extensive enough, but powerful and acceptable from the perspective of particular focuses. The advancement of NIC approach can be seen as developing in this way with a slight extension of focuses, but should be supported with theoretical justification of the models, in particular, with the Endogenous Growth theories.

Overall, the conformity of definitions used in the L&E model with its indicators tends to be weak. Although IC Theory allows for the broad scope of measures to be chosen, their selection and composition procedures have been conducted arbitrarily. As a result, the L&E model, likewise other models on NIC, suffers from the problem of double-counting. In accord, concerning indistinct measures, the major threat for content validity should be referred to qualitative composite indicators which are extensively used by the model. Further, though the L&E scheme proposes a comparatively moderate set of indicators, which are by their nature sound and powerful in established theoretical and empirical regards, their number and composition into final indices create impediments for providing justified conclusions, in particular, in relation to economic growth. The major reason for this could be seen in the lack of theoretical clarity of the measurement scheme proposed by the model.

To summarize the discussion, the L&E model is lacking in content validity in both conceptualization and operationalization aspects. Although, according to its statements and used definitions, the model aims to provide measures for assessing IC as an economic driver, the concepts and their metrics do not conform to each other in this line of research. It has resulted primarily from the high subjectivity and arbitrariness of applied selection and composition procedures. Though broad definitions and taxonomies of IC Theory allow for the multidimensional interpretation of the concept, the choice of attributes and indicators should have been theoretically justified, especially while estimating the interrelations of IC and economic growth. In this vein, the NIC approach can suggest more powerful theoretical statements and methodological guidelines, in accord with the Endogenous Growth Theories, than those applied in the L&E.

## **4.2 Construct validity**

This section aims to estimate construct validity of L&E indices of NIC in four aspects, such as reliability, convergent validity, discriminant validity, and nomological validity. These aspects are examined in an Endogenous Growth Theory perspective.

### **4.2.1 Reliability**

As discussed (section 3), the reliability of L&E constructs is examined in the current study in two aspects: cross-national (internal consistency) and cross-temporal (stability).

The internal consistency of first-order indicators was estimated in the L&E model by its authors (see Appendix 2). As could be seen, notwithstanding the optimistic conclusions made by researchers, not all variables meet the requirements of acceptable loadings on higher-level components: such measures, as skilled labour, pupil-teacher ratio, openness of culture, export of goods, and capital availability correlate with corresponding indices with coefficient much lower than 0,50. Since the data on these first-level variables is not available from L&E, other advanced techniques, suggested for instance by Adcock and Collier (2001) or Hair et al (1998), to examine this lower level constructs in depth can not be applied in the study. Therefore, the internal consistency will be further examined on a subcomponent level.

According to calculations, indices of NIC subcomponents are consistent in the L&E model (see table 7). Thus, alpha-values for each of the subcategories and its correlations to compound index range from 0,82 to 0,91, that is much higher of acceptable limit. In addition, all item-to-item correlations exceed 0,30, and hence signify the internal consistency of L&E second-order components. However, amongst high item-to-item correlations in the construct, the indices of market capital correlate with a relatively lower strength. As could be seen, the correlation coefficient of market capital indices with renewal and financial capital reach low, albeit acceptable, levels of 0,45 and 0,47 respectively. In cope with evidence of unreliable first-order loadings, this exclusive view of correlations of market capital measures also questions their reliability. Besides internal consistency of all constructs, in order to establish reliability, the stability of indices over time should be examined.

Table 7 - Measures of internal consistency of L&E NIC indices and its subcomponents, for average levels in 1995-2008

Component	Correlation coefficients						Alpha-coefficient
	Human capital	Market capital	Process capital	Renewal capital	Financial capital	NIC index	
Human capital	1,00	0,53	0,90	0,84	0,84	0,94	0,85
Market capital	0,53	1,00	0,77	0,45	0,47	0,70	0,91
Process capital	0,90	0,77	1,00	0,84	0,82	0,98	0,82
Renewal capital	0,84	0,45	0,84	1,00	0,71	0,91	0,90
Financial capital	0,84	0,47	0,82	0,71	1,00	0,84	0,89
NIC index	0,94	0,70	0,98	0,91	0,84	1,00	-

All measures are significant at 0,05 level

Source: own calculations

According to the estimation, the cross-temporal correlation between levels of L&E NIC indices over time is high (see table 8). The bivariate correlations vary in strength from 0,80 to 0,99. Hence, with cross-temporal correlation coefficients, the reliability of the construct of NIC indices can be established.

Table 8 - Stability of L&E NIC indices for 1995-2008

	L&E NIC index
Average	0,97
Min	0,80
Max	0,99

Significant at 0,001 level

Source: own calculations

Besides the direct estimation of reliability, above calculations with extremely high correlations provide evidence of methodological flaws in NIC sub-indices. Thus, correlation between subcomponents and NIC index is so high, as each of these sub indices can independently approximate NIC. Similarly, correlation between some subcategories, such as human capital, process capital and renewal capital is excessively strong. That being so, these results offer sufficient evidence that L&E indicators of NIC are indistinct due to the problem of double-counting. Furthermore, too high cross-temporal correlation indicates that examined measures of NIC are considerably constant over short periods of time. This evidence may indicate that the NIC index of the L&E model comprises primarily prescriptive attributes of IC.

Overall, reliability of L&E constructs in both aspects of internal consistency and cross-temporal stability can be established. However, some indicators of subcomponents appear to be internally inconsistent. In addition, the analysis provides evidence of indistinctness and inadequacy of some constructs in the model.

#### 4.2.2 Convergent validity

As discussed (section 3), the convergent validity of L&E constructs is examined for two groups of analogous and similar measures: NIC indices (from Weziak, 2007) and national competitiveness indices (Global Competitiveness Indices from WEF) respectively.

According to calculations, L&E measures and Weziak's measures of NIC converge strongly. Thus, the ranking correlation coefficient reaches 0,88 that is much higher of acceptable level (significant at 0,001 level). Noteworthy, this convergence is expectable, since, as mentioned (see section 2.2), definitions, taxonomies and attributes of NIC overlap significantly in both models. Moreover, principles of selection and composition of IC constructs are the same. In all, convergent validity of the L&E model estimated with analogous measures of NIC can be established. Since the number of overlapping items is less than acceptable, it is advisable to examine also the second group of indicators.

As illustrated, L&E rankings and Global Competitiveness rankings correlate heavily. Originally, both indices follow each other considerably in rankings of countries for 1998-2008 (figure 4). The relative divergence can be indicated mostly in ratings between developed countries, such as United Kingdom or Iceland, but overall tendency of convergence is considerably evident.

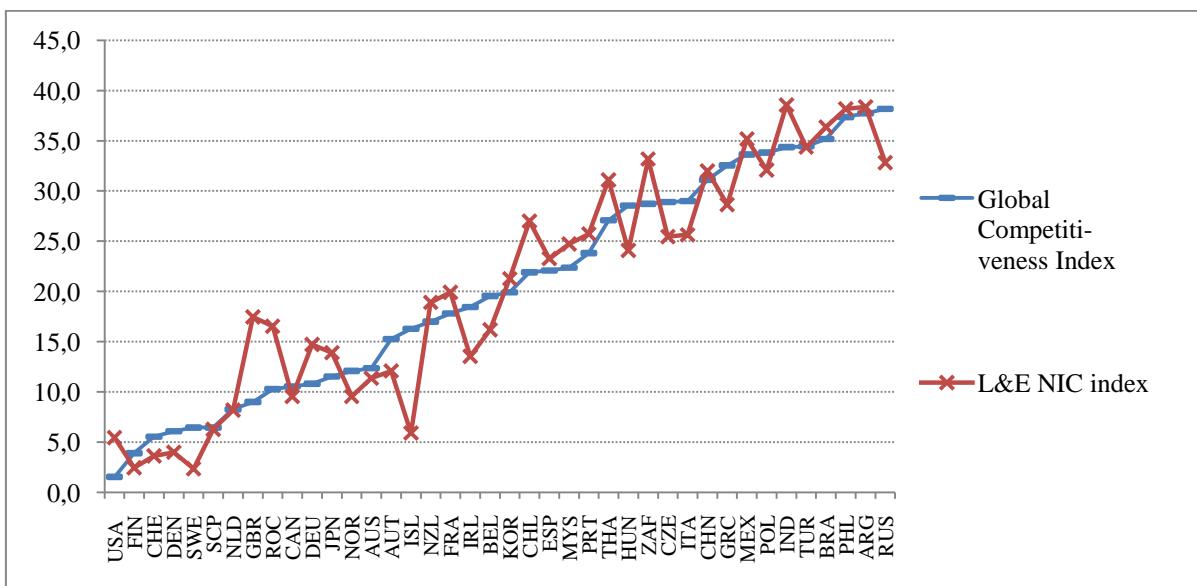


Figure 4 – Pattern of convergence between L&E NIC indices and Global Competitiveness Indices, average ranking for 1998-2008 for 40 countries

Source: own calculations

Further, the estimates of correlation between levels of L&E indices and Global Competitiveness indices supports evidence of their strong convergence (see table 9). According to calculations, rank correlations between L&E NIC indices and Global Competitiveness indices average at 0,89, and range from 0,75 to 0,95, thus in all cases exceed an appropriate level. All

given, L&E indicators are valid in the aspect of their convergence with similar measures of NIC. However, this considerably high correlation also signals about conceptual and methodological distortions in the L&E model.

Table 9 – Convergence of L&E NIC indices with Global Competitiveness indices for 1998-2008

	GC indices
L&E NIC indices, average	0,89
Min	0,75
Max	0,95

Significant at 0,001 level

Source: own calculations

Paradoxically, established extremely strong convergence of L&E measures with competitiveness indices signifies that they are not able to tackle the dynamics of IC as an economic driver. Following competitiveness measures in their methodology, the NIC approach may lose its conceptual focus on knowledge-base value creation (Stähle & Pöyhönen, 2005). As stated in the literature, the future of nation is considered to be dependent on national competitiveness, which on the other hand is relied on tangible and intangible resources; in developed countries competitive advantage is defined with NIC (e.g. Stähle, 2006; Stähle & Grönroos, 2000). From this theoretical view, NIC indicators should not be regarded as extended measures of competitiveness or national wealth, but rather its drivers. On account of this, measurement of NIC as a replica of competitiveness models tends to be conflicting with the concept of IC, and hence questions the possibility to capture the impact on economic growth with implications for economic policy (Scott & Rothberg, 2005). Therefore, established extreme convergence of L&E measures with other similar constructs, such as competitiveness indices, indicates that they more probably can serve as their extended versions.

