Intangibles and national economic wealth – a new perspective on how they are linked

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1. Introduction

National competitiveness is a major current interest not only among academics, but also national leaders, policy makers and world organizations. Countries are keen to find ways to drive their competitiveness. According to the World Economic Forum definition, national competitiveness refers to the set of institutions, policies and factors that determine the level of productivity of a country (Schwab, 2011: 4). Level of productivity, then, determines the country's level of prosperity and the rates of return on national investments.

How, then, to drive competitiveness? We know from the past development of advanced economies that production requires not only traditional factors such as capital and labour, but also skills, organizational structures and processes, and other "intangible assets" (Brynjolfsson, Hitt and Yang, 2002). Intangibles have important productivity benefits. In the US economy, for instance, human capital dwarfs the value of physical assets, R&D assets yield benefits in the form of positive product and market valuations, and certain organizational practices have been shown to be associated with significant increases in productivity in the late 1980s and early 1990s (Brynjolfsson et al. 2002).

Although difficult to demonstrate and measure, intangible factors have a major economic impact. Their role has attracted growing research interest, and investors are also keen to incorporate intangible assets into their valuations of firms (Brynjolfsson et al. 2002). The evolving research tradition has approached the subject from different vantage-points, applying different methods and pursuing different goals – although with the same underlying objective of facilitating world well-being. In the post-financial crisis era it has become clear that countries with higher national intangibles weathered the crisis better and rebounded more robustly than those with lower intangibles (Lin et al. 2013: 71). As highlighted by the substantial impact of macroeconomic dynamics on firms and industries and the inability of traditional monitoring tools to prevent crisis, there is an ever-growing need to monitor and analyse trends in national intangibles.

The role of intangibles in economic growth was relatively neglected in research studies in the late nineteenth and early twentieth century. Neoclassical growth models (Solow 1956) believed that technological change had an exogenous origin, and this strand of literature assumed that technological change is embodied in physical capital and labour. Neoclassical researchers tried to reduce the residual (unknown factors affecting productivity) in empirical studies pioneered by Denison (1962).

Growth models developed in the 1980s and 1990s viewed technological change as an endogenous process, and emphasized the role of technology and knowledge as major drivers of growth. In contrast to neoclassical models, these new growth models allowed for increasing returns to scale arising from R&D spillovers flowing into the economy. Knowledge was thus assumed to be a major determinant of technological change, proxied by education (Romer 1986, 1990) or R&D investments (Lucas 1988). New growth theory also explored the role of other intangible entities. Barro and Sala-i-Martin (1998) considered a wide range of institutional factors and organizations that influence growth, while other researchers also investigated sociological factors (social capital Ishise 2009, innovation Fritsch 2002, Czarnitzki 2008, value added efforts Ang 2009). Furthermore, new growth theory emphasized the importance of both domestic and global factors for economic growth. In this framework, Abramovitz (1994) suggested that economic success was dependent not only on individual skills, but also on organizations in the private and public sector as well as on the broader societal environment, including international linkages. Lall (1992) pointed out that national technological advantage is constituted by general and technical competencies, R&D, patents, technical personnel, political decision-making and more long-lasting institutions.

The concept of intangible asset was first included in productivity calculations in the 1980s when Romer (1986) augmented the Cobb-Douglas production function with human capital (in practice education). Over the past 20 years, the field of national intangible assets has seen the growth of three distinct research traditions that have had only little mutual exchange and dialogue. The earliest stream of intangible capital research was mainly focused on individual factors and their impacts on productivity, with tools of augmentation including technological know-how, innovations and product development (Romer 1986, Ikonen 1999, Fritsch 2002, Yoo 2003, Ang 2009, Ishise and Sawada 2009). This stream of research used the concept of human capital. Another vantage-point for intangible asset research is the national accounting framework (Corrado 2005, Aghion and Howitt 2007, Hulten 2008), initiated by the Corrado, Hulten and Sichel (CHS) model (Corrado et al. 2009). This tradition measures intangibles via monetary values and operates with the concepts of *intangibles* or *intangible assets*, consisting mainly of computerized information, innovation and R&D, and economic competency. The third stream of intangible asset research was spawned in Sweden in the 1990s. The focus in this line of inquiry is on defining, modelling and reporting intangibles (Sveiby 1997 and 1998; Edvinsson and Malone 1997; Andriessen 2004, 2008, Navarro 2011, IUS 2012, KAM 2012), and it uses the concept of *intellectual capital (IC)*. The taxonomy of three types of capital – human, organizational and relational – is the most established view within the IC tradition and has been applied in most measurements. The taxonomy was originally presented by Karl-Erik Sveiby in his book Kunskapsledning (Knowledge Management) (Sveiby 1986), and his work from the mid-1980s has been identified as the root of the whole IC movement (Sullivan, 1998; Edvinsson, 2005; Andriessen and Stam, 2004). It has been further developed by many scholars, most notably Edvinsson and Malone (1997).

Drawing on the first two strands of research, this study elaborates on the concept of *intangible capital* to enrich the third intangible research stream – intellectual capital at the national level – by proposing the so-called ELSS model. The IC tradition has commonly drawn on the theoretical assumptions of new growth theories. The impact of IC on economic growth is thus assumed to be endogenous, and its components are taken to be interrelated (Bounfour 2005, Ståhle 2008).

This paper aims to examine to what extent intangible capital explains GDP growth and to assess its impact on GDP formation in different countries. We bring a new perspective to explaining national intangible assets by introducing a theoretically and computationally justified method for the measurement of the economic impacts of intangible capital, and describe the impacts of intangible capital in different countries using the method developed. In addition, our study adds value to this field of research through the following enhancements:

First, the intangibles covered in the first two research streams are limited to human capital (mainly education), IT, R&D and investments in organizational practices. Our proposed ELSS model, which is theoretically based on the IC tradition, covers a wider spectrum of intangibles, namely human capital (the capacities and capabilities of people), market capital (global networks and business attractiveness), process capital (the function of society, including infrastructures and technology), and renewal capital (innovation and knowledge creation).

Second, the data used in the ELSS model are *national* statistics provided by reliable world organizations such as the World Bank, the United Nations, the OECD, and the World Economic Forum, mainly collected through the International Institute for Management Development (IMD) in Switzerland. The data for the CHS and related models are mainly collected at firm (Corrado et al. 2009, 2010) or industrial level (Oliner, Sichel and Stiroh 2007) and then aggregated to national level. The ELSS model therefore provides a more solid foundation for analyses at the national level.

Third, valuations in the first two research streams are mainly based on inputs or investment data. The ELSS indicators include inputs, process and outputs data *to reflect whole value chains*: examples include education expenditure as per cent of GDP (input), government efficiency (process), and students' PISA performance (output).

Fourth, valuations based on aggregation and re-processing from the firm or industry level to the national level often have to be confined to certain economies. Corrado et al. (2009), for instance, obtained their data from the United States, while van Ark et al. (2009) concentrated on the EU countries. The data for our study, by contrast, come from readily available national statistics: they are reliable, longitudinal, comprise a wide range of different indicators, and cover 48 countries. Such data features allow for trend analyses and in-depth country comparisons to meet tailored needs.

Fifth, CHS intangibles rely in large part on computerized information (Corrado, 2005). However as information technology has become ubiquitous it is no longer a valuable intangible asset that differentiates countries (Roach 1998). The ELSS model is based on a balanced mix of indicators from the four categories of intangible capital.

Sixth, our research model and methods mean that the value and impact of national intangible assets on national economic growth can be assessed by examining the interplay between the four different types of intangible capital rather than the relatively unidimensional relationship between intangible capital investments and economic growth.

Seventh, most studies on intangibles are grounded *either* in calculations of monetary values and productivity issues *or* in modelling and reporting perspectives. This study integrates both these perspectives.

In short, our approach to analysing the economic impact of intangible factors at the national level significantly contributes to the development of the current research tradition into intangibles.

The paper is organized as follows. Section 2 gives a brief overview of the field of research and introduces the background of the ELSS model. Section 3 provides a detailed description of the new production function, and section 4 focuses on application by presenting the impact of intangible capital on GDP formation and economic growth. Finally, sections 5 and 6 deal with the applicability of the new production function as well as policy implications and prospects for further research.

2. Background

Intangible factors have an ever-increasing impact on economic growth and productivity in the knowledge economy. In response, a new strand of empirical growth research has emerged over the past decade that is aimed at updating the way that business activity is depicted in macroeconomic data and analysis (Corrado and Hulten 2010). The main impetus for this trend is that economic activity in many countries has shifted from goods production to services production, and national economic growth is increasingly based on knowledge and other intangibles rather than on physical capital. Designed during the manufacturing era, economic statistics have therefore become increasingly outdated (Abraham 2005).

Under these circumstances, theories of growth based on standard inputs and even endogenous growth approaches have become less compelling as frameworks for analysing productivity and economic change (Corrado and Hulten 2010). There is an obvious need to create new means to understand and measure the new sources of economic growth. In what follows, we briefly review three research streams that measure intangible effects.

2.1 Measuring intangible effects on productivity

The Cobb-Douglas production function by Charles W. Cobb and Paul H. Douglas was widely used in the 1940s and 1950s. It provided a sound basis for the measurement of productivity, starting from the twin factors of capital and labour (Cobb and Douglas 1928, Douglas 1976). However over time there was increasing awareness that productivity depended not only on capital and labour, but also on a range of other factors such as education, the application of technology, monetary factors, and investments in R&D.

Work was therefore needed to develop the production function, in two ways. First, by augmentation, which meant that qualitative (non-monetary) variables were added to the function; and second, the production function was expanded with quantitative, monetary values[1].

Augmented growth models are mainly aimed at identifying the crucial qualitative or intangible variables that impact productivity. Among the best-known developers of augmented growth models are Robert Solow and Paul Romer. Solow (1956, 1957) argued that after 1929, technical change had

1 This distinction between expanding and augmenting through quantitative (monetary) and qualitative (indicator-based) variables is made by the authors.

significantly accelerated productivity growth, more than increased capital per man hour. Romer (1968, 1989, and 1990) augmented the production function with human capital (mainly education and science) and argued that technological change alone cannot explain the huge increase in output per hour worked in 1880-1980. Instead, he maintained, skills, knowledge and experience and their impact on national economic growth are more important factors. Over the years, numerous studies have been conducted on various augmenting entities, including human capital (Mankiw et al., 1992; Islam, 1995; Ikonen 1999, Poliment 2007), social capital (Ishise 2009), innovation (Fritsch 2002, Czarnitzki 2008), R&D (Abdih 2008) and value added efforts (Ang 2009). All of these approaches have significantly advanced the measurement of productivity. However, analyses of the impact of intangible capital on productivity have tended to remain rather narrowly focused, usually addressing just one qualitative variable at a time. The challenge still remains of how to take account of all the main qualitative or intangible factors when measuring productivity.