Overall, L&E measures of NIC can be considered as valid in aspect of their convergence with both analogous and similar constructs. However, this extreme overlapping seems to be conflicting, since competitiveness measures are conceptually regarded as an extension of national wealth measures.

#### 4.2.3 Discriminant validity

As stated (section 3), discriminant validity is assessed as the degree of divergence of L&E measures with antecedent economic performance.

According to the estimates, NIC measured within the L&E model tends to follow short-terms fluctuations in economic growth (see figure 5). Thus, correlation between adjusted NIC measures and antecedent GDP per capita reaches 0,75 in average for 1995-2008, that is higher than acceptable level. It seems that either indicators of economic performance biases in perceived level of NIC, or economic growth almost immediately induces IC of a country. It may also

indicate that L&E measures reflect primarily prescriptive attributes of IC which dynamics can be captured only in a short run. In general, this considerably strong correlation between NIC measures and GDP per capita, within statements of measurement theory, indicates that L&E measures of NIC are more likely to serve as its extended version. On account of this, inclusion of indices of financial capital that is made originally by L&E make NIC indices being convergent with GDP even at a larger extent. Therefore, discriminant validity of L&E NIC indices can not be established. Then, indices of subcomponents of L&E model are examined, since they are constituted with relatively different number of supposedly biased first-order indicators.

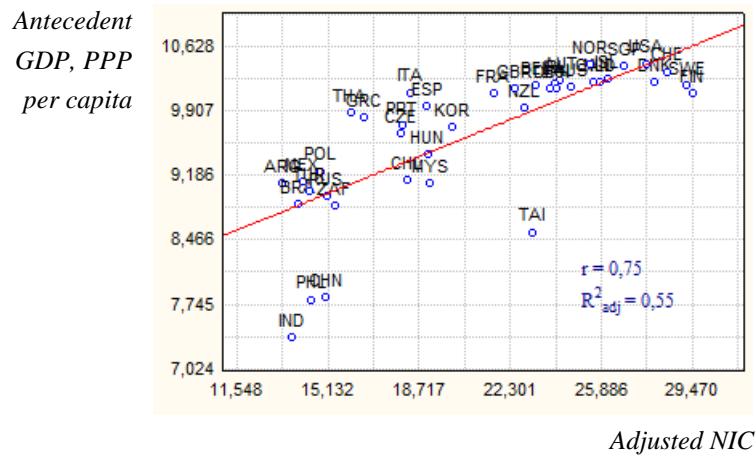


Figure 5 – Correlation between antecedent economic performance and L&E NIC measures, average for 1995-2008

Significant at 0,001 level

Source: own calculations

As could be seen, recent economic performance has strong correlation almost with all NIC sub-indices (see table 10). Excluding market capital, all coefficients exceed 0,50. It signifies that the L&E model highlights primarily prescriptive attributes of NIC that explain short-run fluctuations. Further, as indicated, market capital index, that constructed with relatively more qualitative indicators, correlates with recent economic growth at a lesser, albeit substantial, extent than other sub-indices. This may offer some evidence that other sub-indices are not less perception-biased than market capital index.

Table 10 – Correlation between antecedent economic performance and indices of L&E subcomponents of NIC, average for 1995-2008

	Human capital	Market capital	Process capital	Renewal capital
Antecedent GDP, log PPP per capita	0,80	0,46	0,77	0,64

Significant at 0,001 level

Source: own calculations

Overall, L&E indicators of NIC in their divergence with short-run fluctuations in economic growth should be considered as invalid. Thus, both indicators are biased in perception of NIC attributes and NIC measured within the L&E follows business cycles considerably.

#### 4.2.4 Nomological validity

As discussed (section 3.2), nomological validity of L&E NIC measures are examined in their predictive power for future economic performance.

According to established assumptions, the relation between NIC and economic growth is tested using the model below:

$$\text{Growth} = \alpha + \beta \text{NIC} + \gamma \text{GDP}_{1995} + \varepsilon.$$

As mentioned, growth and NIC variables are tested in both rates and levels. Thus, Growth is either (i) the annual average GDP per capita PPP growth rate between 1995 and 2008 in per cent, or (ii) log of the annual average GDP per capita level between 1995 and 2008 in percentage points. In a similar manner, NIC is either (i) initial NIC in 1995 in units, or (ii) the annual average NIC change rate between 1995 and 2008 in per cent. In addition, this relation first examined in simple regression models, and then in multiple regression models with inclusion of log of initial level of GDP in 1995 in per cent. That being so, 8 (eight) modifications of regression models are tested (see table 11).

As the estimation shows, initial levels of NIC measured with L&E indicators correlate significantly with both levels and rates of economic growth, but with different strength (see figure 6). Thus, L&E NIC indices for a current period correlate rather weakly with future growth rates of GDP: correlation coefficient reaches 0,42 and being significant. Correlation between measures of current NIC and future levels of GDP equals 0,78, thus being significantly strong. Respectively, an explanatory power of the former model is much lower, whereas variation in NIC measures explains 60 per cent of variation in levels of GDP. On account of this, in comparison to other analogous studies, evidence demonstrated with L&E NIC measures in its connection with rates and levels of future economic performance is striking (Andriessen & Stam, 2005; Bontis, 2005). However, it has not been found any significant correlation between change rates of NIC and future economic performance, both levels and rates of growth. In addition, direction of interrelation between rates of economic growth and NIC levels tend to be conflicting.

Table 11 – The explanatory power of the L&E indices of NIC in GDP per capita growth regressions

Independent variable	Dependent variable							
	GDP per capita level, log of average 1995-2008				GDP per capita growth rate, average 1995-2008			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Level NIC <sub>adj</sub> 1995	0,1284* (0,016838)	-	0,0091 (0,007241)	-	-0,0014* (0,000494)	-	-0,0002 (0,000732)	-
NIC <sub>adj</sub> change rate average 1995-2008	-	8,1478 (16,76716)	-	2,2487 (2,962962)	-	0,3183 (0,338148)	-	0,3836 (0,288806)
Initial GDP per capita, 1995, log (Control variable)	-	-	0,8877* (0,041317)	0,9263* (0,026922)	-	-	-0,0094* (0,004175)	-0,0103* (0,002624)
Constant	7,3412* (0,324603)	9,6671* (0,20372)	1,2166* (0,298813)	1,0011* (0,254403)	0,0754* (0,009530)	0,0459* (0,004108)	0,1404 (0,030193)	0,1418* (0,024797)
N	40	40	40	40	40	40	40	40
R <sup>2</sup> <sub>adj</sub>	0,5945	0,0000	0,9691	0,9683	0,1547	0,0000	0,2369	0,2709
F-stat	58,141	0,236	612,250	595,780	8,140	0,886	7,054	8,244

Robust standard errors in parentheses

\* Significant at 0,001 level

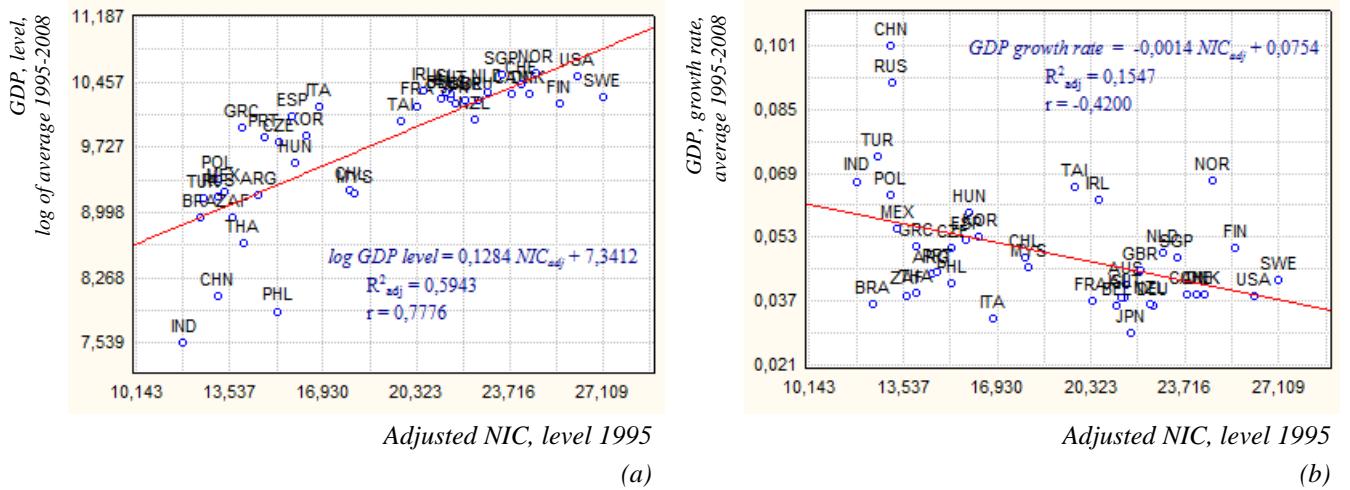


Figure 6 – Correlation between current levels of NIC and future economic performance,  
(a) levels and (b) rates of growth

Significant at 0,001 level

Source: own calculations

While presence of correlation between IC and future national performance conforms to the theory, direction of this correlation measured with the L&E indices is inadequate. An established negative correlation between IC and rates of economic growth confronts to the IC theoretical statements. As argued, this relation should be positive. However, when L&E NIC indices are regarded as extended indicators of economic performance, some explanation can be provided for this empirical finding. Likewise with GDP measures, negative correlation between initial levels of NIC and rates of economic growth replicates *catch-up* phenomenon: countries with low level of NIC will eventually catch up with leaders, countries with high levels of NIC; during the period of catching up the latecomer will have a higher growth rate than leaders (e.g. Baumol et al, 1994). That being so, evidence by means of L&E measures contradicts statements of the IC Theory, but fits into the Growth Theory considerations, in a way that NIC measures substitute measures of national accounts.

When initial level of economic performance is controlled for, results, measured with L&E indicators, become even more conflicting. As table 11 shows, while including initial level of GDP per capita, estimated coefficients for level of NIC in both models with levels and growth rates of GDP are statistically unacceptable (panel 3 and panel 7). Although it is suggested by theory that current level of NIC is an important variable when considered separately from initial level of GDP, its coefficient is not significantly different from zero at least at 0,1 level. According to general considerations of measurement theory (e.g. Hill et al, 2008, pp.154-155), this can be explained in a way that high correlation between initial level of GDP and current level of NIC ( $r = 0,77$ , significant at 0,001) is making it difficult to accurately capture the effect of each indicator. However, as could be seen, explanatory power of modified models has increased considerably in comparison to simple correlations; in particular, in case of level-to-level estimation it accounts for 96% of variance in cope with improved F-statistics. All given, there emerges a research dilemma

of whether level of NIC should be excluded from the model or not. The measurement theory offers two appropriate remedies for this: (a) either to use the model with highly correlated variables for prediction only, but without interpretation of coefficients, (b) or use the simple correlations between each independent variable and the dependent variable to understand independent-dependent relationships (Hair et al, 1998, p.193). In all cases, research solution should be supported by the theory.

According to theoretical assumptions, under strong correlation between IC and initial level of economic performance, NIC variables can not be used in any model. As the IC theory suggests, intangible capital may affect economic performance more strongly than tangible factors of production, especially for developed countries. Moreover, according to assumptions of the Endogenous Growth Theories, this impact of IC should be separated from effects of other tangible factors of production. Taken this, using the multi-regression model with both initial levels of GDP and NIC, which are proxies of tangible and intangible factors respectively, makes it impossible to distinguish their influences on future economic performance. As stated, research tactics can be also to examine economic effects of NIC in simple correlation between L&E NIC indices and GDP levels or growth rates. However, this also appears to be problematic, since the behavior of NIC indices is identical to national accounts measures for level-to-rate relationships. In addition, using NIC indices for prediction in simple models creates some methodological impediments for translating obtained results into policy prescriptions.

Undoubtedly, while taking L&E NIC indices as a predictor of current and future economic performance, it is unclear how to interpret final results. At a brief glance, the overall meaning of NIC's beta-coefficients can be regarded rather easily in examined log-linear models (table 11, panels 1 and 5): when NIC increases by 1 unit, GDP changes with plus 12,84 per cent in levels and minus 0,14 per cent in growth rates. Subcomponents of IC – human capital, market capital, process capital, and renewal capital – contribute to economic growth with the same coefficients, since, as mentioned, final NIC indices were given with summation of sub-indices. However, within deeper analysis, for L&E indices which sub-metrics were originally benchmarked, averaged and then summated it appears to be considerably difficult to generate any constructive conclusions. For instance, literacy rate in this case should be judged relatively to other countries, and after relatively to other metrics of NIC. While extensively used in the L&E, qualitative measures which are naturally compound aggregated indicators are not less troubling for interpretation. Moreover, beta-coefficients appear to be strongly dependent on an original ratio of indicators within NIC subcomponents; as shown, sub-indices have been stated in the model in such a way, that renewal capital, for instance, appears to be measured as a lowest. Therefore, when a large number of metrics is reproduced arbitrarily in measures of IC, likewise in L&E NIC indices, retranslation of results tends to be impossible. This means that using NIC indices in simple correlations is also not provident.

To summarize the discussion on construct validity, L&E measures should be regarded as invalid in their construction to capture the impact of NIC on economic growth. The major reason for this is that IC dynamics and impact on economic growth covered with L&E measures do not conform to theoretical assumptions. In general, L&E NIC indices are reliable and converge highly with similar measures of NIC. In addition, NIC indicators closely follow business cycles. However, this resemblance indicates that L&E indicators should not be used for assessing IC dynamics with economic growth in multiple regression models. For simple correlations, it is considerably difficult to generate any constructive conclusions and interpret results on their basis. In contrast to theoretical statements, the behavior of NIC indices in level-to-rate relationships with economic performance is similar to growth output measures. Given all points, the NIC L&E indices may serve only as descriptive indicators of macroeconomic performance which do not reflect the NIC concept.

## 5. Conclusion

This section aims to summarize major critical points on validity of L&E model, present proposals on its improvement, and indicate research contributions of this study.

The danger of providing *measurement without theory* has been pointed out long ago (Koopmans, 1947). Koopmans (1947) claims that “the decision not to use theories ... limits the value to economic science and to the maker of policies” (p.172). In this vein, validation of measures and results obtained through research can serve as a powerful instrument in science and policy since it examines overall adequacy of measures to theoretical assumptions.

Measures of NIC are not lacking in grounded theory. Even though macroeconomic research on IC is young and still developing, its bordering theories are long-established and proved themselves as comprehensive theoretical tools. Thus, NIC approach tends to share ideas and demonstrate implications similarly to various approaches to intangibles which originated from either Neoclassical Theories or Evolutionary Theories of economic growth. Within neoclassical traditions, it is the Endogenous Growth Theories which resemble strongly with basic statements of IC and its current line of research. Due to this diversity of applied approaches, current NIC studies differentiate a lot in interpretation of the major concepts. As a result, the choice of indicators which attributed to these concepts varies strongly. In addition, NIC macro measurement models were replicated directly from micro IC studies that originally have some flaws, and this also creates conceptual and methodological diffuseness. Therefore, concerning IC research validity should be questioned not only because theory is not conceptualized, but also because scholars tend to misuse it in empirical studies.

The L&E measurement model of NIC, that represents a prevailing perspective in current NIC research, belongs to the family of studies which examine levels of IC across nations with proposed synthetic indices and thus allow for providing comparative analysis on their basis. Indeed, the model’s composite indices of NIC are not originally devoted to explore causal connections between knowledge and economic growth. However, while considering implementation of their results, L&E strongly recommend using the results obtained with their measures for policy-makers to elaborate prescriptions, and for academia to investigate economic effects of NIC. This notion tends to thrust itself upon validation of suggested indicators in an Endogenous Growth Theory perspective. More precisely, while validating L&E methodological model it is decisive to consider disembodiment hypothesis: NIC indices are to be used for assessing the dynamics of IC in connection to economic performance, and in addition, its economic effect can be separated from effects of tangible factors.

The current study demonstrates that the L&E measurement model is valid neither in its content nor in the construction. The model claims for using established concepts of IC theory, and while aiming to capture the complicated nature of knowledge assets, chooses diverse attributes for IC measures. However, selection and composition procedures applied in the model are arbitrary and not justified by the theory. In fact, the relative importance of each component of IC singled out in the model is attributed by the research team rather than by theoretical assumptions. This

means that results obtained with NIC indices depend heavily upon the value judgments of the scholars. In this vein, although indices highly correlate with economic growth, it is considerably difficult to generate any constructive and theoretically adequate conclusions on their basis.

Furthermore, L&E indices are reliable and converge highly with similar measures of NIC. However, this resemblance indicates that examined indicators more probably can serve as measures of competitiveness or economic performance than of NIC. In line, indices are highly affected by short-term fluctuations in economic growth, whereas they must indicate IC as a long-term phenomenon. Further, while contradicting to IC theory, NIC measured with L&E indices negatively correlate with rates of economic growth, and this corresponds with the behavior of traditional growth measures, in particular, illustrates the catch-up effect. For the reason of high resemblance with growth measures, the use of L&E indices are not applicable in growth multiple regression models. Although the common sense allows for using them in prediction models without interpretation of coefficients, it appears to be misleading since economic effect of IC can not be distinguished from effects of tangible factors. In other words, it is impossible to test or at least explore the embodiment hypothesis with these indices.

The validation of the L&E model is a basis for further development of NIC measurement models. The main notion for this development is that results obtained with NIC indices should be capable of interpreting, at least in simple correlations. In this case, major suggestions can be proposed for providing valid NIC models that could be stated as follows:

- Definitions used in the IC models must be clarified for a macroeconomic dimension. These definitions need to emphasize primarily the perspective on NIC as an economic driver. As a consequence, theoretical clarity of used concepts will allow for attributing them with appropriate indicators.
- There must be chosen a small set of distinct and complete indicators, all defended with theoretical and empirical grounds. Composite indices should not be considered. Preference should be given mainly to quantitative measures. Qualitative indicators can also be attributed, but only accurately, and with providing adequate normalization procedures.
- Composing indicators into final indices needs to be produced soundly, based on established taxonomies of NIC. As justified by the theory, construction procedures must be conducted with summing and weighting of sub-indicators, thereby accenting the most significant metrics of NIC.

Remarkably, all stated suggestions consider specification of the measurement model and narrowing its perspective, and thus define the scope of future research on NIC. All construction procedures, namely, precision of NIC concept and its attributes, selection of indicators, and their composition into final indices – that is NIC measurement scale, – should be distinguished in models subject to the type of the economy. As an additional aspect, reliable NIC data, especially on qualitative indicators, is not available for some countries. All given, these aspects consider inter-nation comparisons of NIC as being meaningless and impossible in a desirable framework for sample with highly diverged countries. As to established taxonomies of NIC, this implies that

unified NIC models can not be constructed, especially by replication from micro studies. In support of this notion, recent NIC empirical studies indicate that the IC dynamics differentiates according to the developmental stage of the economy. In this vein, narrowing NIC perspective with distinction between propositional and prescriptive attributes of NIC, that proposed in the current study, can be decisive. Their separate consideration in the NIC models may also help to specify the dynamics of IC for time periods. As discussed, propositional factors of IC, which are crucial for technological change, sustain economic growth in a long run, whereas prescriptive factors incrementally affect economic performance in a short run and are inclined to saturate. For the reason of this diverse dynamics, propositional and prescriptive factors of NIC and its components should be considered separately in models. Factually, in terms of stated research question, it implies practical impossibility to develop valid measurement models in a perspective that prevails in current NIC research – with composite indices, leastwise uniformly for all types of countries. While only being specified, NIC measurement models can be justified in their adequacy for economic science and economic policy.