2.2 Measuring intangibles as monetary values

Another line of development has involved expanding the production function by calculating monetary values for intangibles. Lev (2001, 2005a, 2005b) and Corrado et al. (2005), for instance, have included new factors in their analyses to capitalize intangibles.

Lev (2005a) has proposed a calculation system that is based on the structural characteristics of intangibles, including innovation, human resource, and organization-related variables. This has led to the development of estimates of business investment in intangibles based on their cost of production. The same approach was earlier taken by the OECD in 1998 (www.oecd.org), Nakamura (2001) and then later by CHS (Corrado and Hulten, 2010). Lev and Radhakrishnan (2005b) expanded the production function by calculating monetary values for organizational capital, which they define on the basis of three features: firms' operating capabilities (product design systems, and production management and engineering), investment capabilities (advanced project selection mechanisms and personnel training), and innovation capabilities (unique R&D practices, and capabilities to flexibly learn from others). They calculate the monetary value of organizational capital from total factor productivity (TFP) by including firm expenditures on advertising and employee training, which they capitalize firm-specifically (Lev & Radhakrishnan 2005b). Since TFP also includes other random variables besides organizational capital, Lev incorporated softer intangibles such as social capital, "the value of relationships" in his term. However, this proved too difficult to value and he decided to incorporate it as an unmeasured residual with no calculated monetary value (Lev 2005a: 301).

The computational approach is represented by the widely used CHS method as developed by Corrado, Hulten and Sichel (2005). They found that investments in intangibles had overtaken investments in tangibles as the major systematic source of growth, and that the omission of these inputs gives a biased picture (Corrado and Hulten 2010). To improve Lev's approach, CHS (2005) developed a broad scheme for categorizing business intangible investment, and the authors pointed out that Lev's model only brings the cost of acquiring the marginal asset into equality with the discounted present value of future income. In the CHS model, investments are placed under the new category of "new capital," which is considered the equivalent of intangible assets. The model estimates business spending on intangible assets by identifying three groups of intangibles, namely

1) computerized information (knowledge embedded in computer programs and computerized databases), 2) innovative property (R&D spending data and non-scientific R&D, including commercial copyrights, licences and designs) and 3) economic competencies (brand names, firm-specific human capital, and organizational structure) (Corrado 2005, Corrado and Hulten, 2010).

The CHS model does not augment the production function with qualitative variables, but instead deals only with monetary values, i.e. it uses monetary investment, more precisely, capitalized expenses in intangibles as a proxy for intangible value. The CHS model is coherent and easy to use, but it does involve some problems. First, it lacks a theoretical grounding for the three intangible categories with selected proxies (such as management pay, staff training expenses, software purchase costs, sales and marketing costs, and mineral exploration costs). Second, the CHS model deals with intangible assets simply as monetary investments, mainly capitalized expenses, which leads to the paradox that all investments would always be productive and equal to the value generated, which obviously is not true to reality. Third, using the cost of inputs to measure real outputs – which is how government output is usually measured – implies zero productivity growth (Salgado, 1997). Fourth, information technology is now widely viewed as a critical element of the business infrastructure and businesses operations, and therefore in itself can no longer help sustain profit margins (Roach, 1998). The value of IT investment has saturated over the years and does not necessarily increase technological efficiency (van Ark et al 2003; Ståhle and Bounfour 2008; Hughes et al 2005 and Vicente 2011). For these reasons, the validity of the CHS model must be reconsidered.[2]

On the quantitative side of research, production function calculations have mainly focused on the monetary values of intangibles and on growth accounting, specifically TFP annual changes. However, the important connection of TFP *with* intangible capital has largely remained unexplored. Nonetheless Lev's work and the CHS model have greatly increased awareness about the importance of intangible assets and created a relevant foundation for future research.

2.3 Measuring intangibles by statistical indicators

The third stream of research takes a more theoretical, conceptual and comprehensive approach to intangibles. It uses the term intellectual capital (IC) to refer not just to knowledge and skills, but also to the structural set of intangible assets used to create value. The IC research tradition was first developed at the micro-economic level in the mid-1990s. Furthermore, a pioneering method for the measurement of a company's IC was put forward by the Swedish company Skandia (Edvinsson and Malone 1997). Following these company-specific analyses of intangibles, several scholars have expanded this research perspective and measured the IC of nations and regions. National IC reports have been published in several countries (e.g. Israel, Poland and Luxembourg), and several IC initiatives have been launched at national level (e.g. Sweden and Denmark) (Bounfour 2003). Regional level examples of IC measurement include the national intellectual capital index (NICI) for the Arab region (Bontis 2004) and an initiative for the Pacific Islands (Bounfour 2003). Since the turn of the millennium, research on IC advanced to the macro-economic level. At European

[2] For a more detailed analysis of the CHS method, see Ståhle & Ståhle 2012.

Union level, national IC measurements have been conducted by Bounfour (2003) and Andriessen and Stam (2004).[3]

The main focus in the IC line of inquiry is on defining, modelling and reporting intangibles (Andriessen 2004, 2008, Navarro 2011, IUS 2012, KAM 2012). For the IC tradition, capital is fundamentally a non-economic concept that describes a company's or a nation's intellectual growth potential. More recently, this tradition has taken an increasing interest in the measurement of intangible capital, turning away from monetary values and focusing instead on indicators describing the level of knowledge capital and on country comparisons (e.g. Lin and Edvinsson 2011, Bontis 2004). An active research community has subsequently grown up around this premise, keeping the discussion going both through scientific journals (e.g. Journal of Intellectual capital) and international seminars and conferences (e.g. Intellectual Capital for Communities).

Within this tradition measurements are based both on the established IC model and on the statistical, comparable indicators incorporated in the model in recent years. The main strength of this vantage-point is its comprehensive model of IC, which has been widely adopted in the IC research community over the past 20 years. However the difficulty and challenge with this approach is how to convert its various components into measurable units that can reliably describe intangible capital and its impacts on economic growth.

There are several variants of the model, but their basic elements are largely similar to the classification originally developed by Edvinsson and Malone (1997) for the corporate level. Lin has summarized the most commonly used national intellectual capital (NIC) components, which are human capital, process capital, market capital and renewal capital (Lin and Lee 2006, Lin and Edvinsson 2011). A model of 28 indicators was statistically tested to represent national intangibles. However, Lin's work is limited to country index ranking, without exploring to what extent the composite indices or individual capital explain national economic growth or the impact of NIC on GDP formation. Ultimately all that such calculations can show is that countries with high GDP have, on average, high productivity and high IC levels (Lin and Edvinsson 2011, Barro 1991, 2001; Cohen 2007). Clearly it would be useful to learn in more depth about the associations with country growth or development. Pucar (2013) points out that IC offers a deeper explanation of total factor productivity (TFP), and furthermore TFP could become the most important performance measure of intangible capital in general. This notion has been applied in the ELSS model, which incorporates both the NIC research tradition and the Cobb-Douglas production function.

[3] Since the mid-1990s there have been several attempts to measure national intellectual capital (IC) linked with economic impact or value. At least two methods can be mentioned that are loosely connected to the IC tradition: Calculated Intangible Value (CIV) introduced by Tom Stewart in 1997 (Stewart 1997) and the Value Added Intellectual Coefficient (VAIC) developed by Ante Pulic (2000). However, a critical analysis of these methods by Ståhle et al. (Aho, Ståhle & Ståhle 2011; Ståhle et al. 2011) concluded that neither of them provide valid measurements of intangible capital.

Table 1: Research streams and originators aimed at measuring intangible effects on economy

Key sources	**Measuring intangible effects on productivity**	**Measuring intangibles as monetary values**	**Measuring intangibles by statistical indicators**
Cobb & Douglas 1928 Douglas 1976	Created the basis for the measurement of productivity by the factors of capital and labour		
Solow 1956, 1957	Developed augmented growth models;showed that technical change significantly accelerates productivity growth.		
Romer 1968, 1989, 1990	Developed growth models augmented with human capital, mainly education and science.		
	Impact on productivity remains narrowly focused, since only one or two qualitative variables at a time are involved.		
Lev 2001, 2005, Lev & Radhakrishnan 2005		Calculation system based on innovation, human resource, and organization-related variables. Expanded the production function by calculating monetary values for organizational capital.	
Corrado, Hulten & Sichel 2005 Corrado & Hulten, 2010		Model uses monetary investment, i.e. capitalized expenses in intangibles as a proxy for intangible value	
		Connection of total factor productivity TFP with IC has mainly remained unexplored.	
Lin & Edvinsson 2008, 2011, 2013 Lin, Edvinsson, Chen & Beding 2013			Structural NIC model developers;IC ranking for 48 countries using IMD data base;analyses of the EU crisis countries.
Andriessen & Stam 2004, 2008			Translation of the Lisbon goals to 38 indicators to IC measures for EU-19
Bontis 2004			NICI index for the Arab region; index development and hypothesis testing.
			Limited to country index rankings or correlation analyses without explaining the impact of IC on national economic growth or GDP formation.

2.4 ELSS model: database and production function

A brief history of the model is as follows. The 28 indicators for four IC categories – human capital, process capital, market capital and renewal capital, i.e. the NIC model – were first published by Lin in 2006, and later developed by Lin and Edvinsson in 2011 (www.nic40.org). Over time it was apparent that modified indicators and refined calculations would be needed, and therefore a revised and expanded model was developed by Lin, P. Ståhle and S. Ståhle. Instead of 28 indicators, the new model had 48 indicators. After normalization, the inclusion of time effects and country demographics made the data more accurate in calculating the final indices. The database currently covers the period from 2001 to 2011, and it is constantly updated[4]. (For the full list of countries and indicators, see Appendix A1, www.nic4nations.com). The method itself is explained in the following section.

"ELSS" refers to Edvinsson, Lin, Ståhle & Ståhle: Leif Edvinsson is creator of the IC model at corporate level, and Carol Lin is creator of the NIC model and the initial database of 40 countries (statistics mainly based on IMD Country Competitiveness data), which was further developed by Carol Lin, Pirjo Ståhle and Sten Ståhle, who added 8 new countries and 24 new indicators (for statistical sources, see section 4 and footnote 11). Sten Ståhle and Pirjo Ståhle further developed the database by taking into account time and country specifics, and developed the production function approach so as to enable measurements of the impact of NIC on GDP formation and GDP growth.