The current study contributes to the NIC research not only with suggested paths for development of NIC models. Certainly, while revealing flaws in NIC indices, it enables powerful and adequate measures for NIC and its dynamics to be built. This undoubtedly should be done with a proposed basic NIC model on economic attributes. Besides this, by clarification of place of the IC approach among other theories this study enables their major implications and achievements to be used by IC researchers. It appears to be possible since the current study precises the fundamental idea of NIC as an economic driver in an Endogenous Growth Theory view. Moreover, with investigation of NIC dynamics it allows for further examining the causality between NIC and economic growth. Future studies on economic impacts of NIC should also recognize its particular phenomena, such as saturation effects, which also have been discussed in the thesis. As for measurement theory and practice, validation framework conducted in the study can be generalized to other composite indices. Thus, the study's scheme of testing appears to be applicable to any of the international indices, since it does not require techniques specific to IC Theory. All told, the current study and future research on intangibles are seen as a powerful instrument for policy-makers to identify NIC drivers and steer them for economic growth.

As a final notion, the current study shows that concepts built by the IC theory lack in theoretical clarity and hence allow for their arbitrary multi-dimensional interpretation. This corresponds certainly with conceptual complexity of intangible nature of IC. In this vein, the L&E study is a necessary tool for NIC research to solve well-known paradox of conceptualization emphasized in Kaplan's (1964, p.53): "proper concepts are needed to formulate a good theory, but we need a good theory to arrive at the proper concepts... The paradox is resolved by a process of approximation: the better our concepts, the better the theory we can formulate with them, and in turn, the better the concepts available for the next, improved theory". Thus, current NIC studies by means of a trial-and-error method are constructing the IC theory. Their validation, in turn, can quicken and anesthetize this process.

## References

- ADCOCK, R. & COLLIER, D. (2001). Measurement validity: A shared standard for qualitative and quantitative research. *The American Political Science Review*, 95, 529-546.
- AHO, S., STÅHLE, S. & STÅHLE, P. (2011). Critical analyses of the Calculated Intangible Value (CIV) method. *Measuring Business Excellence*, 4, 27-35.
- ALEXANDER, S. (2006). An Intellectual Capital Audit of the Grand Duchy of Luxembourg. Retrieved from [http://info.worldbank.org/etools/docs/library/235909/s4\\_p1.pdf](http://info.worldbank.org/etools/docs/library/235909/s4_p1.pdf). Accessed 2012/03/08.
- ANDRIESSEN, D. (2004). *Making sense of intellectual capital: Designing a method for the valuation of intangibles*, Oxford, Elsevier.
- ANDRIESSEN, D. & STAM, C. (2004). Intellectual capital of the European Union: measuring the Lisbon agenda. HOLLAND University of professional education, de Baak - Management Centre VNO-NCW: Centre for Research in Intellectual Capital. Retrieved from <http://www.weightlesswealth.com/downloads/ICofEU2004.pdf>. Accessed 2012/03/08.
- ANDRIESSEN, D. & STAM, C. (2005). Intellectual capital of the European Union. Hamilton, Ontario, Canada.
- ANDRIESSEN, D. & TISSEN, A. (2000). *Weightless wealth: Find your real value of intangible assets*, Bolton, Person Education.
- ANTONELLI, C. (2003). Knowledge complementarity and fungability: Implications for regional strategy. *Regional Studies*, 37, 595-606.
- ARCHIBUGI, D. & COCO, A. (2005). Measuring technological capabilities at the country level: A survey and a menu for choice. *Research Policy*, 34, 175-194.
- ARNOLD, L. (2005). The Jones R&D growth model: Comment on stability. *University of Regensburg Discussion Papers in Economics*, 1-27.
- ARROW, K. (1962). The economic implications of learning by doing. *The Review of Economic Studies*, 29, 155-173.
- BAILY, M. (1981). Productivity and the services of capital and labor. *Brookings Papers on Economic Activity*, 1, 1-65.
- BASU, S., FERNALD, J., OULTON, N. & SRINIVASAN, S. (2004). The case of the missing productivity growth, or does information technology explain why productivity accelerated in the United States but not in the United Kingdom? *NBER Macroeconomics Annual*, 18, 9-82.
- BAUMOL, W., NELSON, R. & WOLFF, E. (1994). *Convergence of productivity: Cross-national studies and historical evidence*, Oxord, Oxford University Press.
- BECKER, G. (1975). *Human capital, 2nd edition*, New York, Columbia University Press.
- BERGHEIM, S. (2005). Human capital is the key to growth. Deutsche Bank Research. Retrieved from [www.dbresearch.com](http://www.dbresearch.com). Accessed 2012/03/08.

- BOHRNSTEDT, G. (1970). Validity, invalidity, and reliability. In: BORGATTA, E. & BOHRNSTEDT, G. (ed.) *Sociological methodology*. (pp. 104-129). San Francisco: Jossey-Bass.
- BOLLEN, K. (1989). *Structural equations with latent variables*, New York, Wiley.
- BONI, M. (2009). Intellectual capital of Poland. Kancelaria Prezesa Rady Ministrów, lipiec 2009. Retrieved from [http://www.swisschamber.pl/de/act/upl\\_imp/other\\_downloads/report\\_int\\_capital\\_poland\\_english.pdf](http://www.swisschamber.pl/de/act/upl_imp/other_downloads/report_int_capital_poland_english.pdf). Accessed 2012/03/08.
- BONTIS, N. (2001). Assessing knowledge assets: a review of the models used to measure intellectual capital. *International Journal of Management Reviews*, 3, 41-60.
- BONTIS, N. (2005). National intellectual capital index: The benchmarking of Arab countries. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 113-138). Oxford, UK: Elsevier Butterworth-Heinemann.
- BONTIS, N. & CHOO, C. (2002). *The strategic management of intellectual capital and organizational knowledge*, New York, Oxford University Press, Inc.
- BONTIS, N. & WU, S. (2005). "Tiger" brainpower: Taiwan's intellectual capital development. *Journal of Intellectual Capital*, 6, 2.
- BOUNFOUR, A. (2000). Competitiveness and intangible resources: towards a dynamic view of corporate performance. In: BUIGUES, P., JACQUEMIN, A. & MARCHIPONT, J.-F. (ed.) *Competitiveness and the value of intangibles*. Edward Elgar Publishing.
- BOUNFOUR, A. (2002). Measuring intellectual capital's dynamic value: the IC-dVAL approach. *Proceedings of the 5<sup>th</sup> World Congress on Intellectual Capital*. Canada: Mc Master University.
- BOUNFOUR, A. (2005a). Assessing performance of European innovations systems: An Intellectual Capital Indexes Perspective. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 97-112). Oxford, UK: Elsevier Butterworth-Heinemann.
- BOUNFOUR, A. (2005b). Modeling intangibles: Transaction regimes versus community regimes. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 3-19). Oxford, UK: Elsevier Butterworth-Heinemann.
- BOUNFOUR, A. & EDVINSSON, L. (2005). A public policy perspective on intellectual capital. In: MARR, B. (ed.) *Perspectives on intellectual capital* (pp. 170-183). Elsevier Butterworth-Heinemann: Burlington.
- BROOKING, A. (1996). *Intellectual capital: Core asset for the third millennium enterprise*, London, International Thomson Business Press.
- CABRITA, M. & VAZ, J. (2006). Intellectual capital and value creation: Evidence from the Portuguese banking industry. *The Electronic Journal of Knowledge Management*, 4, 1, 11-20. Retrieved from [www.ejkm.com](http://www.ejkm.com). Accessed 2012/03/09.
- CAPELLI, P. (2012). A cautionary view of construct validity. *Human Resource Management Review*, doi:10.1016/j.hrmr.2011.11.009.

- CARMINES, E.G. & ZELLER, R.A. (1979). *Reliability and validity assessment*. Sage Publications, Beverly Hills.
- CARPER, B. (1976). The validity of selected surrogate measures of human resource value: A field study. *Accounting Organizations and Society*, 1, 2-3, 143-151.
- CHURCHILL, J. (1979). A paradigm of developing measures of better marketing research. *Journal of Marketing research*, 16, 64-73.
- COCKBURN, I. & GRILICHES, Z. (1988). Industry effects and appropriability measures in the stock market's valuation of R&D and patents. *American Economic Review*, 78, 419-423.
- COLWELL, D., LIU, Y, & SIM, A.B. (2007). The effect of intangible assets on jumps in stock returns. Retrieved from [http://www.fmpm.ch/docs/10th/papers\\_2007\\_web/C2a.pdf](http://www.fmpm.ch/docs/10th/papers_2007_web/C2a.pdf). Accessed 2012/03/09.
- CORRADO, C., HULTEN, C. & SICHEL, D. (2004). Measuring capital and technology: An expanded framework, 2004-65. Finance and Economics Discussion Series, Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington DC.
- CORRADO, C., HULTEN, C. & SICHEL, D. (2009). Intangible capital and U.S. economic growth. *Review of Income and Wealth*, 55, 661-685.
- CRONBACH, L. (1971). Test validation. In: THORNDIKE, R. (ed.) *Educational measurement* (pp. 443-507). Washington, D.C.: American Council on Education.
- DRUCKER, P. F. (1993). *Post-capitalist society*, New York, HarperCollins.
- EDQUIST, C. (2005). Systems of innovation: Perspectives and challenges. In: FAGERBERG, J., MOWERY, D. & NELSON, R. (ed.) *The Oxford handbook of innovation* (pp. 181-209). Oxford: Oxford University Press.
- EDVINSSON, L. (2005). Regional intellectual capital in waiting: a strategic intellectual capital quest. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities* (pp. 19-36). Oxford.: Elsevier.
- EDVINSSON, L. & MALONE, M.S. (1997). *Intellectual capital: Realizing your company's true value by finding its hidden brainpower*, New York, NY., HarperBusiness.
- EDVINSSON, L. & SULLIVAN, P. (1996). Developing a model for managing intellectual capital. *European Management Journal*, 14, 4, 356-364.
- EIS (2006). European Innovation Scoreboard 2006: Comparative analysis of innovation performance, MERIT. Retrieved from [http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm). Accessed 2012/03/11.
- EIS (2007). European Innovation Scoreboard 2007: Comparative analysis of innovation performance, MERIT. Retrieved from [http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm). Accessed 2012/03/11.
- EIS (2008). European Innovation Scoreboard 2008: Comparative analysis of innovation performance, MERIT. Retrieved from [http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm). Accessed 2012/03/11.

- EIS (2009). European Innovation Scoreboard 2009: Comparative analysis of innovation performance, MERIT. Retrieved from [http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm). Accessed 2012/03/11.
- EIS (2010). European Innovation Scoreboard 2010: Comparative analysis of innovation performance, MERIT. Retrieved from [http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm). Accessed 2012/03/11.
- EIS (2011). European Innovation Scoreboard 2011: Comparative analysis of innovation performance, MERIT. Retrieved from [http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm). Accessed 2012/03/11.
- EU (2004). Competitiveness and benchmarking European competitiveness. Working document SEC (2004) 1397, Office for Official Publications of the European Communities.
- EU (2005). Effectiveness of ICT RTD Impacts on the EU innovation system. Retrieved from <http://www.inthekzone.com/pdfs/EN2Polis%20-%20EU%20Innovation%20System.pdf>. Accessed 2012/03/11.
- EU (2006a). Evaluating the effectiveness of European ICT RTD and innovation systems. Retrieved from [http://ec.europa.eu/dgs/information\\_society/evaluation/studies/s2005\\_03/index\\_en.htm](http://ec.europa.eu/dgs/information_society/evaluation/studies/s2005_03/index_en.htm). Accessed 2012/03/12.
- EU (2006b). Effectiveness of IST RTD impacts on the EU innovation system. Annexes to the Final Report. Retrieved from [http://ec.europa.eu/dgs/information\\_society/evaluation/studies/s2005\\_03/index\\_en.htm](http://ec.europa.eu/dgs/information_society/evaluation/studies/s2005_03/index_en.htm). Accessed 2012/03/12.
- FEINSTEIN, C. & THOMAS, M. (2002). *Making history count: A primer in quantitative methods for historians*, Cambridge, Cambridge University Press.
- FIRER, S. & WILLIAMS, M. (2003). Intellectual capital and traditional measures of corporate performance. *Journal of Intellectual Capital*, 4, 348-360.
- FLAMHOLTZ, E. (1972). Assessing the validity of a theory of human resource value: A field study. *Journal of Accounting Research*, 10, 241-266.
- FREEMAN, C. (2002). Continental, national and sub-national innovation systems, complementarity and economic growth. *Research Policy*, 2002, 31, 191-211.
- GARDNER, T. & WRIGHT, P. (2009). Implicit human resource management theory: a potential threat to the internal validity of human resource practice measures. *The International Journal of Human Resource Management*, 20, 1, 57-74.
- GLAESER, E., LA PORTA, R., LOPEZ-DE-SILANEZ, F. & SHLEIFER, A. (2005). Do institutions cause growth? *Journal of Economic Growth*, 271-303.
- GRILICHES, Z. (1981). Market value, R&D and patents. *Economic Letters*, 7, 183-187.
- HAIR, J., ANDERSON, R., TATHAM, R., & BLACK, W. (1998). *Multivariate data analysis*, New Jersey, Prentice-Hall International.
- HALL, B. (1993). The stock market value of R&D investment during the 1980s. *American Economic Review*, 83, 259-264.

- HALL, B. & HALL, R. (1993). The value and performance of U.S. corporations. *Brookings Papers on Economic Activity*, 1, 1-34.
- HARTMAN, E. (1992). Validity of job classifications: an examination of alternative indicators. *Human Performance*, 5, 191-211.
- HERVAS-OLIVER, J. & DALMAU-PORTE, J. (2007). Which IC components explain national IC stocks? *Journal of Intellectual Capital*, 8, 444-469.
- HERVAS-OLIVER, J., ROJAS, R., MARTINS, B. & CERVELLÓ-ROYO, R. (2011). The overlapping of national IC and innovation systems. *Journal of Intellectual Capital*, 12, 111-131.
- HERVAS-OLIVER, J.L. & DALMAU-PORTE, J.I. (2005). How to measure IC in clusters? Empirical evidence. *Journal of Intellectual Capital*, 7, 354-380.
- HEUSLER, H. & SCHEDL, H. (2005). Can the state stimulate the creation of regional networks? Experiences from the virtual market place Bavaria initiative. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 265-275). Oxford, UK: Elsevier Butterworth-Heinemann.
- HILL, R., GRIFFITHS, W. & LIM, G. (2008). *Principles of econometrics. Third Edition.*, USA, John Wiley & Sons.
- HOFMAN, J. (2005). Value intangibles! Intangible capital can and must be valued – owners and valuers alike will benefit. Deutsche Bank Research. Retrieved from [www.dbresearch.com](http://www.dbresearch.com). Accessed 2012/03/08.
- HOWELLS, J. (2005). Innovation and regional economic development: A matter of perspective? *Research Policy*, 2005, 1220–1234.
- HULTEN, C. (2000). Total factor productivity: a short biography. *NBER Working papers*, 1-77.
- IMD (2003). IMD World Competitiveness Yearbook. Retrieved from <http://www.imd.org/research/publications/wcy/index.cfm>. Accessed 2012/03/05.
- IMD (2004). IMD World Competitiveness Yearbook. Retrieved from <http://www.imd.org/research/publications/wcy/index.cfm>. Accessed 2012/03/05.
- JONES, C. (2002). The economics of ideas. In: JONES, C. (ed.) *Introduction to economic growth* (pp. 78-95). New York: W.W.Norton.
- JONES, C. (2005). R&D-based models of economic growth. *Journal of Political Economy*, 103, 759-784.
- JORGENSEN, D. (1966). The embodiment hypothesis. *Journal of Political Economy*, 74, 1-17.
- JORGENSEN, D. (2001). Information technology and the U.S. economy. *American Economic Review*, 91, 1-32.
- KAPLAN, A. (1964). *The conduct of inquiry*, San Francisco, Chandler.
- KHAN, M. (2001). Investment in knowledge. *STI Review*, 42, 19-48.

- KHAN, M. (2005). Estimating the level of investment in knowledge across OECD countries. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 37-60). Oxford, UK: Elsevier Butterworth-Heinemann.
- KING, G., KEOHANE, R. & VERBA, S. (1994). *Designing social inquiry: scientific inference in qualitative research*, Princeton, NJ, Princeton University Press.
- KIRK, J. & MILLER, M. (1986). *Reliability and validity in qualitative research*, Beverly Hills, CA, Sage.
- KLEINKNECHT, A. & REIJEN, J. (1993). Practitioners' corner towards literature-based innovation output indicators. *Structural Change and Economic Dynamics*, 4, 199-207.
- KOOPMANS, T. (1947). Measurement without theory. *The Review of Economics and Statistics*, 29, 3, 161-172.
- KURTZ, M. & SCHRUNK, A. (2006). Growth and governance: models, measures and mechanisms. *Journal of Politics*, 69, 538-554.
- LALL, S. (2001). Competitiveness indices and developing countries: an economic evaluation of the Global Competitiveness Report. *World Development*, 29, 1501-1525.
- LERRO, A., CARLUCCI, D. & SCHIUMA, G. (2005). Intellectual capital index relationships between intellectual capital and value creation capability within Italian regions. *Frontiers of e-business research*, Center for Business Performance, Cranfield School of Management, 320-335.
- LEV, B. (2001). *Intangibles. Management, measurement and reporting*. New York: Brookings Institution Press.
- LEV, B. (2005). Intangible assets: Concepts and measurements. In: KIMBERLY, K. (ed.) *Encyclopedia of social measurement* (pp. 299-305). Vol.2. Elsevier Inc.
- LEV, B. & ZAROWIN, P. (2003). The boundaries of financial reporting and how to extend them. In: HAND, J. & LEV, B. (ed.) *Intangible assets: Values, measures, and risks* (pp. 487-511). Oxford: Oxford University Press.
- LIN, C. & EDVINSSON, L. (2011). *National intellectual capital: A comparison of 40 countries*, New York Dordrecht Heidelberg London, Springer New York.
- LJUNGBERG, J. (2004). Technology and human capital in historical perspective. An Introduction. In: LJUNGBERG, J. & SMITS, J. (ed.) *Technology and human capital in historical perspective* (pp. 1-21). Basingstoke: Palgrave Macmillan.
- LOCKE, E. (2011). Construct validity vs. concept validity. *Human Resource Management Review*, doi:10.1016/j.hrmr.2011.11.008.
- LUCAS, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 1988, 3-42.
- LUCE, R., KRANTZ, D. SUPPES, P. & TVERSKY, A. (1990). *Foundations of measurement, Vol. III Representation, axiomization, and variance*, San Diego, Academic Press, Inc.