3. Calculation of the ELSS production function

In this section, we outline a method that can provide a more accurate measure of the economic impact of national intangible capital than any of the tools currently available. Using elements drawn from the NIC research tradition, the method is based on an expansion and augmentation of the Cobb-Douglas production function. In our analysis, we significantly improve the calculation method employed by Lin & Edvinsson (2011) and Bontis (2004). Our augmentation of the Cobb-Douglas production function is based on the battery of 48 intangible capital indicators (ELSS database, www.nic4nations.com).

The basic Cobb-Douglas production function is based on three elements, namely capital, labour and residual (total factor productivity TFP). Outside of capital and labour, there exist factors that are unspecified (and their contribution to GDP is embedded in the residual) but that are known to have an impact on productivity. It is generally thought that TFP consists primarily of the impact of technology on productivity (e.g. learning and the transfer effects of technology). Although it is impossible to define the exact content of TFP, its role is crucial because it indicates how much more a country produces relative to its capital and labour assets. In others words, TFP is a numerical coefficient by which the combined output of capital (K) and labour (Lh) need to be multiplied in order to obtain the final GDP value.[5] In Norway, for instance, the numeric value of simple[6] TFP in

[4] 2013 update due May 2014, covering 59 countries in 2001 – 2013.

[5] For a comprehensive introduction to TFP, see Hulten 2000, and for more on the measurement of TFP, see Diewert 2001, Lipsey 2001, Aiyar and Dalgaard 2004.

2011 was 14, meaning that the country's GDP was 14 times the value produced by capital and labour alone. Other leading countries in this respect are the United States (simple TFP = 12), Belgium (12), Finland (11) and the United Kingdom (10). This shows that a crucial driver of productivity in these countries is TFP, i.e. production factors cannot be directly reduced to capital or labour. It is clear that if a country increases its use of capital or labour, this will also increase its GDP, whereby growth is based on tangible investments (physical capital K or working hours Lh). If, on the other hand, the effects of TFP can be intensified, then there will be no need to increase capital or labour input, and productivity will increase without additional capital or labour.

However, the problem is that we do not know exactly what TFP includes or how it can be influenced. There have been some attempts in recent years to try and understand the contents and impact of TFP through an expansion or augmentation of the original Cobb-Douglas production function (e.g. CHS, Lev and Ikonen, 1999, Poliment, 2007; Ishise, 2009; Fritsch, 2002, Czarnitzki, 2008; Abdih, 2008; Ang, 2009). These attempts have always been aimed at reducing the final residual (TFP) to minimize the effects of unexplained variables. Ideally, the whole residual will be explained, in which case its numeric value is 1 (i.e. the combined effect of all variables in the production function is the same as GDP).

The ELSS production function focuses on the numerical value of TFP, not on its annual changes as the growth accounting tradition does. During the past 150 years of growth estimates, the value of TFP has increased by 1500% (about 1.8 % a year) (Shackleton 2013), and therefore the level of TFP is an essential part of the ELSS model. TFP is treated in the model as a separate production function constructed by intangible capital and global and domestic markets.

In the Cobb-Douglas production function, TFP is a purely *numerical* factor: it has no structure or content. It simply indicates how much of GDP *remains unexplained* by the production function variables. On the other hand, TFP is an indicator of efficiency. The higher the TFP figure, the more countries make use of the resources and drivers that are not reported in national accountings, such as R&D investment and the effects of intangible assets. National accounting reports focus mainly on tangible GFCF (Gross Fixed Capital Formation) and labour statistics (workforce L times working hours a year). *In other words, the residual is a core variable that can be used to calculate the impacts of intangible capital on GDP*. TFP is a residual, a "black box" that includes the effects of intangible capital, but also a mix of other factors.

Since intangible capital is part of TFP, it is important to add variables into the production function so that the residual can be unravelled. Variables can be added through expansion, i.e. by adding capital variables and converting them into monetary values (e.g. R&D investment), or through augmentation, i.e. by adding qualitative variables that cannot be directly converted into monetary values (e.g. government efficiency). In the new production function, we adopted the NIC model (Lin and Lee 2006, Lin and Edvinsson 2011) as a basis for further development and elaboration (see all 48 indicators of the model in Appendix A2).

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[6] Simple TFP only includes the effects of capital and labour, i.e. TFP = GDP / $((K^{a}\ (Lh)^{b})$, where a = 0.325 and b = 0.675. Simple TFP is not aggregated and does not take account of demographics and country specifics. It also presupposes that output shares for capital and labour (a and b) are equal in different countries.

The method is based on both quantitative (expanding) and qualitative (augmenting) IC dimensions, and takes into consideration the following elements:

1. General Cobb-Douglas production function $Y = GDP = A\, f(K, L, h) = A\,(K)^a\,(Lh)^b$ (Capital K, labour L and hours worked h. Production output share for capital a, and production output share for labour b)
2. National Intellectual Capital model, consisting of four NIC categories: Human Capital (NHC), Process Capital (NPC), Market Capital (NMC), and Renewal Capital (NRC). Thus NIC = g(NHC, NMC, NPC, NRC).
3. Essential external and tangible productivity factors, including country specifics that have a major impact on GDP formation.

3.1 First step: Expanding by adding new capital and aggregating by demographic structures

As discussed earlier, the direct productivity of capital K and labour L*h (=Lh) and exponents a and b in the equation provide only an incomplete explanation of GDP composition. Therefore it is necessary to *expand* the production function. In order to retain the simplicity of the equation, only *key monetary value capital variables* are added to the function. These include 1) investment-related variables, which are aimed at future yield (usually taken into account through capitalized R&D investments, denoted by N), 2) extreme resources, i.e. variables describing country specifics (e.g. oil in Norway, cheap labour in China, financial centres and markets in Luxembourg, exceptionally low tax rates in Ireland) denoted by O (outlier KLEMS). Most previous studies have not taken these capital variables into account, despite their significance, rendering country comparisons invalid.

The production function is thus expanded by using two monetary capital variables, i.e. R&D investment (N) – because of its major impact on productivity (Zachariadis 2004, Sveikauskas 2007) – and the economic impacts of extreme resources represented by outlier KLEMS[7] (O). The purpose of the concept of outlier KLEMS (natural resources in excess, extreme economic or financial comparative advantages, low taxation and cheap labour resources, etc.) is to prevent such extreme resources from distorting the productivity results, i.e. TFP.

The production function can thus be written as $Y = A'\, f(K, Lh, O, N)$, with the residual being A' = eTFP[8]. The basic function in Cobb-Douglas form is:

$$\text{(1a)}\quad Y = f(A', K, Lh, O, N) = A'\, K^{a'}\,(Lh)^{b'}\,O^{c'}\,N^{d'}$$

[7] KLEMS: Statistical data for capital (K), labour (L), energy (E), material (M) and services (S) as input measures in production. Definition by OECD: KLEMS multi-factor productivity (MFP) is a productivity measure that relates gross output to primary (capital and labour) and intermediate inputs (energy, other intermediate goods, services). A comprehensive list of KLEMS data sources is available at http://www.worldklems.net/data/index.htm
For EU KLEMS, http://www.innodrive.org provides data with CHS new capital included.

[8] TFP when the production function is expanded with O and N = eTFP.

R&D investment is entered as a variable in the production function by capitalizing both public and private annual R&D investments (N). Formula (1a) also means that we have incorporated production-related factors that have a direct impact on productivity: major natural resources, strong financial centres that control the world markets, extreme tax benefits, significant sources of cheap labour, and metropolization. The monetary capital value of these resources is calculated so that a (significant) difference between exports and imports (oil and financial services) is taken into account as capital, and significant wage and tax benefits are also capitalized. Furthermore, the production function is aggregated so that the country's economic and demographic structure is taken into account.[9] The adjustment is based on research which shows that metropolitan regions have a higher than average productivity rate (by some 25%), suburban regions are close to the national average, while productivity in rural areas is around 25% below the national average (e.g. Brinkhoff 2013, UNESA 2012). In other words, metropolitan regions drive up productivity relative to the national average, and rural areas depress the average.

These steps and the newly entered variables contribute to explain 15–25% of residual A.[10]

Aggregation and the new capital classes (outlier KLEMS O and R&D N) reduce the residual in advanced economies on average by about 28% and in developing economies by about 34%.[11]

3.2 Second step: Augmenting by adding global and domestic market indicators and NIC

The expansion and aggregation described above have significantly reduced the residual. However, there are still some important variables that are missing from the production function, including global markets, domestic markets and intangible capital (NIC). The contributions of these three factors can be revealed by augmenting the function using both NIC indices (see Appendix A2) and numerical indices that show the economic impacts of external and internal markets (those that are not included in the outlier KLEMS). In this study, MTFP denotes factors that measure the effects of the global economy on individual countries' GDP formation and growth of the global economy (GDP and GDP growth), and the contribution of different countries to world trade, defined mainly via trade, inward FDI (Foreign Direct Investments) and foreign employees as share of total labour force. DTFP denotes factors that affect the domestic market, including domestic consumption, the savings rate and imports. The MTFP and DTFP variables are used to analyse the impact of the global and domestic market on TFP (for MTFP and DTFP, see Appendix A3).

When this is taken into account, the augmented residual A can be written generally as A = TFP = R g(MTFP, DTFP, NIC) with the new residual (R). Based on step one, TFP as part of the Cobb-Douglas production function will be treated as a separate Cobb-Douglas production function and the augmentation is done in three consecutive steps:

$$\text{(2a)} \quad A' = \text{eTFP} = \text{aTFP}\,(\text{MTFP})^{e}\,(\text{DTFP})^{f}\,(\text{NIC})^{g}$$

[9] Data for aggregation: competitiveness online (2013), UNESA (2012) and Brinkhoff (2013). Aggregation is done at two levels: urbanization (metropol-suburban-rural area weights) and structure of economy (industry-public service-private service-agricuture sector weights).

[10] Appendix B1; see the percentage change between Simple TFP and Aggregated and Expanded eTFP.

[11] For the results for all countries and country groups, see Table 2 and Appendix A1.