- LUNDVALL, B. (2005). National innovation systems - analytical concept and developmental tool. *DRUID 10<sup>th</sup> Anniversary Summer Conference 2005 on Dynamics of industry and innovation: Organizations, networks and systems, Copenhagen, Denmark, June 27-29, 2005*, 1-43.
- M'PHERSON, P. & PIKE, S. (2001). Accounting, empirical measurement and intellectual capital. *Journal of Intellectual Capital*, 2, 246-260.
- MACHLU, F. (1962). *The production and distribution of knowledge in the United States*, Princeton, Princeton University Press.
- MALHOTRA, Y. (2000). Knowledge assets in the global economy: Assessment of national intellectual capital. *Journal of Global Information Management*, 8, 5-15.
- MALHOTRA, Y. (2003). Measuring knowledge assets of a nation: Knowledge systems for development. *Ad Hoc Group meeting Knowledge for Development*.
- MANUELLI, R. & SESARDI, A. (2010). Human capital and the wealth of nations. Department of Economics: University of Wisconsin-Madison.
- MARR, B. & STAROVIC, D. (2005). Understanding corporate value: Managing and reporting intellectual capital. The Chartered Institute of Management Accountants, CIMA.
- MASUYAMA, S. (2005). Japan and other East Asian economies under the knowledge-based economy. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 165-194). Oxford: Elsevier Butterworth-Heinemann.
- MOKYR, J. (2000). Knowledge, technology, and economic growth during the Industrial Revolution. In: VAN ARK, B., KUIPERS, S. & KUPER, S. (ed.) *Productivity, technology and economic growth* (pp. 253-292). New York: Springer.
- MOKYR, J. (2005). The intellectual origins of modern economic growth. *The Journal of Economic History*, 65 (2), 285-351.
- MOURITSEN, J., BUKH, P., & MARR, B. (2005). A reporting perspective on intellectual capital. In: MARR, B. (ed.) *Perspectives on intellectual capital* (pp. 69-82). Elsevier Butterworth-Heinemann: Burlington.
- MUHSAM, H. V. (1970). The assessment of the validity of human resources indicators by means of Cobb-Douglas production function. UNESCO: Division of socio-economic analysis. Retrieved from <http://unesdoc.unesco.org/images/0015/001585/158562eo.pdf>. Accessed 2012/03/05.
- NAKAMURA, L. (2001). What is the US gross investment in intangibles? (At least) One trillion dollars a year! *Federal Reserve Bank of Philadelphia Working Paper*, 01-15, 1-43.
- OECD (1999). Ducharme, L. (ed.) Introduction: main theories and concepts. OECD symposium on Intangible Investments. Retrieved from <http://www.oecd.org/dataoecd/45/15/1943178.pdf>. Accessed 2012/03/15.

- OECD (2001). The wellbeing of nations: The role of human and social capital. Center for educational research and innovation research paper. Retrieved from <http://www.oecd.org/dataoecd/48/22/1870573.pdf>: Paris: OECD. Accessed 2012/03/15.
- OECD (2006). Intellectual assets and value creation: Implications for corporate reporting, OECD, Paris. Retrieved from [www.oecd.org/dataoecd/2/40/37811196.pdf](http://www.oecd.org/dataoecd/2/40/37811196.pdf). Accessed 2012/03/15.
- ORTIZ, M. (2006). Intellectual capital (intangible assets) valuation considering the context. *Journal of Business & Economics Research*, 4, 35-42.
- PASHER, E. (1999). *The intellectual capital of the state of Israel*, Herzlia Pituach, Edna Pasher PhD & Associates.
- PASHER, E. & SHACHAR, S. (2005). The intellectual capital of the state of Israel. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities* (pp. 139-150). Jordan Hill, Oxford, UK: Elsevier Butterworth-Heinemann.
- PASHER, E. & SHACHAR, S. (2007). The intellectual capital of the state of Israel: 60 years of achievement. Retrieved from <http://www.moital.gov.il/ic>. Accessed 2012/03/25.
- PIEKKOLA, H. (2010). Intangibles: Can they explain the unexplained? *INNODRIVE Working Paper*, 2, 1-41. Retrieved from [http://www.innodrive.org/attachments/File/workingpapers/Innodrive\\_WP\\_2\\_Piekkola2010.pdf](http://www.innodrive.org/attachments/File/workingpapers/Innodrive_WP_2_Piekkola2010.pdf). Accessed 2012/03/25.
- PIEKKOLA, H. (2011). Intangible capital agglomeration and economic growth: An analysis of regions in Finland. *INNODRIVE Working Paper*, 20, 1-36. Retrieved from [http://www.innodrive.org/attachments/File/workingpapers/Innodrive\\_WP\\_20\\_Piekkola2011.pdf](http://www.innodrive.org/attachments/File/workingpapers/Innodrive_WP_20_Piekkola2011.pdf). Accessed 2012/03/25.
- PULIC, A. (2000). MVA and VAIC analysis of randomly selected companies from FTSE 250. Retrieved from [www.vaic-on.net/start.htm](http://www.vaic-on.net/start.htm). Accessed 2012/03/25.
- PULIC, A. (2003). Intellectual capital – does it create or destroy value? submitted to PMA Intellectual Capital Symposium, Cranfield.
- PULIC, A. (2005). Value creation efficiency at national and regional levels: Case study—Croatia and the European Union. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 197-213). Jordan Hill, Oxford, UK: Elsevier Butterworth-Heinemann.
- RAGIN, C. (1987). *The comparative method: moving beyond qualitative and quantitative strategies*, Berkeley, University of California Press.
- REMBE, A. (1999). The governmental invest in Sweden Agency – ISA: Report 1999. Halls Offset AB, Stockholm. ISA: Report 1999. Halls Offset AB, Stockholm.
- ROBERT HUGGINS ASSOCIATES (2003). Robert Huggins Associates (2003), World Knowledge Competitiveness Index 2003. Retrieved from <http://www.cforic.org/downloads.php>. Accessed 2012/03/25.
- ROBERT HUGGINS ASSOCIATES (2004). Robert Huggins Associates (2004), World Knowledge Competitiveness Index 2004. Retrieved from <http://www.cforic.org/downloads.php>. Accessed 2012/03/25.

ROBERT HUGGINS ASSOCIATES (2005). Robert Huggins Associates (2005), World Knowledge Competitiveness Index 2005. Retrieved from <http://www.cforic.org/downloads.php>. Accessed 2012/03/25.

ROBERT HUGGINS ASSOCIATES (2008). Robert Huggins Associates (2008), World Knowledge Competitiveness Index 2008. Retrieved from <http://www.cforic.org/downloads.php>. Accessed 2012/03/25.

ROBERT HUGGINS ASSOCIATES (2002). Robert Huggins Associates, World Knowledge Competitiveness Index. Retrieved from <http://www.cforic.org/downloads.php>. Accessed 2012/03/25.

RODRIGUEZ, B. & VIEDMA, M. (2006). The region's intellectual capital benchmarking system: enabling economic growth through evaluation. *Journal of Knowledge Management*, 5, 10, 41-54.

ROMER, P. (1990). Endogenous technological change. *The Journal of Political Economy*, 98, 71-102.

ROMER, P. (1993). Two strategies for economic development: Using ideas and producing ideas. Proceedings of the World Bank Annual Conference on Development Economics, 1992. World Bank.

ROMER, P. (1994). The origins of endogenous growth. *The Journal of Economic Perspectives*, 8, 3-22.

ROOS, G. & ROOS, J. (1997). Measuring your company's intellectual performance. *Long Range Planning*, 30, 413-426.

ROOS, J. (1997). Exploring the concept of intellectual capital (IC). *Long Range Planning*, 31, 150-153.

SCOTT, G. & ROTHBERG, H. (2005). The intellectual capital of the United States. *Proceedings of the 6th European Conference of Knowledge Management (ECKM)*. University of Limerick, Limerick.

SMEDLUND, A. & PÖYHÖNEN, A. (2005). Intellectual capital creation in regions: a knowledge system approach. In: BOUNFOUR, A. & EDVINSSON, L. (ed.) *Intellectual capital for communities: Nations, regions, and cities* (pp. 227-252). Oxford, UK: Elsevier Butterworth-Heinemann.

SMITH, G. (2005a). On construct validity: issues of method and measurement. *Psychological Assessment*, 17, 396-408.

SMITH, K. (2005b). Measuring innovation. In: FAGERBERG, J., MOWERY, D. & NELSON, R. (ed.) *The Oxford handbook of innovation* (pp. 148-179). Oxford: Oxford University Press.

SOLOW, R. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, 39, 312-320.

STÅHLE, P. (2006). Intellectual capital and national competitiveness: Conceptual and methodological challenges. In: BOUNFOUR, A. (ed.) *Capital immatériel, connaissance et performance* (pp. 415-429). Paris: L'Harmattan.

- STÅHLE, P. (2008). National intellectual capital as an economic driver: perspectives on identification and measurement. In: AHONEN, G. (ed.) *Inspired by Knowledge in Organizations. Essays in honour of Professor Karl-Erik Sveiby in his 60th birthday 29th June 2008.*: Swedish School of Economics and Business Administration.
- STÅHLE, P. (2012a). e-mail 09 March. <PIRJO.STAHLE@UTU.FI>.
- STÅHLE, P. (2012b). e-mail 19 April. <PIRJO.STAHLE@UTU.FI>.
- STÅHLE, P. & BOUNFOUR, A. (2008). Understanding dynamics of intellectual capital of nations. *Journal of Intellectual Capital, special issue of Intellectual Capital of Communities: The Next Step*, 9, 164-177.
- STÅHLE, P. & GRÖNROOS, M. (2000). *Dynamic intellectual capital knowledge management in theory and practice*, WSOY: Porvoo, Helsinki, Juva.
- STÅHLE, P. & PÖYHÖNEN, A. (2005). Intellectual capital and national competitiveness: a critical examination. Case Finland. *Proceedings of the 6th European Conference of Knowledge Management (ECKM)*. University of Limerick, Limerick.
- STÅHLE, P., STÅHLE, S & AHO, S. (2011). Value Added Intellectual Coefficient (VAIC): a critical analysis. *Journal of Intellectual Capital*, 12, 4, 531-551.
- STÅHLE, S. & STÅHLE, P. (2012). Towards measures of national intellectual capital: an analysis of the CHS model. *Journal of Intellectual Capital*, 13, 164-177.
- STEWART, T. (1997). *Intellectual capital – the new wealth of organizations*, Doubleday, New York, NY.
- STONE-ROMERO, E.F. (2002). The relative validity and usefulness of various empirical research designs. In: ROGELBERG, S.G. (ed.) *Handbook of research methods in industrial and organizational psychology* (pp. 77-98). Malden: Blackwell.
- SVEIBY, K. (1998). Measuring intangibles and intellectual capital - an emerging first standard. Retrieved from <http://www.sveiby.com/articles/EmergingStandard.html>. Accessed 2012/03/05.
- THOMAS, M.A. (2008). What do the worldwide governance indicators measure? Manuscript, Johns Hopkins University.
- UNDP (2000). Survey of economic and social development in the ESCWA region 1999–2000. United National Development Programme Research Paper. New York, NY: Retrieved from <http://www.arab-hdr.org/publications/other/escwa/eco-socialdev-07e.pdf>. Accessed 2012/03/25.
- UNPAN (2003). Expanding public space for the development of the knowledgesociety, Ad Hoc Expert Group Meeting on Knowledge Systems for Development, 4-5 September. Retrieved from [www.unpan.org](http://www.unpan.org). Accessed 2012/04/01.
- VAN LEEUWEN, B. (2007). *Human capital and economic growth in India, Indonesia, and Japan: A quantitative analysis*, 1890-2000, Netherlands.

- VERSPAGEN, B. (2005). Innovation and economic growth. In: FAGERBERG, J., MOWERY, D. & NELSON, R. (ed.) *The Oxford handbook of innovation* (pp. 487-514). Oxford: Oxford University Press.
- VIEDMA, J.M. (2003). CICBS: Cities' International Capital Benchmarking System. A methodology and a framework for measuring and managing intellectual capital of cities. A practical application in the city of Mataro'. Retrieved from <http://capitalintelectual.galeon.com/Presentacion/UClase8.pdf>. Accessed 2012/04/04.
- WEF (1998). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (1999). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2000). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2001). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2002). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2003). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2004). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2005). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2006a). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2006b). The Lisbon Review: Measuring Europe's progress in reform, World Economic Forum. Retrieved from <https://members.weforum.org/pdf/gcr/lisbonreview/report2006.pdf>. Accessed 2012/03/28.
- WEF (2007a). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2007b). The Lisbon Review 2007: Measuring Europe's progress in reform, World Economic Forum. Retrieved from <https://members.weforum.org/pdf/gcr/lisbonreview/report2007.pdf>. Accessed 2012/03/28.
- WEF (2008a). The Global Competitiveness Report. Retrieved from <http://www.weforum.org/issues/global-competitiveness>. Accessed 2012/03/10.
- WEF (2008b). The Lisbon Review 2008: Measuring Europe's progress in reform, World Economic Forum. Retrieved from [http://www3.weforum.org/docs/WEF\\_LisbonReview\\_Report\\_2008.pdf](http://www3.weforum.org/docs/WEF_LisbonReview_Report_2008.pdf). Accessed 2012/03/28.

- WEF (2010). The Lisbon Review 2010: Towards a more competitive Europe? Retrieved from [http://www3.weforum.org/docs/WEF\\_LisbonReview\\_Report\\_2010.pdf](http://www3.weforum.org/docs/WEF_LisbonReview_Report_2010.pdf). Accessed 2012/03/28.
- WESTEN, D. & ROSENTHAL, R. (2003). Quantifying construct validity: Two simple measures. *Journal of Personality and Social Psychology*, 84, 608-618.
- WEZIAK, D. (2007). Measurement of national intellectual capital: application to EU countries. *IRISS Working Paper Series, 2007*, 1-45.
- WORLD BANK (2001). World development indicators. Washington, DC: World Bank: Retrieved from [http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2004/08/19/000009486\\_20040819135251/Rendered/PDF/220990see0cat0info0in0IRAMs.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2004/08/19/000009486_20040819135251/Rendered/PDF/220990see0cat0info0in0IRAMs.pdf). Accessed 2012/03/10.
- WORLD BANK (2012). The knowledge assessment methodology and scoreboards. Retrieved from [www.worldbank.org/kam](http://www.worldbank.org/kam). Accessed 2012/03/30.

## **APPENDIX**

## Appendix 1 – The L&E measurement model

Source: Lin and Edvinsson (2011) pp.17-20, Appendix 1 on pp.27-29

### Proposed National Intellectual Capital Measurement Model

As described in Chap. 2, in the past, researchers from different backgrounds have proposed different models to evaluate national intellectual capital. Since this field of study is still developing, a consensus regarding the set of determinants that should be employed has yet to be reached. Building on past relevant research, we propose a framework and model of IC measurement and then test this model by using the widely accepted International Institute for Management Development (IMD) databases, which contain both quantitative and qualitative indicators. Although national wealth can be assessed from different perspectives, including

**Table 3.1** Variables in each type of capital proposed by this study

<i>Human capital index</i>	<i>Market capital index</i>
Skilled labor <sup>#</sup>	Corporate tax <sup>#</sup>
Employee training <sup>#</sup>	Cross-border venture <sup>#</sup>
Literacy rate	Openness of culture <sup>#</sup>
Higher education enrollment	Globalization <sup>#</sup>
Pupil-teacher ratio	Transparency <sup>#</sup>
Internet subscribers	Image of country <sup>#</sup>
Public expenditure on education	Exports of goods
<i>Process capital index</i>	<i>Renewal capital index</i>
Business competition environment <sup>#</sup>	Business R&D spending
Government efficiency <sup>#</sup>	Basic research <sup>#</sup>
Intellectual property rights protection <sup>#</sup>	R&D spending/GDP
Capital availability <sup>#</sup>	R&D researchers
Computers in use per capita	Cooperation between universities and enterprises <sup>#</sup>
Convenience of establishing new firms <sup>#</sup>	Scientific articles
Mobile phone subscribers	Patents per capita (USPTO+EPO)

Remarks: (1) Financial capital is the logarithm of GDP per capita adjusted by purchasing power parity. (2) Variables marked with # are rated qualitatively using a scale of 1–10

health, poverty, and gender empowerment (Bontis 2004), the main focus of this paper is on the most commonly used national intellectual capital framework, including human capital, market capital, process capital, renewal capital, and financial capital as indicated in Table 3.1.

### Indicator Selection and Validation

Indicators we used were selected in two rounds. In the first round, variables that were used at least two times in relevant studies (please refer to Appendix 1 for the source of these variables) were matched with the IMD World Competitiveness Yearbook. *Market capital* turned out to have the fewest number of variables supported by at least two studies. In the second round, a focus group was formed to obtain feedback regarding the appropriateness of the selected variables. With input from ten Taiwanese professors who all are engaged in intellectual capital-related research, focal variables were finalized, as shown in Table 3.1. *Financial capital* is also included as it is a key indicator of national wealth and represents the output dimension. Consequently, a total of 29 variables were selected – seven each for human capital, market capital, process capital, and renewal capital, and a single variable (GDP per capita adjusted by purchasing power parity) representing financial capital. Herein after, this set of 29 variables is referred as NICI40 (National Intellectual Capital Indices for 40 countries).

The first type of national intellectual capital, *human capital*, is defined as the competencies of individuals in realizing national goals (Bontis 2004). According to OECD

Appendix 1 continued

**Table 3.2** Definition of the indicators

Indicators	Definition
<i>Human capital</i>	
Skilled labor <sup>#</sup>	Whether skilled labor is readily available
Employee training <sup>#</sup>	Whether employee training is a high priority in companies
Literacy rate	Adult (over 15 years) literacy rate as a percentage of population
Higher education enrollment	Percentage of population that has attained at least tertiary education
Pupil-teacher ratio	Ratio of teaching staff to students
Internet subscribers	Number of internet users per 1,000 people
Public expenditure on education	Total public expenditure on education (percentage of GDP)
<i>Market capital</i>	
Corporate tax encouragement <sup>#</sup>	Whether corporate taxes encourage entrepreneurial activity
Cross-border venture <sup>#</sup>	Whether international transactions can be freely negotiated with foreign partners
Openness to foreign culture <sup>#</sup>	Whether the national culture is open to foreign culture ideas
Attitudes toward globalization <sup>#</sup>	Whether attitudes toward globalization are generally positive in a given society
Transparency <sup>#</sup>	Whether transparency of government policy is satisfactory
Country image <sup>#</sup>	Whether the image abroad of a given country encourages business development
Exports of goods	Exports of goods (percentage of GDP)
<i>Process capital</i>	
Business competition environment <sup>#</sup>	Whether competition legislation is efficient in preventing unfair competition
Government efficiency <sup>#</sup>	Whether government bureaucracy hinders business activity
Intellectual property rights protection <sup>#</sup>	Whether intellectual property rights are adequately enforced
Capital availability <sup>#</sup>	Whether cost of capital encourages business development
Computers in use per capita	Number of computers per 1,000 people
Convenience of establishing new firms <sup>#</sup>	Whether creation of firms is supported by legislation
Mobile phone subscribers	Number of subscribers per 1,000 inhabitants
<i>Renewal capital</i>	
Business R&D spending	Business expenditure on R&D (per capita)
Basic research <sup>#</sup>	Whether basic research enhances long-term economic development
R&D spending/GDP	Total expenditure on R&D (percentage of GDP)
R&D researchers	Total R&D personnel nationwide per capita (Full-time work equivalent per 1,000 people)
Cooperation between universities and enterprises <sup>#</sup>	Whether knowledge transfer is highly developed between universities and companies
Scientific articles	Scientific articles published by origin of author (per capita)
Patents per capita (USPTO + EPO)	USPTO and EPO total patents granted (per capita)
<i>Financial capital</i>	
GDP per capita (PPP) (from IMF)	Gross domestic product based on purchasing power parity (PPP) per capita

## Appendix 1 continued

(2000), human capital consists of knowledge about facts, laws, and principles in addition to knowledge relating to teamwork, and other specialized and communication skills. Education is the foundation of human capital. The variables used in this study include the amount of skilled labor, the degree of employee training, the rate of literacy, the level of enrollment in institutions of higher education, the pupil-teacher ratio, the number of Internet subscribers, and the amount of public expenditure on education. Readers are referred to Table 3.2 for the definition of indicators selected.