(2b) $NIC = (NHC)^{\eta} (NMC)^{\mu} (NPC)^{\rho} (NRC)^{\varsigma}$

(2c) $NHC^{\eta} = (NHC1)^{\eta 1} \ldots (NHC12)^{\eta 12}$; alike for NMC, NPC and NRC

(2a) determines the impacts of global markets MTFP, domestic markets DTFP and NIC on GDP formation and GDP annual growth. (2b) determines the impact factors of NHC (Human Capital), NMC (Market), NPC (Process) and NRC (Renewal) as shares of NIC total impact. (2c) determines the impact factors of each single indicator (for a full list of indicators, see Appendix A2).

It is noteworthy that even though MTFP and DTFP impact TFP and contribute to explaining the different formation of the residual in different countries, they are still treated as economic indices, not as monetary values. In this way, all non-financial factors are "forced" into the NIC variable and the new residual aTFP. MTFP and DTFP are created purely on the basis of financial indicators and therefore they do not directly involve or measure technological or qualitative elements and consequently no NIC variables either. However, when MTFP, DTFP and NIC (2a) are combined, they give us a rough idea of the structure of the TFP variable – not a complete and accurate picture, but complete enough. Up to this stage, GDP formation is affected by labour, capital, outlier KLEMS and N (R&D) as well as three key drivers: real economy MTFP (global markets) and DTFP (domestic markets) and embedded NIC (intangible capital).

The MTFP, DTFP and NIC contributions to GDP are calculated using marginal productivities (3), because this is the best way to take account of the specific level of the variable, not only its general productivity. The NIC share in GDP formation can thus be expressed as follows (following 2a):

(3) NIC share in GDP formation (%) = $eTFP / (aTFP\ (MTFP)^{e}\ (DTFP)^{f}\ )*100\ \%$

In advanced economies the second step explains 68% of the impact of TFP on productivity; in developing economies the figure is 25%. [12]

Taken together, the first and the second step explain about 77% of TFP productivity effects in advanced economies, and 31% in developing economies.[13]

4. Applying the new production function

This section begins with a description of how NIC indices have been calculated (4.1). Next, we discuss the impact of the expansion and augmentation on the residual, and what the outcome tells us in general terms about the structures and drivers of the economies in different country categories. Furthermore, this section discusses the interaction between the economy and intangible capital (4.2). We then proceed to analyse the contribution of intangible capital to GDP formation in different countries (4.3), and finally describe the impact of intangible capital on national economic growth (4.4).

[12] See Table 3: Groups by wealth, Column TFP e-a % change.

[13] See Table 3: Groups by wealth, Column TFP s-a % change.

The analyses have been performed using the ELSS database (www.nic4nations.com), which contains national NIC indices for 48 countries covering the period from 2001 to 2011. Most statistical figures are drawn from IMD online (2011, 2012); the other sources are WTO, ILO, EUROSTAT, INNODRIVE, UN, OECD (Pisa), ETH Zurich, Transparency international, Reporters without borders for freedom of information, the U.S. Patent and Trademark Office and the European Patent Office. The database covers 48 basic indicators in four categories: human, market, process and renewal capital. Each category contains 12 indicators that are aggregated to form a single index for each category.

4.1 Calculation of NIC index level

There are two different types of data in the ELSS database: data with an absolute value, such as "patents per capita," and data with a qualitative rating based on a scale from 1 to 10, such as "image of your country." The four NIC categories contain 12 indicators that are aggregated as geometric weighted averages to form single indices for each category. Finally, the four upper level indices are aggregated as weighted geometric averages to form a single NIC index for each country and each year. In addition, *original normalized scores are adjusted in the ELSS database for both time accumulation and country specifics.*

Basic normalized indices were modified in two stages:

1. Time effects were taken into account via the time lags with which the practical actions related to the indicators have economic or social impact. This was done by weighting prior years with higher weights and calculating each year as a weighted average of present and prior years.

    a. For indicators where economic or social effects depreciate quite rapidly (e.g. brand value), the opposite weighting principle was used, i.e. present year or near present year was given a higher weight than prior years.
    b. For indicators involving both a time lag and depreciation aspect (e.g. R&D investments), the highest weight was set at 3-5 years prior to the present year.

2. Country specifics were taken into account through a) level of metropolization and b) structure of economy with respect to industry and service sector shares in GDP formation. This was done by multiplying the indicator with a factor of 0.90 - 1.10 to reflect the level of metropolization and the levels of industrialization and service.

    c. The highest metropolization together with the highest combined levels of industry and service sectors shares in GDP formation yielded a factor of 1.10 and the lowest levels a factor 0.90. This estimation is based on research results for productivity in relation to metropolization and structure of economy, which show a +/- 25 % variation.

Modified and original indices where tested by comparing correlations to 1) total factor productivity TFP, 2) labour productivity GDP/EMP and 3) GDP per capita GDP/POP.

Table 2: Correlations for original and modified indices

Correlation Average 2001 - 2011	Original normalized	Acknowledging time	Acknowledging country specifics
Total factor productivity TFP	0.791	0.873	0.913
Labour productivity GDP/EMP	0.762	0.847	0.875
GDP per capita GDP/POP	0.706	0.791	0.833

These transformation procedures have been repeated for all numerical indicators of national human capital (NHC), market capital (NMC), process capital (NPC), and renewal capital (NRC). As a result, each of the four NIC components has 12 indicators (Appendix A2) on the same scale. Furthermore, the sub-indices were aggregated to obtain NHC, NMC, NPC and NRC index scores. General NIC score ("Index NIC" in Table 3) is the final geometric weighted average of the component capitals score for each country.

It is clear from the increasing correlations that when time lags and country specifics are acknowledged and properly incorporated in the NIC index calculations, the linkage of the NIC indexes to both GDP/POP and economic performance (TFP and GDP/EMP) is significantly strengthened.[14] In other words the time lags and country specifics make relevant adjustments to the calculated NIC indexes.

4.2 Residual explains economic drivers in different country groups

The TFP residual provides crucial information about the foundations of economic productivity and growth in different countries. It is easy to appreciate the significance of the residual and its derivatives when we consider its behaviour following the expansion, augmentation and aggregation of the production function. The effects of these steps are demonstrated by comparisons with simple TFP. In Table 3, *simple* total factor productivity (sTFP) indicates the residual when the production function has not been aggregated, expanded or augmented. eTFP is an *aggregated* and *expanded* production function, and aTFP indicates the residual when the production function is additionally *augmented* (i.e. aTFP is aggregated, expanded and augmented). Furthermore, Table 3 shows the percentage changes between different steps from simple to expanded (TFP s-e), from expanded to augmented (TFP e-a) and from simple to augmented (TFP s-a), which then *indicates the percentage of country productivity explained by the new variables, i.e. the extent to which economic development is dependent on factors other than capital and labour.*

[14] All (Pearson) correlations are significant at alpha = 0.05. Multicollinearity was tested using variance inflation factor VIF. VIF ranged between 2.69 (NIC - TFP) and 3.72 (NIC - GDP/POP) indicating no multicollinearity problems, i.e. VIF is well below 5 and/or 10.

Table 3: Reduction of residual and explanatory power of expanding and augmenting production function in different countries and country groups in 2011[15]

NIC48	/2011	Index NIC	TFP Simple	Aggregated TFP Expanded	Aggregated TFP Augmented	TFP s-e % change	TFP e-a % change	TFP s-a % change
	NIC48 unweighted avg	6.1	8.1	6.5	2.7	24.1	54.4	62.3
Europe								
	European Union	6.4	9.7	7.3	2.8	23.7	62.2	71.0
	EMU countries	6.7	10.6	7.6	2.8	27.8	63.8	73.8
USA		8.9	12.0	9.1	3.8	24.4	58.5	68.7
	NORDIC COUNTRIES	8.0	11.2	8.1	3.3	26.7	59.8	70.6
	Sweden	8.5	11.0	8.1	3.8	26.5	52.6	65.1
	Denmark	8.3	11.6	8.3	3.5	28.7	57.7	69.9
	Finland	8.2	11.0	8.2	3.6	25.1	56.6	67.5
	Norway	7.6	14.0	9.2	3.4	33.9	62.9	75.5
	Iceland	7.5	8.3	6.7	2.1	19.3	69.3	75.3
Economic groups								
	ASEAN	5.9	5.9	5.4	2.7	30.7	43.3	50.5
	BRICS	4.7	4.7	4.7	2.9	36.1	36.8	42.3
	PIIGS	5.8	9.7	6.9	2.4	28.0	65.1	74.8
Groups by wealth								
	GDP/POP[16] 1 /Rich	7.8	11.3	8.0	2.6	28.4	**68.0**	**77.1**
	GDP/POP 2 / Median	6.3	9.2	6.8	2.6	25.1	60.9	70.3
	GDP/POP 3 / Poor	4.4	3.5	4.1	3.0	34.3	**25.3**	**30.8**
Groups by NIC impact								
	GDP/NIC 1 / High	8.0	11.2	8.3	3.5	25.4	57.9	68.6
	GDP/NIC 2 / Median	6.6	9.7	7.2	2.7	24.4	61.2	70.6
	GDP/NIC 3 / Low	4.3	4.1	4.4	3.1	28.8	27.0	37.0
Groups by level of NIC								
	NIC 1 / High	8.3	10.7	7.9	3.0	26.7	62.3	72.1
	NIC 2 / Median	6.1	8.7	6.6	2.5	23.0	61.1	69.8
	NIC 3 / Low	4.1	4.1	4.4	2.5	28.3	39.6	46.3

Overall 62.3% of the residual in all 48 countries is explained (Table 3, TFP s-a column). The figures for EU and EMU countries are significantly higher (71.0% and 73.8%) than for other country groups. This means that these countries are highly dependent on factors others than capital and labour.

The economy of BRICS countries is mainly explained by aggregation and expanding with outlier KLEMS (36.1%, see column TFP s-e), which means that their development is mainly dependent on natural resources, cheap labour, tax benefits, etc. ASEAN and PIIGS (Portugal, Ireland, Italy, Greece and Spain) countries, on the other hand, draw very little from outlier KLEMS (and aggregation and R&D, only 30.7% and 28.0%). Instead, they benefit significantly when augmenting by MTFP, DTFP and NIC (43.3% and 65.1%), which means that their economic drivers come from global and domestic markets and intangible capital. BRICS benefit to a significantly lesser extent from augmentation, only 36.8%. *The analyses show that both the BRICS and ASEAN countries are*

[15] The percentage changes of TFP s-e, e-a, and s-a are calculated as unweighted averages from the basic data in Appendix B1: percentage changes are first calculated for each country individually, and then the NIC48 average is calculated as the unweighted average of the individual changes. The same approach is used for all groups.

[16] GDP/POP = GDP at PPP per capita

dependent on global and domestic markets, but additionally that even NIC is a strong driver in ASEAN countries.

aTFP can be understood in two ways: it is a measure of *what is not yet explained*, but also a measure of the *effects of unexposed drivers* (TFP as a measure of the effects of the drivers that have not been incorporated into the ELSS analysis model).[17] From the latter point of view the United States, for instance, uses these unrecognized drivers more than the EU, as its aTFP residual (3.8) is significantly higher than the EU's (2.8). In a comparison of the Nordic countries, results from 2011 show that Sweden makes the most use of additional drivers (3.8,) followed by Finland (3.6) and Norway (3.4), while Iceland lags far behind (2.1) (Table 3).

It is interesting that PIIGS seem to belong to the same group as developed countries (measured by NIC levels) in that their drivers are based on augmenting variables in the same ratio as in the countries with a high NIC level, i.e. their economic structure resembles that of the EMU countries. This is a somewhat worrying result because the level of NIC in PIIGS countries is not high enough to sustain a competitive advantage (simple TFP well below EMU averages). As is shown in Table 3, the average NIC index value for PIIGS is only 5.8, well below the median values for advanced economies at 6.1 and the EU and EMU values of 6.4 and 6.7, respectively.

Correlation analysis (Table 4) shows that simple, aggregated and expanded TFP still contain large effects from NIC (r= 0.835 and 0.855), but the final residual – after augmentation – contains only minor NIC effects (r= 0.151). *This means that most NIC effects have been extracted from the residual*. It is interesting that the effects on GDP formation of both MTFP (global) and DTFP (domestic) correlate negatively with both NIC and with simple aggregated and expanded TFP (r= -0.597 and -0.776). This means that the impacts of global and domestic markets are rival to both TFP and NIC, i.e. low TFP and/or NIC are compensated by increasing global and/or domestic business activities *per se*.

Table 4: Correlations for TFP's and impacts of global (MTFP) and domestic (DTFP) market, and NIC in GDP formation 2011

NIC48 /2011	TFP	Aggregated TFP		NIC	Percentage share in GDP formation		
Correlations	Simple	Expanded	Augmented	Index	MTFP %	DTFP %	NIC %
Simple TFP		0.985	-0.012	0.835	-0.544	-0.727	0.788
Expanded TFP			0.029	0.855	-0.597	-0.776	0.849
Augmented TFP				0.151	**-0.034**	**-0.123**	0.107
NIC Index					-0.552	-0.852	0.886
MTFP %						0.355	-0.714
DTFP %							-0.908
NIC %							

[17] aTFP can be used as such as a measure of the impact of unexplained drivers, or the percentage can be calculated as 100 % – TFPs-a.

4.3 Overall impact of intangible capital on GDP formation

When all 48 countries are included in the analysis, the impact of NIC on GDP formation ranges from 13.5% to 72.5% (Appendix B1), depending on the country's level of development and economic structure. The results for selected countries, economic groups and regions are presented in Table 5 below.

Table 5: Impact of intangible capital (NIC), global markets (MTFP) and domestic markets (DTFP) on GDP formation as % of GDP 2011

NIC48	/2011	Index NIC	Percentage share in GDP formation MTFP %	DTFP %	NIC %	MTFP Sensitivity
	NIC48 weighted by GDP	6.5	23.1	29.2	47.7	0.8
Europe						
	European Union	6.7	20.0	28.4	51.6	0.7
	EMU countries	6.7	21.2	28.9	49.8	0.7
USA		8.9	8.8	21.0	70.3	0.4
	NORDIC COUNTRIES	8.1	18.8	16.5	64.7	1.1
	Sweden	8.5	14.3	13.2	72.5	1.1
	Denmark	8.3	16.7	15.7	67.6	1.1
	Finland	8.2	14.3	16.1	69.7	0.9
	Norway	7.6	29.5	21.4	49.1	1.4
	Iceland	7.5	20.8	22.9	56.4	0.9
Economic groups						
	ASEAN	5.3	34.6	25.8	39.6	1.3
	BRICS	4.8	34.6	31.9	33.4	1.1
	PIIGS	5.7	24.2	36.4	39.4	0.7
Groups by wealth						
	GDP/POP 1 /Rich	8.7	11.0	21.1	67.9	0.5
	GDP/POP 2 / Median	6.1	23.7	33.5	42.8	0.7
	GDP/POP 3 / Poor	4.7	34.6	31.2	34.2	1.1
Groups by NIC impact						
	GDP/NIC 1 / High	8.6	10.3	21.0	68.7	0.5
	GDP/NIC 2 / Median	7.2	24.0	31.8	44.2	0.8
	GDP/NIC 3 / Low	4.4	28.6	44.7	26.7	0.6
Groups by level of NIC						
	NIC 1 / High	8.6	13.3	23.5	63.3	0.6
	NIC 2 / Median	6.0	24.0	32.8	43.2	0.7
	NIC 3 / Low	4.2	27.6	43.1	29.4	0.6

Our results demonstrate the significant impact of NIC on GDP formation (average for NIC48 47.7%). This is in line with previous research results (cf. Chapter 2), but the impact is considerably stronger than anticipated by previous studies. This is mainly due to the structure of the ELSS production function (2a-c), which dissects TFP as a whole rather than focusing on its annual changes (cf. CHS and growth accounting in general). However, the high impacts are also due to the fact that previous studies have focused only on single components of NIC via augmentation (cf. section 2.1), whereas NIC is a more comprehensive measure and contains 48 indicators of national intangible capital.

Looking at the overall global picture then, NIC accounts for 47.7% of GDP formation in the 48 database countries. This means that roughly 45% of world GDP originates from intangible capital.[18] Figures for the European Union come close to 50 %, but the Nordic countries stand out with a higher figure at 64.7%: NIC contributes 72.5% to GDP in Sweden, followed by Finland at 69.7% and Denmark at 67.6% (see Appendix B1.) The low NIC share in Norway at 49.1% is mainly due to the fact the economy is heavily dependent on its global oil business (global MTFP share 29.5%, well above the figure of 18.8% in the other Nordic countries). Likewise, Iceland has suffered from its banking crisis (financial service as outlier KLEMS), but it is also heavily dependent on the global markets (high MTFP share, 22.9 %).

It is important to note that NIC is not an economic realm comparable to global markets (and MTFP share in GDP) and domestic markets (and DTFP share in GDP). *MTFP and DTFP reflect the real economy, whereas NIC acts as a driver within the economy as a whole.* The ratio of MTFP to DTFP also serves as a measure of "sensitivity to global markets" (see Table 5, column *MTFP sensitivity).* MTFP sensitivity is equal to MTFP % / DTFP %. When MTFP sensitivity is equal to 1, global and domestic are in balance and both have an equal impact on GDP formation (a sensitivity figure of less than 1 means that domestic markets are dominant and a figure higher than 1 means that global markets are dominant).

The United States has an extraordinarily low MTFP dependency of 0.4, compared to the EU figure of 0.7 and ASEAN's 1.3. The United States' low MTFP sensitivity is most likely due to its extensive and efficient domestic markets. In this comparison the European Union lags far behind the United States, and the figure of 0.7 clearly highlights its problems with the home markets. The PIIGS countries in particular have a very high DTFP dependency, which means that they will need to invest in NIC and the globalization of their markets in order to boost their competitiveness.

Looking at the country categories by wealth (GDP per capita at PPP[19]), wealthier nations show less MTFP sensitivity (0.5) than poor countries (1.1), which underlines their dependence on global markets and the growth of global markets (Table 5). As for the groups formed on the basis of how advanced their knowledge economies are (Table 5, groups by NIC impact and level of NIC), the median group in both reveals that the transition from a low to a high level economy increases the country's MTFP sensitivity. In other words moving away from globally dependent economic structures (e.g. BRICS and ASEAN countries) may imply a low level of domestic market development and social structures (e.g. the present situation in China and India). This is an important finding in that NIC is mainly a domestic issue, and also a major source of competitiveness at higher levels of economic development.

The Nordic countries, too, show a high level of MTFP sensitivity (1.1). This probably reflects their relatively small home markets, which are unable to sustain and drive the economy, i.e. they are highly dependent on global market factors and trends.

[18] The world estimate is calculated on the basis of the results for NIC48, which represent 91.2% of world GDP (2011). The countries that are not in the ELSS database represent 8.8 % of world GDP, which has been taken into account in the estimation. For these countries the estimation was based on a 20% NIC share, given the fact that most of them are poor and underdeveloped countries.

[19] GDP/POP in Table 5

5. Applicability of the new production function

Our analyses indicate that NIC has a much greater impact on GDP formation and GDP growth than has been previously assumed: the figures are 50-100% higher than suggested by previous models (CHS 2005, Piekkola 2010a, 2010b). Part of the reason for this is that earlier studies have always expressed intangible capital in terms of monetary capital value (N) as a proportion of GDP, which inevitably means that the percentages will be low (e.g. capitalized R&D investments as % of GDP). Furthermore, as we explained above (2.2.), the differences can be traced back to the confined model and calculation of intangibles. However even common sense tells us that in advanced Western economies, the impact of intangible factors amounts to more than a few percentage points.

It is inherently difficult to define, in precise monetary terms, the value of intangible capital; what price does one put on freedom of speech, for instance? For this reason we have here chosen to analyse value in terms of monetary *impact on GDP formation*. In other words we do not ask what the price of freedom of speech is, but instead consider its impact on the economy. This we can define via the production function. When intangible capital is analysed in monetary value terms only, most of it will obviously be excluded from the analysis, and consequently the impact of intangible capital will be severely underestimated.

It is also important to recognize that the meaning of the concept of capital varies in different lines of research inquiry. In the IC research tradition, capital is fundamentally a non-financial concept, describing the intellectual potential of humankind, whereas in an economic context capital always has a purely monetary value. Even though we have taken no stand on the question of how the impact of intangible capital could be interpreted in terms of monetary value, there is good reason to speculate that our method can bring this field of research closer to the true value of intangible capital than earlier calculations (for instance by using the CHS model as applied by Corrado, Piekkola or IUS). Based on extant measurement models, for instance, the total value of Finland's intangible capital is no more than half the value of the country's physical capital (Piekkola 2010a, 2010b). Our calculation shows that Finland's TFP is 11 times as high as its GDP as explained in Section 3, which better reflects the realistic contribution of TFP.