The second type of national capital, *market capital*, is similar to external relational networking and social capital in a micro setting in that it represents a country's capabilities and successes in providing an attractive and competitive incentive in order to meet the needs of its international clients, while also sharing knowledge with the rest of world (Bontis 2004). The present study takes into consideration investment in foreign countries and achievements in foreign relations, as well as exports of goods and services. In this study, the authors focus primarily on each country's corporate tax encouragement, cross-border ventures, openness to foreign cultures, degree of globalization, and transparency of economic information, as well as the image that the country projects abroad, and the country's export and import of commercial services.

The third type of national capital, *process capital*, comprises the non-human sources of knowledge in a nation. Embedded in a country's infrastructure, these sources facilitate the creation, accessibility, and dissemination of information. This type of capital is measured through the parameters of a fair business competition environment, government efficiency, intellectual property rights protection, the availability of capital, the number of computers per capita, the ease with which new firms can be established, and the number of mobile phone subscribers.

The fourth type of national capital, *renewal capital*, is defined as a nation's future intellectual wealth and the capability for innovation to sustain a nation's competitive advantage. Business R&D spending, basic research, R&D spending as a percentage of GDP, the number of R&D researchers, the level of cooperation between universities and enterprises, scientific articles, and USPTO and EPO (i.e., the patent number recorded in both United States Patent and Trademark Office and European Patent Office) per capita are included in this type of capital.

The fifth type of national capital, *financial capital*, is represented by a single indicator: the logarithm of GDP per capita adjusted by purchasing power parity. This is the most common measurement of the financial wealth of a nation.

Appendix 1 continued

Variable data sources for each type of capital		Appendix 1
Capital	Variables	Sources
Human capital	Skilled labor	1. World Bank 2. OECD 3. APEC 4. US Department of Commerce (2000) 5. Commission of European Community (2000) 6. Singapore Department of Trade and Industry (2001)
	Employee training	1. World Bank 2. US Department of Commerce (2000) 3. Australia Department of Industry and Science and Resource Branch (2000)
	Literacy rate	1. World Bank 2. Australia Department of Industry and Science and Resource Branch (2000) 3. Bontis (2004)
	Higher education enrollment	1. World Bank 2. Australia Department of Industry and Science and Resource Branch (2000) 3. Bontis (2004)
	Pupil-teacher ratio	1. World Bank 2. Malhotra (2000)
	Internet subscribers	1. APEC 2. US Department of Commerce (2000) 3. Commission of European Community (2000) 4. Australia Department of Industry and Science and Resource Branch (2000)
Public expenditure on education		1. World Bank 2. Australia Department of Industry and Science and Resource Branch (2000)
		3. Pomed et al. (2002)

(continued)

Appendix 1 continued

Capital	Variables	Sources
Market capital	Corporate Tax	1. World Bank 2. Focus group
	Cross-border venture	Focus group
	Openness of culture	1. World Bank 2. Bontis (2004) 3. Malhotra (2002)
	Globalization	1. APEC 2. Malhotra (2000)
	Transparency	1. World Bank 2. Focus group
	Image of country	1. Malhotra (2003) 2. Focus group
	Exports of goods	1. APEC 2. Malhotra (2000)
	Competition environment	1. World Bank 2. APEC
Process capital	Government efficiency	1. World Bank 2. APEC
	Intellectual property rights protection	1. World Bank 2. APEC
	Capital availability	1. World Bank 2. APEC 3. US Department of Commerce (2000) 4. Commission of European Community (2000) 5. Malhotra (2002)
	Computers in use per capita	1. World Bank 2. APEC 3. Australia Department of Industry and Science and Resource Branch (2000) 4. Singapore Department of Trade and Industry (2001) 5. Malhotra (2000)
	Convenience of establishing new firms	1. World Bank 2. Commission of European Community (2000) 3. Singapore Department of Trade and Industry (2001)
	Mobile phone subscribers	1. World Bank 2. OECD 3. APEC 4. Australia Department of Industry and Science and Resource Branch (2000) 5. Singapore Department of Trade and Industry (2001)

(continued)

Appendix 1 continued

Capital	Variables	Sources
Renewal capital	Business R&D spending	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. OECD</li> <li>3. APEC</li> <li>4. US Department of Commerce (2000)</li> <li>5. UK Department of Trade and Industry (2000)</li> <li>6. Australia Department of Industry and Science and Resource Branch (2000)</li> <li>7. Malhotra (2000)</li> </ol>
	Basic research	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. APEC</li> </ol>
	R&D spending/GDP	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. OECD</li> <li>3. APEC</li> <li>4. Commission of European Community (2000)</li> <li>5. Australia Department of Industry and Science and Resource Branch (2000)</li> <li>6. Singapore Department of Trade and Industry (2001)</li> <li>7. Bontis (2004)</li> </ol>
	R&D researchers	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. OECD</li> <li>3. APEC</li> <li>4. Australia Department of Industry and Science and Resource Branch (2000)</li> <li>5. Bontis (2004)</li> <li>6. Malhotra (2000)</li> </ol>
	Cooperation between universities and enterprises	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. OECD</li> <li>3. APEC</li> <li>4. UK Department of Trade and Industry (2000)</li> <li>5. Australia Department of Industry and Science and Resource Branch (2000)</li> </ol>
	Scientific articles	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. UK Department of Trade and Industry (2000)</li> <li>3. Malhotra (2000)</li> </ol>
	Patents per capita (USPTO+EPO)	<ol style="list-style-type: none"> <li>1. World Bank</li> <li>2. US Department of Commerce (2000)</li> <li>3. Commission of European Community (2000)</li> <li>4. Australia Department of Industry and Science and Resource Branch (2000)</li> <li>5. Singapore Department of Trade and Industry (2001)</li> <li>6. Bontis (2004)</li> <li>7. Malhotra (2000)</li> </ol>

## Appendix 2 – Validation of the L&E model

Source: Lin and Edvinsson, 2011, p.21, Appendix 2 on pp.30-31

In our model, except for financial capital, there are seven variables for each of the four component capitals. To assure the validity of the selected variables in measuring the four constructs (human capital, market capital, process capital, and renewal capital), statistical analyses were utilized to test the measurement model. Data analyses showed that all the variables are significant at  $\alpha=0.05$ , which means the selected variables are sufficient to evaluate the four component capitals. Thus the measurement model is valid for assessing national intellectual capital consisting of human capital, market capital, process capital, and renewal capital. Additional statistical analysis information concerning the measurement model validation is provided in Appendix 2.

## Methods

Using the variables listed in Table 3.1, we collected data for the maximum number of 47 countries from the IMD World Competitiveness Yearbook. However, due to the large number of missing values in their datasets, those for Colombia, Hong Kong, Indonesia, Israel, Luxembourg, Slovenia, and Venezuela were excluded. The data analyzed in this book, therefore, describes 40 countries over a period of 14 years, from 1995 to 2008. To differentiate this model from other National IC Models and for easier reference, the designation “NICI40” has been employed to represent the 29-indicator national intellectual capital model for 40 countries developed by the authors. To avoid confusion, for each individual component capital, HC40 (Human Capital Index for 40 Countries), MC40 (Market Capital Index for 40 Countries), PC40 (Process Capital Index for 40 Countries), RC40 (Renewal Capital Index for 40 Countries), and FC40 (Financial Capital Index for 40 Countries) will be used whenever referring to the ranking of each component capital of the 40 countries.

In this study, there are two different types of data: data with an absolute value, such as “patents per capita,” and data with a qualitative rating based on a scale of 1–10, such as “image of country.” Although subjective, qualitative rating on the degree or magnitude of certain variables is unavoidable, as evaluating intangible assets cannot be fully represented by merely adding up absolute numbers. For a meaningful integration of the quantitative score and qualitative rating, the ratio of the absolute value relative to the highest value of each quantitative variable was calculated and multiplied by 10 to transform the number into a 1–10 score. The data transformation procedures have been repeated for all numerical indicators of human capital, market capital, process capital, and renewal capital. Financial capital is represented by the logarithm of GDP per capita adjusted by the purchasing power parity of each country, its ratio calculated to the highest value and then transformed into a 1–10 score.

## Appendix 2 continued

### The Validation of NICI40 Measurement model

### Appendix 2.

In this model, excluding financial capital, there are seven variables for each of the four types of capital with the latent concept. Therefore, the LISREL technique was adopted and the “Amos 5” program was used to test the model. In the measurement model shown hereunder,  $\xi_1$ ,  $\xi_2$ ,  $\xi_3$ , and  $\xi_4$  represent the latent constructs of national intellectual capital, including human capital, market capital, process capital, and renewal capital, respectively. The  $X$  variables represent the indicators of the four latent constructs. The Greek letter  $\lambda$  stands for the factor loading of an indicator variable to its corresponding latent construct and  $\delta$  stands for the measurement error of the indicator. All the paths in the measurement model are significant with  $\alpha = 0.05$ , which means that the indicators are sufficient to evaluate the latent constructs.

### Results of NICI40 measurement model

Latent variables ( $\xi$ )	Indicator (X)	Standardized estimate
Human capital	X1: Skilled labor	0.276
	X2: Employee training	0.573
	X3: Literacy rate	0.593
	X4: Higher education enrollment	0.721
	X5: Pupil–teacher ratio	0.493
	X6: Internet subscribers	0.849
	X7: Public expenditure on education	0.587
Market capital	X8: Corporate tax	0.770
	X9: Cross-border venture	0.648
	X10: Openness of culture	0.424
	X11: Globalization	0.674
	X12: Transparency	0.790
	X13: Image of your country	0.888
	X14: Export of goods	0.394
Process capital	X15: Business competition environment	0.905
	X16: Government efficiency	0.750
	X17: Intellectual property rights protection	0.942
	X18: Capital availability	0.737
	X19: Computers in use per capita	0.840
	X20: Convenience of establishing new firms	0.460
	X21: Mobile phone subscribers	0.547
Renewal capital	X22: Business R&D spending	0.957
	X23: Basic research	0.744
	X24: R&D spending/GDP	0.924
	X25: R&D researchers	0.844
	X26: Cooperation between universities and enterprises	0.719
	X27: Scientific articles	0.833
	X28: Patents per capita (USTPO + EPO)	0.888

Appendix 2 continued