For future intangibles researchers, the ELSS production function will help to give a more realistic picture of the value and impact of national intangible capital. The results of our analysis shown in Table 3 are largely consistent with the general perception that intangibles and country specifics are major drivers of advanced economies (77.1%, 70.3%, and 30.8% in GDP formation for the high, middle and low GDP groups, respectively).

Briefly, we have dissected the residual into smaller parts in order to uncover the realistic value of intangible capital beyond monetary inputs, and at the same time taken account of country specifics. The ELSS formula is comprehensive yet not too complicated to replicate. The ingredients we have added to the simple Cobb-Douglas TFP model are as follows:

1. Aggregation - acknowledging the structure of the economy (industrial-service-agriculture) and level of metropolization (metropol-suburban-rural)

2. KLEMS – outliers in natural resources, strong financial centres, extreme tax benefits, significant sources of cheap labour, and metropolization
3. N – R&D investment
4. MTFP – impact of global economy on individual countries' GDP formation as represented by factors such as trade export, FDI flows inward and share of global trade
5. DTFP – factors that affect the domestic market, including domestic consumption, the savings rate and foreign import
6. NIC – national human capital, market capital, process capital, and renewal capital

We incorporate in our model not only the indicators proposed by earlier studies, but also expand and augment, both quantitatively and qualitatively, the explanatory power of the residual for a more realistic presentation of the true value of intangible capital.

6. Academic and policy implications

If NIC is important to economic development, then it would obviously be useful to have a reliable measure of these intangible assets. The ELSS model presented in this paper marks a step forward on the path to uncovering hidden economic drivers. Previous studies have made the crucial recognition that the economy is impacted not only by capital and labour, but other factors as well. This has led to the simple production function (TFP), which shows the extent to which a country's economy is dependent on factors other than known capital and labour. TFP was itself a valuable measure, highlighting the extent to which a country could benefit from unexplained sources. But it is necessary to do more. In order to reduce the share of unknown economic drivers, the simple TFP has been augmented through the inclusion of single factors such as education, technology or R&D as well as multiple factors. To gain a more coherent and holistic view, Lev's intangible model includes firms' operation, investment and innovation capabilities, while Corrados's model includes computerized information, innovative property and economic competencies.

As intangible indicators have previously been selected based on common sense views only, it is impossible to know to what extent intangible capital has been excluded from the calculations, without any academic or theoretical reflection. Furthermore, it is highly problematic that when intangibles are described by investment costs only, the returns on investment become irrelevant. In addition, the use of company-level data aggregated to the national level means that a nation's intangible capital consists solely of business intangible capital, while national infrastructures and cultural practices, for instance, become irrelevant.

The ELSS model solves some important parts of these problems. First, the model of national intangible capital is coherent, holistic and theoretically well-grounded. Second, it operates with comprehensive, national level data from reliable international sources. Third, by augmenting the production function with NIC indicators, we have managed to uncover 77% of TFP in developed economies and calculate the effect of intangible capital on GDP and GDP growth. A number of scholars in this field have paved the way to developing the ELSS model, putting us in the position to take this big step forward.

Even so, some challenges do still remain. The NIC indices used in the ELSS model need to be further evaluated and the indicator base needs to be constantly tested in order to keep up with societal and economic changes. This is true most particularly of time effects, country specifics and developmental stages of the economy in the calculation of cross-country comparable indices. Also, as the expanded Cobb-Douglas production function is sensitive to valuations of capital inputs (K, outlier KLEMS O and intangible assets N) and sensitive to estimates of production shares for various augmenting and expanding inputs, further work is needed to develop and test methodologies for the assessment of all of these.

Apart from its academic contribution, the ELSS model has important policy implications as well. First, it provides a new lens through which to examine national development in what is an increasingly knowledge and intangibles dominated global economy. Second, the intangible capital position of each individual country or region can easily be identified in the 48-country landscape (e.g., Table 3 and Appendix B1). This feature is important and beneficial for country diagnosis and for benchmarking purposes. Third, the model provides a detailed diagnosis for strategizing national development on a 48-country global platform rather than a standalone single country analysis. For example, for purposes of identifying national strengths and weaknesses and for cross-country comparisons, the percentage impacts of outlier KLEMS, R&D investment, global economy, domestic markets, and NIC can be listed together with similar non-rivalry measures, e.g. economic performance and competitiveness measures. In addition, NIC can be further calculated to extract the individual influence of single drivers (indicators) within national human capital, market capital, process capital and renewal capital for future strategic resource allocation. Fourth, the ELSS model bases its country analyses on valid, reliable and high quality national level data. Policymakers, national consultants and researchers can rest assured that the results are sound. The robustness of this type of research relies on the quality of the data and the research framework. Our data are mainly sourced from international organizations, including the World Bank, the United Nations, the World Economic Forum, and the IMF through the IMD. Data points draw from the same sources, and therefore data quality is unified for rich and poor countries and enables cross-country comparisons. In addition, the NIC framework has been statistically validated for reliability.

In the future it will be possible to conduct more detailed analyses of various economic blocs, such as the Nordic countries, the ASEAN group, and BRIC countries. Comparisons of different intangible capital models will also add value to this field of research.

The evidence presented in this paper indicates that NIC is a reliable indicator of national intangible assets. Furthermore we have shown that NIC, as measured in the ELSS model, is statistically robust and shows a strong positive correlation with economic growth. We hope that the results presented here will encourage other researchers to join this line of inquiry. There is much at stake as the accumulation of national intangible capital will probably be a key determinant of future national economic performance. Policymakers committed to reducing cross-country gaps in living standards will need to try and figure out what steps are needed to reduce these cross-country NIC differences. Overall, the main contribution of the present study is to provide new estimates of national intangible capital and its impact on GDP formation and growth, and to highlight the importance of intangibles as drivers of economic growth.

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Appendix A1: NIC48 countries and abbreviations

Short name	Countries
NIC48	Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China Mainland, Colombia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Korea, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Romania, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, USA, Venezuela
EMU	Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain
EU	Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Spain, Sweden, United Kingdom
PIIGS	Portugal, Ireland, Greece, Spain **,Italy**
SCAND	Denmark, Finland, Iceland, Norway, Sweden
ASEAN	China Mainland, Hong Kong, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand
BRICS	Brazil, Russia, India, China Mainland, **South Africa**

Appendix A2: NIC categories and indicators

National IC, NIC

National human capital, NHC			National market capital, NMC		
0.26	η		0.18	µ	
NHC1	0.40	Skilled labour	NMC1	0.16	Corporate tax encouragement
NHC2	0.48	Employee training	NMC2	0.49	Cross border venture
NHC3	0.59	Secondary education up enrollment	NMC3	0.11	Openness of culture
NHC4	0.41	Pupil-teacher ratio	NMC4	0.43	Transparency of government policies
NHC5	0.51	Public expenditure on education	NMC5	0.34	Image of your country
NHC6	0.24	Population aged 15-64	NMC6	0.46	Capital availability
NHC7	0.19	Qualified engineers	NMC7	0.16	Trade to GDP ratio (exports + imports)
NHC8	0.61	Students' PISA performance	NMC8	0.22	Current account balance %GDP
NHC9	0.69	Human Development Index	NMC9	0.43	Investment flows %GDP
NHC10	0.43	Gender equality	NMC10	0.74	Country credit rating
NHC11	0.59	Years of education	NMC11	0.73	Investment risk
NHC12	0.65	R&D researchers	NMC12	0.57	KOF Globalization index

National process capital, NPC			National renewal capital, NRC		
0.23	ρ		0.33	ς	
NPC1	0.56	Business competition environment	NRC1	0.78	Business R&D spending
NPC2	0.40	Government efficiency	NRC2	0.64	Basic research
NPC3	0.87	Computers per capita + Mobile subscribers	NRC3	0.72	R&D spending/GDP
NPC4	0.75	Internet subscribers + Broadband subscribers	NRC4	0.77	R&D US$ per capita
NPC5	0.37	Ease of business startup + start up days	NRC5	0.72	IP right protection
NPC6	0.62	Goods & services distribution efficiency	NRC6	0.56	Utility Patents/ R&D expenditure
NPC7	0.94	Overall productivity	NRC7	0.63	Cooperation between corporations and university
NPC8	0.24	Unemployment % + Youth unemployment %	NRC8	0.75	Scientific articles
NPC9	0.40	Consumer price inflation	NRC9	0.77	Patents per capita (USTPO+EPO)
NPC10	0.73	Health & environment	NRC10	0.12	Entrepreneurship
NPC11	0.73	Corruption	NRC11	0.56	Development & application of technology
NPC12	0.64	Freedom of speech	NRC12	0.61	Venture capital

Appendix A3: MTFP and DTFP indicators

MTFP and DTFP indicators	
MTFP	Global markets and global market linked TFP
DTFP	Domestic markets and domestic market linked TFP

MTFP		DTFP	
MTFP1	Foreign employment rate	DTFP1	Employment rate
MTFP2	Foreign high skilled people	DTFP2	Outward FDI
MTFP3	Inward FDI	DTFP3	Import ratio
MTFP4	Direct investment stock inward	DTFP4	Domestic consumption
MTFP5	Export ratio	DTFP5	Savings rate
MTFP6	Share of world trade	DTFP6	Govt spending

Appendix B1: Reduction of TFP's and impacts of MTFP, DTFP and NIC in GDP formation 2011

NIC48 Rank	/2011	TFP Simple	Aggregated TFP Expanded	Augmented	Index NIC	Percentage share in GDP formation MTFP %	DTFP %	NIC %	NIC % share Rank
44	Argentina	6.6	5.6	1.8	4.2	27.2	38.2	34.56	**40**
15	Australia	11.0	7.8	2.2	7.4	21.3	25.4	53.31	**17**
19	Austria	11.1	7.9	2.3	7.2	22.0	25.4	52.56	**19**
16	Belgium	12.0	8.8	3.9	7.3	17.8	19.6	62.61	**7**
34	Brazil	5.3	4.7	3.8	4.7	31.7	49.1	19.25	**48**
41	Bulgaria	5.6	5.0	2.5	4.4	22.7	40.7	36.62	**33**
7	Canada	10.5	7.7	1.9	7.8	19.0	25.6	55.41	**14**
29	Chile	5.6	4.7	3.9	5.5	28.5	40.1	31.39	**41**
32	China Mainland	2.8	4.3	3.3	5.0	39.6	22.6	37.86	**29**
40	Colombia	4.9	4.7	3.2	4.4	25.3	45.4	29.35	**45**
25	Czech Republic	8.0	6.7	2.6	5.6	23.1	22.6	54.39	**15**
4	Denmark	11.6	8.3	3.5	8.3	16.7	15.7	67.61	**4**
5	Finland	11.0	8.2	3.6	8.2	14.3	16.1	69.66	**3**
20	France	11.8	8.1	2.4	7.0	22.8	29.3	47.94	**23**
13	Germany	11.1	8.1	2.8	7.5	17.0	23.4	59.63	**11**
31	Greece	9.5	6.8	2.1	5.2	16.6	47.1	36.27	**34**
12	Hong Kong	9.5	7.2	2.0	7.5	15.5	24.6	59.95	**9**
26	Hungary	7.6	6.4	1.9	5.6	17.9	33.6	48.47	**22**
14	Iceland	8.3	6.7	2.1	7.5	20.8	22.9	56.35	**13**
42	India	2.0	3.6	2.7	4.3	27.7	44.5	27.81	**46**
48	Indonesia	2.3	3.5	3.1	3.6	30.2	44.2	25.54	**47**
23	Ireland	11.0	7.6	2.6	6.8	22.7	23.4	53.91	**16**
11	Israel	10.2	7.8	3.0	7.6	15.3	19.6	65.03	**5**
26	Italy	11.1	7.6	2.6	5.6	24.5	35.9	39.58	**27**
8	Japan	8.4	6.4	3.7	7.8	25.1	33.4	41.52	**26**
35	Jordan	4.3	4.5	3.4	4.7	18.9	44.9	36.16	**35**
22	Korea	6.7	5.7	3.2	6.9	23.1	27.3	49.61	**20**
30	Malaysia	6.2	5.5	2.7	5.4	32.8	29.7	37.53	**30**
38	Mexico	5.3	4.8	3.1	4.5	28.6	40.4	30.99	**43**
9	Netherlands	11.3	8.3	3.4	7.7	20.2	17.1	62.7	**6**
21	New Zealand	8.4	6.5	2.6	6.9	21.9	31.4	46.76	**24**
10	Norway	14.0	9.2	3.4	7.6	29.5	21.4	49.11	**21**
46	Philippines	2.5	3.8	3.2	4.0	19.2	49.8	31.03	**42**
33	Poland	7.7	6.3	2.4	4.8	21.5	33.5	45.03	**25**
28	Portugal	7.6	6.0	2.5	5.5	21.2	42.0	36.79	**31**
45	Romania	5.8	5.5	1.9	4.2	23.3	41.3	35.37	**38**
36	Russia	7.4	5.7	2.0	4.6	30.7	33.3	35.99	**36**
2	Singapore	11.0	7.7	1.7	8.9	28.6	18.6	52.81	**18**
36	South Africa	6.2	5.2	2.6	4.6	25.7	38.8	35.46	**37**
24	Spain	9.2	6.6	2.2	6.0	26.1	35.4	38.58	**28**
3	Sweden	11.0	8.1	3.8	8.5	14.3	13.2	72.52	**1**
6	Switzerland	10.4	7.4	1.8	8.1	16.9	23.2	59.9	**10**
17	Taiwan	9.2	7.1	1.9	7.3	16.9	24.7	58.39	**12**
42	Thailand	3.2	3.4	2.7	4.3	29.5	35.4	35.1	**39**
39	Turkey	7.1	5.8	1.9	4.5	18.6	44.7	36.71	**32**
18	United Kingdom	10.4	8.3	3.2	7.2	13.6	25.3	61.18	**8**
1	USA	12.0	9.1	3.8	8.9	8.8	21.0	70.26	**2**
47	Venezuela	5.1	5.1	1.9	3.7	29.2	39.9	30.88	**44**

Appendix B2: Index values of NIC and NIC categories, and percentage shares in GDP formation, 2011

NIC48	/2011	Index					Percentage share in GDP formation				
Rank		NIC	NHC	NMC	NPC	NRC	NIC %	NHC %	NMC %	NPC %	NRC %
44	Argentina	4.2	5.0	3.2	3.5	3.3	34.6	11.9	6.2	10.8	5.7
15	Australia	7.4	8.1	6.3	7.0	6.9	53.3	13.7	13.3	13.0	13.4
19	Austria	7.2	7.2	7.2	7.2	6.8	52.6	12.8	12.9	12.7	14.2
16	Belgium	7.3	8.3	6.6	6.6	6.8	62.6	17.1	14.1	17.9	13.6
34	Brazil	4.7	5.1	3.9	3.7	3.6	19.3	5.2	6.0	4.2	3.9
41	Bulgaria	4.4	4.9	3.8	3.6	3.1	36.6	10.5	10.4	10.9	4.8
7	Canada	7.8	8.8	7.1	7.3	7.5	55.4	14.3	13.4	13.7	14.0
29	Chile	5.5	4.9	6.3	5.1	3.9	31.4	7.0	10.9	7.5	6.1
32	China Mainland	5.0	5.4	5.1	3.6	3.8	37.9	10.9	12.5	6.9	7.7
40	Colombia	4.4	4.5	3.8	3.6	3.1	29.4	8.3	7.8	8.0	5.2
25	Czech Republic	5.6	6.0	5.1	4.9	4.3	54.4	15.8	13.8	15.0	9.8
4	Denmark	8.3	8.8	7.7	8.2	7.6	67.6	17.5	14.6	17.9	17.7
5	Finland	8.2	9.1	7.3	7.2	8.0	69.7	17.8	15.1	17.5	19.3
20	France	7.0	7.8	5.8	6.3	6.4	47.9	13.4	11.0	13.1	10.6
13	Germany	7.5	7.8	6.9	6.7	7.2	59.6	14.9	13.3	16.2	15.3
31	Greece	5.2	5.8	4.3	4.5	3.9	36.3	11.1	7.5	10.8	6.9
12	Hong Kong	7.5	7.3	8.6	7.8	7.2	60.0	15.1	16.0	16.3	12.6
26	Hungary	5.6	6.3	4.4	4.9	4.5	48.5	15.8	10.1	14.8	7.8
14	Iceland	7.5	9.2	5.0	7.9	7.7	56.4	18.3	6.6	15.7	15.8
42	India	4.3	4.4	4.3	3.0	3.5	27.8	6.9	8.5	6.4	6.1
48	Indonesia	3.6	4.2	3.7	2.7	2.6	25.5	6.9	7.4	6.2	5.0
23	Ireland	6.8	7.8	6.5	6.3	6.2	53.9	14.3	14.3	12.9	12.4
11	Israel	7.6	8.1	5.5	5.9	8.2	65.0	16.8	14.3	15.1	18.8
26	Italy	5.6	6.1	4.8	5.0	4.6	39.6	12.4	9.2	11.0	6.9
8	Japan	7.8	8.5	5.8	6.7	7.3	41.5	10.1	9.3	10.2	11.9
35	Jordan	4.7	5.5	4.2	4.0	3.7	36.2	10.2	9.8	9.8	6.4
22	Korea	6.9	7.9	5.3	5.7	6.3	49.6	12.6	12.7	11.8	12.6
30	Malaysia	5.4	5.4	5.3	4.6	4.4	37.5	10.1	10.6	9.4	7.5
38	Mexico	4.5	5.0	4.2	3.8	3.1	31.0	8.7	8.2	8.7	5.3
9	Netherlands	7.7	8.0	7.8	7.5	7.2	62.7	16.0	15.0	17.3	14.4
21	New Zealand	6.9	8.2	5.9	6.8	6.0	46.8	12.5	12.2	12.0	10.1
10	Norway	7.6	8.8	7.5	7.6	6.6	49.1	12.5	12.7	11.8	12.1
46	Philippines	4.0	4.7	3.7	2.9	2.9	31.0	8.9	8.5	7.9	5.7
33	Poland	4.8	6.0	4.0	3.7	3.2	45.0	14.3	11.5	12.1	7.2
28	Portugal	5.5	6.4	5.0	5.5	3.9	36.8	11.2	8.1	10.2	7.4
45	Romania	4.2	5.0	3.5	3.3	2.9	35.4	10.8	8.2	10.3	6.1
36	Russia	4.6	6.8	4.0	3.2	3.4	36.0	12.7	8.9	10.1	4.3
2	Singapore	8.9	8.9	9.5	8.0	9.0	52.8	12.7	15.0	12.3	12.8
36	South Africa	4.6	4.0	4.1	3.9	3.9	35.5	8.2	10.1	10.0	7.2
24	Spain	6.0	6.8	5.4	5.3	4.6	38.6	11.4	9.3	10.7	7.2
3	Sweden	8.5	8.9	7.8	7.5	8.0	72.5	16.8	16.7	17.9	21.2
6	Switzerland	8.1	7.9	7.9	7.5	7.9	59.9	13.0	15.3	12.7	18.9
17	Taiwan	7.3	7.9	6.3	6.1	7.1	58.4	16.0	12.7	15.0	14.7
42	Thailand	4.3	4.7	4.2	3.5	3.0	35.1	9.2	10.8	8.6	6.4
39	Turkey	4.5	4.6	3.9	3.9	3.4	36.7	9.9	10.0	10.4	6.4
18	United Kingdom	7.2	7.7	6.4	6.7	6.8	61.2	17.4	12.5	18.5	12.7
1	USA	8.9	9.7	6.6	7.7	9.1	70.3	17.9	13.7	19.8	18.9
47	Venezuela	3.7	4.7	3.2	3.1	3.0	30.9	11.5	6.3	8.8	4.3

Appendix B3: Shares of NIC, MTFP and DTFP in GDP annual growth, 2011

NIC48 Rank	/2011	Index NIC	Growth Real GDP	Fraction share in GDP growth MTFP	DTFP	NIC	**NIC impact Rank**
44	Argentina	4.2	8.8	3.6	4.7	0.5	**45**
15	Australia	7.4	2.2	0.8	0.3	1.1	**17**
19	Austria	7.2	2.7	0.7	0.7	1.2	**12**
16	Belgium	7.3	1.8	0.5	0.2	1.1	**18**
34	Brazil	4.7	2.7	0.4	1.8	0.5	**46**
41	Bulgaria	4.4	1.7	0.9	0.0	0.7	**34**
7	Canada	7.8	2.5	0.4	0.8	1.2	**11**
29	Chile	5.5	6.0	2.2	2.8	1.0	**23**
32	China Mainland	5.0	9.2	4.8	3.6	0.8	**31**
40	Colombia	4.4	5.9	1.6	3.7	0.6	**43**
25	Czech Republic	5.6	1.7	0.5	0.2	1.0	**24**
4	Denmark	8.3	0.8	-0.2	-0.3	1.3	**5**
5	Finland	8.2	2.7	-0.6	1.9	1.5	**3**
20	France	7.0	1.7	0.1	0.6	1.0	**20**
13	Germany	7.5	3.0	1.2	0.6	1.1	**15**
31	Greece	5.2	-6.9	-3.9	-3.8	0.8	**30**
12	Hong Kong	7.5	5.0	3.4	0.5	1.1	**16**
26	Hungary	5.6	1.7	0.7	0.0	1.0	**25**
14	Iceland	7.5	3.1	0.9	0.8	1.4	**4**
42	India	4.3	6.5	1.3	4.5	0.7	**38**
48	Indonesia	3.6	6.5	2.6	3.3	0.5	**47**
23	Ireland	6.8	1.4	0.3	-0.1	1.3	**8**
11	Israel	7.6	4.6	1.3	2.1	1.3	**6**
26	Italy	5.6	0.4	-0.3	0.0	0.7	**37**
8	Japan	7.8	-0.7	0.4	-2.2	1.0	**21**
35	Jordan	4.7	2.5	0.8	0.6	1.0	**27**
22	Korea	6.9	3.6	1.6	0.9	1.2	**14**
30	Malaysia	5.4	5.1	3.2	1.2	0.7	**35**
38	Mexico	4.5	3.9	2.5	0.9	0.6	**42**
9	Netherlands	7.7	1.2	-0.1	0.0	1.2	**10**
21	New Zealand	6.9	1.4	0.2	0.1	1.0	**19**
10	Norway	7.6	1.6	0.3	0.4	0.9	**28**
46	Philippines	4.0	3.9	1.4	1.8	0.8	**33**
33	Poland	4.8	4.3	1.8	1.7	0.7	**36**
28	Portugal	5.5	-1.6	0.7	-3.0	0.8	**32**
45	Romania	4.2	2.5	1.3	0.5	0.6	**41**
36	Russia	4.6	4.3	2.3	1.6	0.5	**44**
2	Singapore	8.9	4.9	3.4	0.3	1.2	**13**
36	South Africa	4.6	3.1	1.3	1.2	0.6	**40**
24	Spain	6.0	0.4	-0.2	-0.2	0.9	**29**
3	Sweden	8.5	4.0	1.1	1.3	1.5	**2**
6	Switzerland	8.1	1.9	0.6	0.1	1.2	**9**
17	Taiwan	7.3	4.0	1.9	0.5	1.6	**1**
42	Thailand	4.3	0.1	-0.9	0.0	1.0	**22**
39	Turkey	4.5	8.5	3.2	4.6	0.6	**39**
18	United Kingdom	7.2	0.8	-0.2	0.0	1.0	**26**
1	USA	8.9	1.8	0.3	0.2	1.3	**7**
47	Venezuela	3.7	4.2	-0.2	4.0	0.3	**48**

Appendix B4: Development of NIC impact in GDP formation, 2001–2011

NIC48 Rank	/2011	Index NIC	NIC % share in GDP formation 2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Change % 2001-11	Rank
44	Argentina	4.2	26.6	30.5	25.3	23.5	24.6	22.8	23.8	24.8	32.1	32.0	34.6	29.9	**18**
15	Australia	7.4	56.8	55.4	55.2	54.0	51.5	52.7	50.5	50.3	54.4	52.7	53.3	-6.1	**47**
19	Austria	7.2	52.9	55.6	52.5	53.2	54.3	54.8	53.3	52.8	52.5	53.7	52.6	-0.6	**42**
16	Belgium	7.3	62.8	66.0	63.9	61.2	60.4	61.7	60.5	59.9	61.2	63.5	62.6	-0.3	**41**
34	Brazil	4.7	19.3	19.7	19.7	18.8	16.2	18.5	20.4	19.9	18.8	19.1	19.2	0.0	**40**
41	Bulgaria	4.4	31.9	36.8	35.0	31.4	32.2	29.9	30.0	29.6	32.1	37.0	36.6	14.7	**26**
7	Canada	7.8	57.8	56.9	56.7	56.2	56.1	55.9	55.8	55.2	56.4	55.1	55.4	-4.1	**46**
29	Chile	5.5	28.5	30.2	33.0	33.5	31.5	31.6	31.1	29.4	30.3	32.6	31.4	10.2	**32**
32	China Mainland	5.0	27.1	27.5	28.2	29.2	32.4	33.6	34.2	34.0	36.1	37.6	37.9	39.5	**13**
40	Colombia	4.4	17.3	18.6	23.9	23.4	24.4	21.9	21.5	20.7	28.6	27.5	29.3	70.0	**9**
25	Czech Republic	5.6	37.7	35.2	39.3	41.3	43.3	48.1	49.2	49.3	51.6	53.9	54.4	44.1	**11**
4	Denmark	8.3	58.5	59.7	58.1	58.6	60.1	58.8	57.9	59.5	63.4	67.3	67.6	15.6	**23**
5	Finland	8.2	63.7	67.1	63.1	65.1	65.0	66.5	66.3	68.3	67.0	69.6	69.7	9.4	**33**
20	France	7.0	49.7	53.6	49.7	47.8	48.7	46.9	47.4	47.6	47.3	47.8	47.9	-3.5	**45**
13	Germany	7.5	53.7	54.9	54.1	54.6	56.2	56.0	55.7	56.0	57.3	59.8	59.6	11.0	**31**
31	Greece	5.2	32.3	35.6	31.9	32.2	34.2	32.0	31.6	35.6	35.3	34.8	36.3	12.3	**30**
12	Hong Kong	7.5	30.3	36.6	35.3	41.5	46.5	49.8	54.6	55.5	55.9	58.4	59.9	97.9	**1**
26	Hungary	5.6	38.2	41.3	38.8	38.1	37.8	45.0	43.6	44.6	47.0	48.5	48.5	27.0	**19**
14	Iceland	7.5	52.5	60.7	55.6	55.2	49.8	45.5	47.6	52.9	53.6	55.0	56.4	7.4	**36**
42	India	4.3	20.4	21.4	19.2	19.1	20.4	22.0	22.2	23.8	26.3	26.4	27.8	36.6	**15**
48	Indonesia	3.6	25.1	24.2	23.5	23.4	24.3	25.7	26.1	26.1	25.9	25.4	25.5	1.8	**39**
23	Ireland	6.8	43.6	48.3	45.2	42.1	40.5	36.3	40.3	41.6	50.0	51.0	53.9	23.5	**21**
11	Israel	7.6	52.9	60.8	59.7	62.6	61.3	62.5	61.4	60.6	65.5	64.1	65.0	22.8	**22**
26	Italy	5.6	39.9	41.3	36.7	33.8	34.3	32.7	34.5	35.3	37.7	38.2	39.6	-0.8	**43**
8	Japan	7.8	33.2	38.6	39.3	41.6	44.6	47.3	49.7	48.9	42.1	43.4	41.5	25.1	**20**
35	Jordan	4.7	33.6	33.3	32.3	32.0	29.0	31.6	37.2	36.6	35.8	34.5	36.2	7.6	**35**
22	Korea	6.9	27.9	31.8	34.7	37.4	37.3	40.2	41.4	44.6	46.6	47.5	49.6	77.9	**5**
30	Malaysia	5.4	19.0	21.8	25.3	28.2	31.1	33.1	32.8	34.1	36.9	36.2	37.5	97.8	**2**
38	Mexico	4.5	23.8	17.5	20.1	22.5	24.5	24.3	25.2	26.5	28.1	30.1	31.0	30.0	**17**
9	Netherlands	7.7	61.4	61.6	56.7	57.3	59.4	60.5	60.0	60.3	60.3	63.3	62.7	2.1	**38**
21	New Zealand	6.9	43.9	46.6	37.8	35.6	35.4	47.9	46.2	47.7	47.6	46.5	46.8	6.5	**37**
10	Norway	7.6	54.0	47.7	49.0	50.6	53.7	54.6	51.8	54.3	50.6	50.2	49.1	-9.1	**48**
46	Philippines	4.0	22.4	23.3	22.9	24.6	26.4	28.5	29.4	28.8	29.9	30.8	31.0	38.6	**14**
33	Poland	4.8	24.7	30.6	30.7	32.7	32.4	35.9	36.2	35.9	44.4	42.2	45.0	82.4	**4**
28	Portugal	5.5	26.0	25.9	22.7	21.2	26.9	30.5	31.0	31.7	34.3	36.0	36.8	41.6	**12**
45	Romania	4.2	22.6	24.3	23.4	24.1	24.3	25.4	24.3	27.4	32.1	33.7	35.4	56.5	**10**
36	Russia	4.6	21.0	22.6	24.9	24.7	25.5	34.4	32.6	37.0	36.9	33.9	36.0	71.3	**8**
2	Singapore	8.9	46.0	48.4	50.9	53.8	59.8	57.6	57.7	51.0	51.9	56.8	52.8	14.7	**25**
36	South Africa	4.6	27.1	30.8	30.5	30.2	30.9	29.7	27.6	31.2	32.9	34.4	35.5	31.0	**16**
24	Spain	6.0	39.1	38.5	32.7	29.9	29.5	28.6	29.4	29.6	35.6	37.4	38.6	-1.3	**44**
3	Sweden	8.5	66.8	67.1	68.0	68.2	68.0	69.0	69.4	68.5	71.5	72.0	72.5	8.5	**34**
6	Switzerland	8.1	52.0	53.1	50.2	50.4	51.2	55.8	57.0	57.8	58.7	59.0	59.9	15.3	**24**
17	Taiwan	7.3	33.6	37.8	36.8	37.2	39.5	45.4	49.5	50.0	54.9	56.0	58.4	73.8	**7**
42	Thailand	4.3	30.7	31.9	31.2	31.7	31.7	33.2	34.5	34.3	34.1	34.9	35.1	14.2	**28**
39	Turkey	4.5	19.9	23.8	17.7	22.3	24.3	29.3	30.7	33.5	35.2	34.3	36.7	84.9	**3**
18	United Kingdom	7.2	53.4	53.5	54.7	54.9	55.9	55.9	53.1	54.5	60.0	60.2	61.2	14.5	**27**
1	USA	8.9	61.6	62.4	63.8	64.9	66.3	63.8	65.6	65.5	67.5	69.7	70.3	14.0	**29**
47	Venezuela	3.7	17.5	16.8	19.2	20.6	21.5	21.1	21.1	22.1	23.8	31.6	30.9	76.2	**6**